WOOD & COMPANY

VIGO Photonics

Buy

Initiation of coverage

Price: PLN 532
Price target: PLN 629

Sensing the growth ahead

We initiate coverage of VIGO Photonics (VIGO) with a BUY rating and a price target (PT) of PLN 629/share, implying 18% upside potential. VIGO is a Polish producer of mid-infrared photon detectors, used for industrial and military purposes. It has developed its own production technology and built a production facility, with annual capacity of up to 100,000 detectors (vs. c.12,000 sold in 2021). In 2022, VIGO's growth pace was harmed by the lack of orders from Safran (its biggest customer) and supply chain issues, as a result of which its sales dropped 6% yoy, while its share price has fallen 25% in the LTM. Both issues, however, are temporary and, from 2023E, we expect VIGO to record a results expansion, driven by strong demand for both industrial and military detectors, and the price hikes it implemented in October 2022. From 2025E, we assume VIGO develops a new revenue stream: infrared arrays that should boost military segment sales growth. We expect VIGO to generate 2022-25E CAGRs of 26% and 49% in sales and EBITDA, respectively. On our forecasts, it is trading at EV/EBITDAs of 12.5-8.6x for 2024-25E, at 14-31% discounts vs. its peers.

A leading global producer of uncooled mid-infrared detectors. VIGO's detectors have applications in the R&D, healthcare, security and defence, industry, transportation, and environmental protection fields. Its detectors work in an ambient temperature, or are cooled using thermoelectric coolers, based on the company's proprietary technology. Thanks to this, they are cheaper, easier to operate, offer faster cooling and warming times than cryocooling, and consume less energy. VIGO claims that, in the mid-wavelength spectrum, its detectors offer best-in-class quality in terms of detectivity ratio compared to the competition. The proof of the products' quality is their use in the NASA and European Space Agency exploration programmes.

Global infrared detectors market to expand at a 7-10% CAGR. According to five different market research sources, the global infrared detectors market's value is estimated at c.USD 0.5bn, while its long-term CAGR is expected at 7-10%. The market is niche: according to Fact.MR, the global sensors market value was USD 180bn in 2020, while the IR detectors share accounted for only 0.23%. VIGO is focused on an even narrower niche of mid-wave infrared detectors, which contribute c.20-25% of the global IR detectors market.

26% 2022-25E sales CAGR. In 2022, VIGO saw total sales of PLN 67.3m, -6% yoy, on the lack of Safran orders and supply chain issues. We expect VIGO's sales to expand by 30-23% in 2023-24E, to PLN 87.5-107.2m, and its EBITDA by 84-38%, to PLN 31.5-43.4m, on an increase in the industry segment demand, a military segment sales acceleration, price hikes and expansion into new geographies (in 4Q22, VIGO's Asian market sales almost doubled yoy). From 2025E, we also expect the military industry revenues to be supported by VIGO's new initiative: infrared arrays.

PLN 629/share PT. We initiate with a BUY and a PLN 629/share PT. Our PT is the average of our comparative valuation (PLN 662.1/share PT) and our DCF valuation (PLN 595.8/share PT). We assign equal 50% weights to both methods. We see VIGO's valuation as relatively attractive as, on our forecasts, it trades at EV/EBITDAs of 12.5-8.6x for 2024-25E, at 14-31% discounts vs. its peers, while offering a stronger growth outlook: we expect VIGO to generate a 49% 2022-25E EBITDA CAGR vs. the 10% peers' median.

Expected events

4Q22 results	18 April
1Q23 results	23 May
2Q23 results	19 September
3Q23 results	21 November

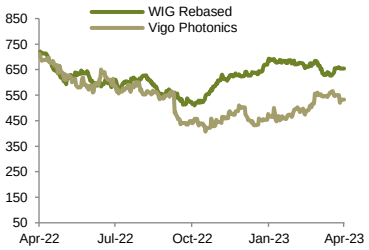
Key data

Market Cap	PLN 388m
3M ADTV	PLN 0.2m
Free float	62.1%
Shares outstanding	0.73m
Major Shareholder	Warsaw Equity Mgmt
Bloomberg Code	VGO PW
WIG Index	58,539

Price performance

52-w range	PLN 407-712
52-w performance	-25.3%
Relative performance	-17.2%

VIGO Photonics 12M share price performance



Year	Revenues	Adjusted EBITDA	NI	Net debt	Organic FCF	Organic FCF yield	EV/adj. EBITDA
	PLNm	PLNm	PLNm	PLN	PLNm	%	x
2020	53.5	24.5	32.5	14.2	10.4	3%	16.4
2021	71.5	29.1	32.3	28.2	-8.8	-2%	14.3
2022E	67.3	14.2	11.3	55.8	-23.6	-6%	31.1
2023E	87.5	28.2	13.0	81.0	-20.2	-5%	16.6
2024E	107.2	39.4	20.4	106.1	-24.0	-6%	12.5
2025E	134.7	54.3	29.5	80.8	25.3	7%	8.6

EQUITY RESEARCH

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Closing Prices as of 07 April 2023

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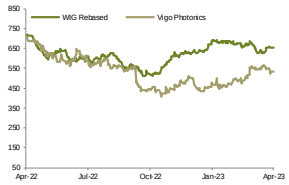
Company snapshot – BUY, PT PLN 629.0/share

VIGO Photonics

BUY	
Bloomberg ticker	VGO PW
Closing price (PLN)	532.0
Price target (PLN)	629.0
Upside to PT	18%
Shares outstanding (m)	0.73
Market cap (PLNm)	388
Free float	62.1%
3M ADTV (PLNm)	0.2
52 Week performance	-25.3%
52 Week relative performance	-17.2%
52 Week Range (PLN)	407-712

SHARE PRICE PERFORMANCE



COMPANY DESCRIPTION

VIGO Photonics is a Poland-based company that specialises in the development and manufacturing of advanced photonics and infrared technologies. The company was founded in 1987 and has since grown into one of the leading global producers of uncooled, infrared photon detectors. VIGO's detectors have found applications in fields such as research and development, healthcare, security and defence, industry, transportation, and environmental protection. In 2021, the company sold 12,200 detectors and modules, and generated sales of PLN 71.5m, of which 96% was generated abroad (mainly in Europe). In 2021, the group employed c.184 people. The company has been listed on the WSE since December 2014.

RATIOS

PER SHARE RATIOS	2020	2021	2022E	2023E	2024E	2025E
No. shares (m)	0.73	0.73	0.73	0.73	0.73	0.73
EPS	44.65	44.37	15.55	17.83	27.94	40.49
BVPS	137.97	180.01	198.70	216.54	244.48	284.97
DPS	0.00	0.00	0.00	0.00	0.00	0.00
Organic FCFPS	14.29	-12.10	-32.33	-27.70	-32.98	34.74
FINANCIAL RATIOS	**2020**	**2021**	**2022E**	**2023E**	**2024E**	**2025E**
Adj. EBITDA margin	46%	41%	21%	32%	37%	40%
EBITDA margin	50%	44%	26%	36%	41%	42%
EBIT margin	38%	35%	12%	22%	28%	30%
Net margin	60.9%	45.2%	16.9%	14.9%	19.0%	21.9%
Net debt/ adj. EBITDA	0.6x	1.0x	3.9x	2.9x	2.7x	1.5x
Net debt/equity	14%	21%	39%	51%	60%	39%
Capex/Sales	43%	72%	80%	72%	72%	15%

DUPONT ANALYSIS	2020	2021	2022E	2023E	2024E	2025E
Net margin	60.9%	45.2%	16.9%	14.9%	19.0%	21.9%
Asset turnover	0.3x	0.3x	0.3x	0.3x	0.3x	0.3x
ROA	19.5%	14.8%	4.3%	4.1%	5.3%	7.5%
Leverage	1.7x	1.7x	1.8x	2.0x	2.2x	1.9x
ROE	32%	25%	8%	8%	11%	14%
ROIC	17%	17%	4%	7%	9%	11%
VALUATION RATIOS	**2020**	**2021**	**2022E**	**2023E**	**2024E**	**2025E**
EV/adj. EBITDA	16.4x	14.3x	31.1x	16.6x	12.5x	8.6x
P/E	11.9x	12.0x	34.2x	29.8x	19.0x	13.1x
EV/sales	7.5x	5.8x	6.6x	5.4x	4.6x	3.5x
Dividend recorded yield	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Organic FCF yield	2.7%	-2.3%	-6.1%	-5.2%	-6.2%	6.5%

COMPANY FINANCIALS

INCOME STATEMENT. PLNm	2020	2021	2022E	2023E	2024E	2025E
Net revenues	**53.5**	**71.5**	**67.3**	**87.5**	**107.2**	**134.7**
COGS	-17.8	-26.4	-31.0	-37.9	-43.5	-50.9
Gross profit (loss) on sales	**35.6**	**45.1**	**36.3**	**49.6**	**63.7**	**83.8**
Selling costs	-3.4	-4.3	-11.8	-14.1	-15.8	-16.4
General and administrative costs	-15.9	-20.0	-21.5	-20.9	-24.9	-28.3
Other operating revenues	4.4	5.9	8.2	8.1	9.9	5.0
Other operating expenses	-0.6	-1.9	-3.4	-3.4	-3.4	-3.4
Profit (loss) on operating activities	**20.2**	**24.7**	**7.7**	**19.3**	**29.5**	**40.8**
Financial revenues	0.0	0.5	0.1	0.1	0.1	0.1
Financial expenses	-2.2	-0.8	-2.7	-3.3	-4.4	-4.4
Gross profit (loss)	**18.1**	**24.4**	**5.1**	**16.0**	**25.1**	**36.4**
Income tax	14.5	7.9	6.2	-3.0	-4.8	-6.9
Net profit	**32.5**	**32.3**	**11.3**	**13.0**	**20.4**	**29.5**
EBIT	**20.2**	**24.7**	**7.7**	**19.3**	**29.5**	**40.8**
D&A	6.2	6.7	9.4	12.2	13.9	15.5
EBITDA	**26.5**	**31.5**	**17.2**	**31.5**	**43.4**	**56.3**
EBITDA adjusted	**24.5**	**29.1**	**14.2**	**28.2**	**39.4**	**54.3**
CASH FLOW STATEMENT. PLNm	**2020**	**2021**	**2022E**	**2023E**	**2024E**	**2025E**
Net cash flow from operations	**21.2**	**24.1**	**6.8**	**18.4**	**29.1**	**43.8**
Changes in WC	-5.7	-8.6	-11.0	-13.2	-14.5	-12.6
Cash flow from investing activities	**-15.9**	**-34.6**	**-33.6**	**-40.3**	**-49.7**	**-14.0**
Capex	-23.0	-51.2	-53.9	-63.3	-77.7	-20.0
CF from financing activities	**-5.1**	**3.1**	**23.3**	**21.7**	**20.6**	**-29.4**
Changes in debt	-4.7	3.4	24.2	25.0	25.0	-25.0
Dividends and other payments to ow ners	0.0	0.0	0.0	0.0	0.0	0.0
Total net cash flows	**0.2**	**-7.4**	**-3.5**	**-0.2**	**0.0**	**0.3**
Cash eop	**13.0**	**6.5**	**3.0**	**2.8**	**2.8**	**3.1**
FCF	**4.9**	**-10.7**	**-27.7**	**-25.2**	**-25.0**	**25.3**
Organic FCF	**10.4**	**-8.8**	**-23.6**	**-20.2**	**-24.0**	**25.3**

BALANCE SHEET. PLNm	2020	2021	2022E	2023E	2024E	2025E
Tangible fixed assets	70.7	99.2	121.9	134.4	156.4	158.3
Intangible assets and expenditures on R&D	39.6	53.9	71.6	105.1	145.9	148.5
Deferred tax assets	14.5	22.4	28.6	25.6	20.8	13.9
Other	4.3	8.2	12.4	17.4	18.4	18.4
Fixed assets	**129.1**	**183.7**	**234.4**	**282.5**	**341.4**	**339.0**
Inventory	9.2	6.9	12.5	15.2	17.6	22.1
Trade and other receivables	9.9	14.4	12.2	15.8	19.4	24.4
Cash and cash equivalents	13.2	6.5	3.0	2.8	2.8	3.1
Other	5.6	6.6	3.5	3.5	3.5	3.5
Total current assets	**38.0**	**34.3**	**31.2**	**37.4**	**43.3**	**53.2**
Total assets	**167.1**	**218.0**	**265.6**	**319.9**	**384.8**	**392.2**
Equity	**100.6**	**131.2**	**144.9**	**157.9**	**178.2**	**207.7**
Long term debt	24.1	22.2	33.7	58.7	83.7	58.7
Deferred income	25.3	35.1	48.2	63.1	81.2	82.2
Other long-term liabilities	0.3	0.2	0.2	0.2	0.2	0.2
Long-term liabilities	**49.6**	**57.5**	**82.1**	**122.0**	**165.1**	**141.1**
Short term debt	6.4	12.5	25.3	25.3	25.3	25.3
Trade payables	1.7	8.1	4.6	6.0	7.4	9.3
Deferred income	2.9	2.4	2.4	2.4	2.4	2.4
Other current liabilities	5.7	6.4	6.4	6.4	6.4	6.4
Total current liabilities	16.9	29.3	38.6	40.0	41.4	43.3
Total equity and liabilities	**167.1**	**218.0**	**265.6**	**319.9**	**384.8**	**392.2**
Debt	**30.6**	**34.7**	**58.9**	**83.9**	**108.9**	**83.9**
Net debt	**14.2**	**28.2**	**55.8**	**81.0**	**106.1**	**80.8**

OPERATIONS

SEGMENT RESULTS. PLNm	2020	2021	2022E	2023E	2024E	2025E
Detection modules sales	51.5	67.2	63.1	81.6	99.9	125.6
Volume (ths)	8.4	12.2	11.0	11.7	14.1	15.9
Average price (EURths)	1.4	1.3	1.3	1.6	1.6	1.8
Detection modules EBITDA	25.5	30.7	16.3	30.2	41.7	53.9
Semiconductor materials sales	1.9	4.3	4.2	5.9	7.3	9.1
Semiconductor materials EBITDA	1.0	0.8	0.8	1.3	1.8	2.3

REVENUE STRUCTURE BY INDUSTRY. PLNm	2020	2021	2022E	2023E	2024E	2025E
Science and medicine	7.8	4.0	7.1	9.2	11.1	12.7
Other	0.4	0.3	0.5	0.8	0.9	1.0
Industry	23.6	31.1	41.1	47.5	59.3	68.3
Transport	6.2	8.7	7.8	7.8	9.0	9.9
Military	13.4	23.2	8.1	16.3	19.5	33.6
Semiconductor materials	1.9	4.3	4.2	5.9	7.3	9.1

Investment summary

We initiate coverage of VIGO Photonics (VIGO) with a BUY rating and a price target (PT) of PLN 629/share, implying 18% upside potential. VIGO is a Polish producer of mid-infrared photon detectors, used for industrial and military purposes. The company has developed its own production technology and built a production facility, with annual capacity of up to 100,000 detectors (vs. the c.12,000 sold in 2021). In 2022, VIGO's growth pace was harmed by the lack of orders from Safran (its biggest customer) and supply chain issues, as a result of which the company's sales dropped 6% yoy, while its share price has fallen 25% in the LTM. Both issues, however, are temporary and, from 2023E, we expect the company to record a results expansion, driven by strong demand for both industrial and military detectors, as well as the price hikes implemented by the company in October 2022. From 2025E, we assume that VIGO develops a new revenue stream: infrared arrays, which should boost the military segment sales growth. We expect VIGO to generate a 2022-25E sales CAGR of 26% and an EBITDA CAGR of 49%. On our forecasts, the company is trading at EV/EBITDAs of 12.5-8.6x for 2024-25E, at 14-31% discounts vs. its peers.

One of the leading global producers of uncooled mid-infrared detectors. VIGO's detectors have found applications in fields such as R&D, healthcare, security and defence, industry, transportation, and environmental protection. Its detectors work in an ambient temperature, or are cooled using thermoelectric coolers, based on the company's proprietary technology. Thanks to this, they are cheaper, easier to operate, offer faster cooling and warming times than cryocooling, and consume less energy. VIGO claims that, in the mid-wavelength spectrum, its detectors offer best-in-class quality in terms of detectivity ratio compared to the competition. The proof of VIGO's products' quality is their use in the NASA and European Space Agency exploration programmes. Throughout 2017-21, VIGO invested c.PLN 90m in the development of production capacity – thanks to the finalisation of the investments listed below, the current capacity of VIGO Photonics (considering its current sales mix) is c.100,000 detectors per year.

Global infrared detectors market to expand at a 7-10% CAGR. According to five different market research sources, the value of the global infrared detectors market is estimated at around USD 0.5bn, while its long-term CAGR is expected to reach 7-10%. All the research companies see increasing demand for motion- and people-sensing devices, smart home solutions, IOT devices, as well as increasing product utilisation in the military industry, industrial plants and the automotive industry as the main drivers of the market. The market is niche: according to Fact.MR, the global sensors market value stood at USD 180bn in 2020, while the IR detectors share accounted for only 0.23%. VIGO Photonics is focused on an even narrower niche of mid-wave infrared detectors, which contribute c.20-25% of the global IR detectors market. In its niche, VIGO competes with Teledyne Judson, Infrared Associates, and Hamamatsu.

IOT market should be one of the main drivers of demand for IR detectors. According to Statista's data (research published in July 2022), the number of Internet of Things devices worldwide should almost triple from 9.8bn in 2020 to more than 29bn in 2030E. According to Statista's research, the value of the global IOT market should expand from USD 181.5bn in 2020 to USD 621.6bn in 2030E (a 13% 2020-30E CAGR).

Levered military budgets should support usage of IR detectors. According to the Polish army modernisation plan for 2021-35, approved in 2019 and later updated by the Homeland Defence Act in 2022: from 2023, Poland is to spend at least 3% of its GDP on defence; in 2021-35, it plans to spend PLN 524bn on new military equipment, and it has set a target of doubling the size of the armed forces from 150,000 to 300,000 personnel. In 2023, Poland will spend a total of PLN 137bn (c.4.2% of the GDP, according to the government's estimates). We note that all the tanks and armoured vehicles can be equipped with the OBRA-3 Laser warning system, which utilises infrared detectors for the detection of vehicles and military objects' radiation from impulse rangefinders or laser illuminators. Apart from the demand from the Polish army, we expect VIGO to benefit from increased spending on army modernisation in Western countries.

M&A in the photonic industry: VIGO can be either an acquirer or a target. VIGO Photonics may be interested in potential acquisitions as, according to its strategy, this could accelerate its entry into new product segments: the company has noted especially manufacturers of mid-infrared sources. We, however, also believe that VIGO Photonics could become an acquisition target, as it holds a unique, hard to copy technology, high-quality products and a global presence. Based on CERES data and our estimates, the average transaction EV/EBITDA in the broad photonics and related industries market stood at 13.4x in 2018-22 (based on 108 deals, in which the majority stake was acquired and the details regarding the financials and the transaction prices were known); while, in the pure photonics segment, 14.4x (based on 23 deals).

2022 results harmed by supply chain issues and lack of orders from Safran. In 2022, VIGO Photonics reported sales of PLN 67.3m, down 6% yoy. The weakness was driven by two main factors: 1) supply chain issues; and 2) the lack of contracts from its biggest client – Safran. Both issues, however, are temporary and, from 2023E, we expect the company to record a results expansion, driven by strong demand for both industrial and military detectors, as well as the price hikes implemented by the company in October 2022. In terms of the demand from Safran: we believe that that the slowdown in revenues from Safran is temporary and might be related to the strong stocking up in 2021 – we note that, in 2021, VIGO generated PLN 20.2m sales from Safran, more than double 2020 (PLN 9.4m) and almost triple 2019 (PLN 7.4m). Considering the solid outlook for Safran's defence segment, in which the company expects to benefit from levered Western countries' army budgets, we believe the demand for VIGO's products should return soon.

2022-25E sales CAGR of 26%. In 2022, VIGO recorded total sales of PLN 67.3m, down 6% yoy, with the drop driven by the lack of orders from Safran and supply chain issues, related to the limited availability of c.10-20% of the electronic components used for the production of detection modules for the transport and industrial applications. In 2023-24E, we expect VIGO's sales to expand by 30-23%, to PLN 87.5-107.2m, and its EBITDA by 84-38%, to PLN 31.5-43.4m, driven by an increase in the demand from the industry segment, a military segment sales acceleration, price hikes and an expansion into new geographies (we note that, in 4Q22, VIGO's sales in the Asian market almost doubled yoy). From 2025E, we also expect the revenues from the military industry to be supported by the launch of VIGO's new initiative: infrared arrays. In our forecasts, we expect volumes of 100-300 in 2025-26E, respectively, and sales of PLN 14.1-42.4m.

Scenario analysis for the infrared arrays project. Out of the three new initiatives assumed in VIGO's strategy, we have pencilled only the infrared arrays project into our model, as we believe its realisation is the most probable. In our forecasts, we assume that VIGO will conclude an agreement with the Polish army and reach the target production volume of 300 infrared arrays/year from 2026E. In this scenario, the project adds PLN 117/share to our PT for VIGO – excluding the project, our PT for VIGO would reach PLN 512/share (i.e., 19% below our base-case scenario PT).

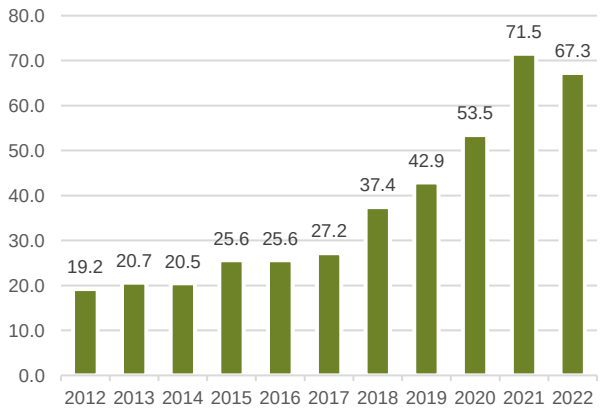
However, we note that our assumptions are conservative compared to the company's plans: VIGO estimates its annual production capacity of the infrared arrays at 500 units, while volumes of 1,000 pieces/year in its strategy. If we pencil volumes of 500 units/annually into our model, our PT would increase to PLN 705/share (12% above our base-case PT), while the annual contribution to sales would increase from the PLN 42m assumed in our base case scenario, to PLN 71m.

PLN 629/share PT. We initiate coverage of VIGO Photonics with a BUY rating and a PLN 629/share PT, implying 18% upside potential. Our PT is the average of our comparative valuation (a PT of PLN 662.1/share) and our DCF valuation (a PT of PLN 595.8/share). We assign equal 50% weights to both methods. We see VIGO's valuation as relatively attractive as, on our forecasts, it trades at EV/EBITDAs of 12.5-8.6x for 2024-25E, at 14-31% discounts vs. its peers, while offering a stronger growth outlook: we expect VIGO to generate a 49% 2022-25E EBITDA CAGR vs. the 10% peers' median.

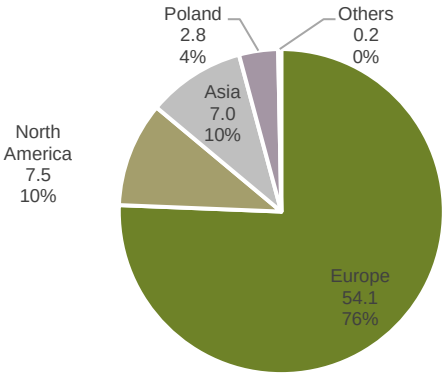
Company description

VIGO Photonics is Poland-based company that specialises in the development and manufacturing of advanced photonics and infrared technologies. The company was founded in 1987 and has since grown into one of the leading global producers of uncooled, infrared photon detectors. VIGO's detectors have found applications in fields such as research and development, healthcare, security and defence, industry, transportation, and environmental protection. In 2021, the company sold 12,200 detectors and modules, generated sales of PLN 71.5m, out of which 96% was generated abroad (mainly in Europe). As of end-2021, the company cooperated with 25 distributors in 18 countries. In 2021, the group employed c.184 people. The company has been listed on the WSE since December 2014.

VIGO Photonics: sales evolution (PLN m)



VIGO Photonics: sales structure by geography in 2021 (%)



Source: Company data, WOOD Research

Company history

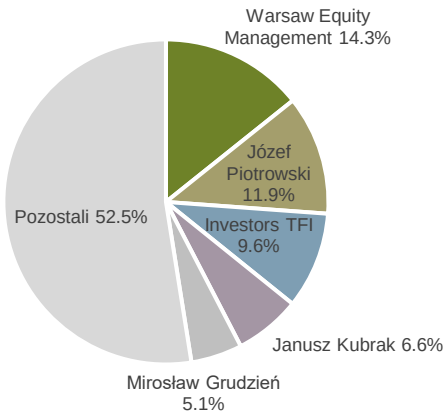
The history of VIGO dates back to the 1970s, when a team led by Professor Józef Piotrowski, PhD (one of the founders and still a shareholder of the company currently; author of 190 publications, 2,817 quotations, h-index: 25, link to the author's profile), developed at the Military University of Technology in Warsaw, Poland, using a special technique for manufacturing detectors operating without cryocooling, which was implemented subsequently at the company. The product was very good quality, and strong demand from the foreign markets prompted the creators of the technology to found their own production company in 1987, which was reformed as VIGO System in 1993. The founders of VIGO System were, Wieslaw Galus, PhD, Mirosław Grudzień, PhD, Janusz Kubrak, PhD, Andrzej Maciak, PhD, Andrzej Nowak, PhD, Professor Jozef Piotrowski, PhD, and Krzysztof Więcław.

VIGO Photonics: milestones

1987	• VIGO Photonics (previously VIGO System) foundation
2003	• Implementation of MOCVD technology
2007	• Relocation of the registered office to Ożarów Mazowiecki
2012	• VIGO detectors on Mars (Mars Curiosity Rover)
2013	• Construction of production facility
2014	• VIGO debut on the WSE main market
2015	• Implementation of MBE technology
2016	• VIGO detectors again on Mars as part of Exomars mission
2019	• New division at VIGO - epitaxy III-V
2020	• Capital raising and switch to WSE main trading floor; establishing VIGO Photonics Taiwan; new production plant with 100,000 detectors annual capacity
2021	• First contract in North America – national intelligence organisation; establishing VIGO Photonics USA
2022	• New VIGO Photonics brand, cleanroom launch

Source: Company data, WOOD Research

VIGO Photonics: shareholders' structure



Source: Company data, WOOD Research

As of end-3Q22, the company's capital group was comprised of VIGO Photonics Taiwan (a company established in 2020 as a sales representative office in the East Asia region; 100% stake), VIGO Photonics Inc. (a company established in 2021 as a sales representative in the North American region; 100% stake) and VIGO Ventures ASI (50% stake).

VIGO Ventures ASI is an investment incubator created by VIGO Photonics and Warsaw Equity Group (50:50 joint venture) in 2017 and transformed into an alternative investment company in September 2022. It aims to invest and develop technological projects (start-ups, spin-offs) with global potential in the production of high-tech devices and components in the areas of photonics, semiconductors, quantum technologies. The target companies should have developed solutions already pre-verified and/or with a working prototype. The projects should be profitable already and/or be potential support for VIGO Photonics. The fund's budget is planned at PLN 36m (PLN 18m to be contributed by each partner) and aims for single investments worth EUR 1-1.5m. The investment horizon reaches 2032 (or until all the investment projects are completed). In 2017-21, VIGO spent PLN 7.9m on investments within VIGO Ventures. As of end-2021, the value of the jointly controlled entities reported by VIGO stood at PLN 6.4m.

VIGO Ventures holds the following investments in its portfolio:

- **Fluence** – a company that develops environmentally stable and immune to shock femtosecond lasers for industrial applications.

- **QustomDot** – a company that created patented quantum dot(QD) technology for colour-conversion (InP) and IR sensing or imaging (InAs). The technology can address the challenge of colour conversion in future applications like microLEDs in various applications like: AR/VR goggles, smart watches, automotive displays, smartphones, etc.

- KSM Vision – a company providing smart machine vision systems for industrial in-line quality control. Pharmaceutical, food, construction or cosmetic industries can optimise their production processes and eliminate errors. The systems are based on a proprietary optics and software platform.

- Deep Detection – a company providing multispectral x-ray cameras for industrial inspection and material separation enabling simultaneous detection and characterisation real time, continuous inspection from production lines to recycling to security.

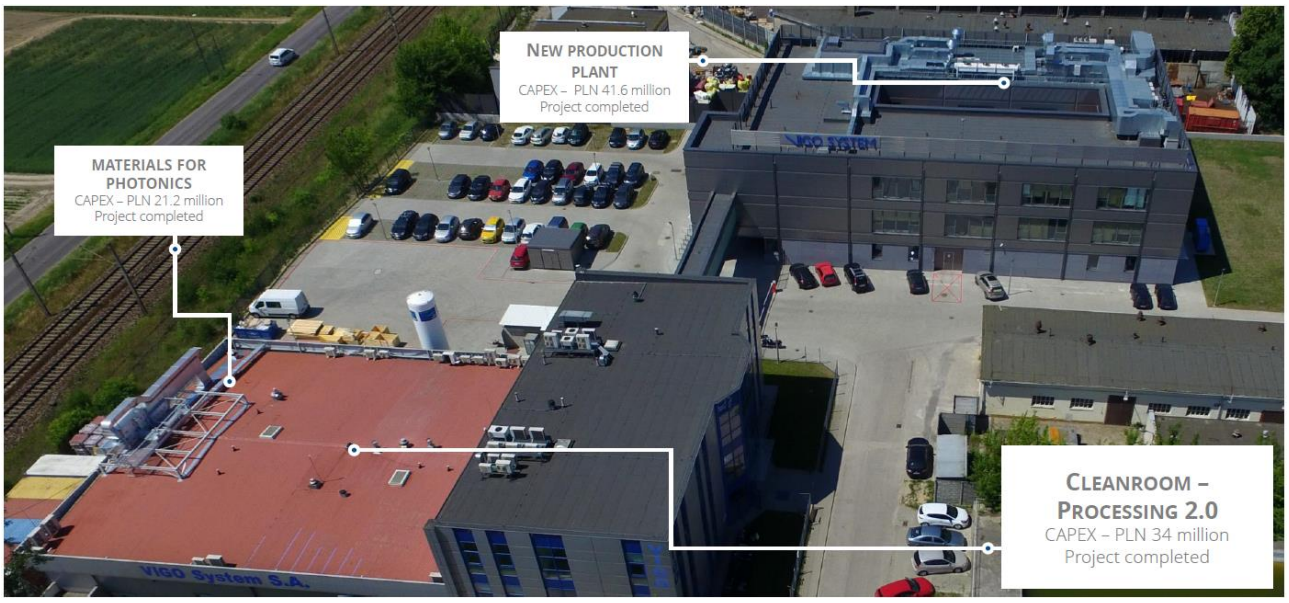
- ChipCraft – ASIC design house (Analog & Digital) with its own developed products. Its technology can also find applications in Photonic Integrated Circuits or Quantum Computing. Semiconductor IP cores' licenses provider.

- PHOTON IP – a company developing technologies for advanced photonics applications. The company – together with leading industrial partners – is working towards providing solutions that will be used (among others) in the automotive industry and telecommunications, in the production of wearable electronics or in data centres.

VIGO's technology and production capacity

VIGO Photonics has a complete front-end and back-end production line for semiconductor high capacity instruments – from the epitaxy of II-IV (tellurium, cadmium, mercury) and III-V groups (indium, arsenic, gallium, antimony), through to detector chips, lasers, and their assembly and integration with electronics. The entire technological process, starting from epitaxial wafer growth, processing, assembly, and integration with electronics and measurements, takes place at VIGO Photonics' premises (the company is the owner of HQ and production facility buildings and all the machinery). The company also has its own modern measurement laboratories, which enable the fast and accurate measurements of products and semi-finished products at every stage of production. Throughout 2017-21, VIGO invested c.PLN 90m in the development of production capacity – thanks to the finalisation of the investments listed below, the current capacity of VIGO Photonics (considering its current sales mix) is c.100,000 detectors per year.

VIGO Photonics: HQ and production facility in Ożarów Mazowiecki



Source: Company data, WOOD Research

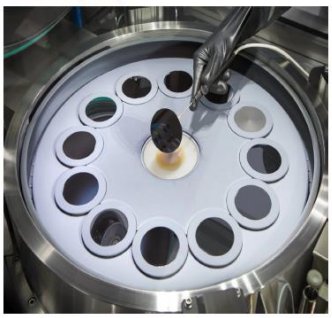
VIGO has four reactors for the production of semiconductor materials, the largest of which is a reactor manufactured by Aixtron and commissioned in 2019. Since the beginning of 2023, VIGO has operated a new epitaxial reactor for the production of III-V semiconductor materials from Aixtron, which was supposed to double its semiconductors production capacity. In 2022, the company also finished the construction of its cleanroom, with a ISO 6/ISO 7 class dedicated to detection chips. The newly-built rooms meet the high standards of cleanliness, temperature and humidity control, and have the necessary protection against chemical hazards. A cleanroom enables the cost-effective and scalable production of detection chips to be used in InGaAs detectors and allow the company to enter the shortwave infrared (SWIR) market. At the same time, VIGO has been able to enter the mid-infrared (MWIR) market with detectors made of III-V materials, which meet the requirements of the new EU legislation on reducing the use of environmentally hazardous substances, introduced by the Restriction of Hazardous Substances (RoHS) Directive.

VIGO Photonics: reactors used by VIGO

MBE (InAs, InAsSb)

MOCVD (HgCdTe/ MCT)

MOCVD (III-V)



Source: Company data, WOOD Research

The techniques used for manufacturing photonics components are:

- MOCVD – for production HgCdTe MWIR and LWIR detectors and detection modules.

The technique used for manufacturing HgCdTe detectors is the metalorganic chemical vapour deposition (MOCVD) method. As a result, multi-layer semiconductor heterostructures are obtained, consisting of more than 20 layers as a maximum, varying in terms of thickness, composition, doping and band gap broadening. They fulfil various functions: structural optical, photoelectric and electronic.

- MBEs – for production of InAs and InAsSb RoHS compliant MWIR LWIR detectors and detection modules.

The molecular beam epitaxy (MBE) growth technology is used for manufacturing bulk InAs, InAsSb and superlattice (SL) InAs/InAsSb detectors. SL detectors made of III-V materials have strong covalent bonds, which results in a higher temperature operating range, a better uniformity of the crystal, and better optical and electrical parameters.

- MOCVD epi III-V- for the production of III-V semiconductor materials for photonic and micro-electronic applications.

The company uses Planetary Reactor MOCVD for manufacturing GaAs or InP based high-quality III-V e and microelectronic devices (diodes, transistors) and others.

Products offered by VIGO

The mission of VIGO Photonics is to provide fast and convenient, easy-to-use IR detectors at any wavelength from 2 to 16 µm, reaching fundamental BLIP limits without cryocooling. The detectors manufactured by VIGO work in environment temperature or utilise thermoelectric coolers instead of cryocooling (used by most of VIGO's competition). Modules are available with different spectral response ranges, time response characteristics and gains. All the products are based on VIGO's proprietary, unique technology. The company provides ready-made and customised solutions, which allow it to create products dedicated to a given customer's application – c.90% of the company's sales are generated on customised products and 10% on standardised products.

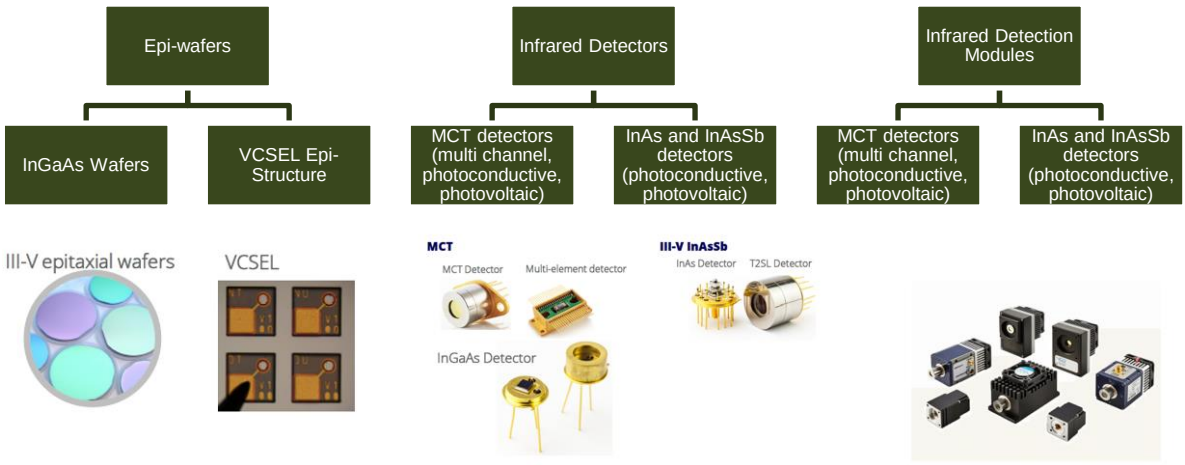
The company offers three main categories of product:

- Epi-wafers – an epitaxial wafer is a type of semiconductor wafer that has a layer of epitaxial material grown on top of a substrate wafer (a crystalline structure that can be made of silicon, gallium arsenide, sapphire, etc.). The company offers high-quality epitaxial structures of III-V semiconductor materials (InGaAs, InAsSb) directly to clients for the in-house production of detectors/chips and VCSEL lasers.

- Infrared detectors – a device that is capable of detecting and measuring the levels of infrared radiation emitted by objects. The company offers older types of detectors based on HgCdTe material, which offer the highest performance out of all the discovered materials suitable for infrared detection (suitable for industry and environmental protection), as well as detectors based on InAs or InAsSb, which are RoHS compliant and suitable for the consumer market.

- Infrared detection modules – infrared detectors integrated with electronics - complete and compact solution for detecting and measuring infrared radiation, with the added convenience of being ready to use out of the box. Detection modules offered by VIGO are characterized by high sensitivity in a wide spectral range from 1 to 16 µm, high speed in frequency bands up to 1 GHz, optimized amplification of the measured signal and operating temperatures in the range from 200 to 300 K. The company offers read-made modules for applications such as gas analysis, temperature control in fast-moving objects, laser spectroscopy. We also have the option of configuring the infrared module to the needs of a specific application. The company also offers all the necessary electrical accessories for its products such as thermoelectric cooler controllers and preamp power supplies and mechanical accessories such as brackets for detectors and infrared modules, base mounting systems and cables.

VIGO Photonics: products



Source: Company data, WOOD Research

VIGO Photonics: current product portfolio

Product	Production method	Annual capacity	Price:	Applications	Sectors
MCT detectors and detection modules	MOCVD	20ths detectors and modules	average EUR 500-1,000/module	Gas analysis, examination of the spatial distribution of temperature, precise determination of the direction of the infrared radiation source, scanning of larger areas for the detection of substances, gases and temperature changes, sorters on production lines	Industrial, military and space technologies
III-V InAsSb detectors and detection modules	MBE	100ths detectors and modules, 1m chips	EUR 100-500/module, EUR 20-30/detection chip	Gas analysis, examination of the spatial distribution of temperature, precise determination of the direction of the infrared radiation source, scanning of larger areas for the detection of substances, gases and temperature changes, sorters on production lines	Environment protection, medicine, robotics, military industry, property protection, industry (automotive, manufacturing)
III-V InGaAs detectors and detection modules	MOCVD, Aixtron G4	1m chips	EUR 30-50/detection chip	Measurement of key parameters - glucose, lactic acid, alcohol, gas analysis, humidity measurement, leakage and emission control, breath analysis, applications in surgery and medical procedures, plastics analysis, food product analysis, health monitoring, next-gen lidar (especially automotive), direct optical communication; industry - non-invasive, verification of product quality	Industry (gas analysis), environment protection, military and space technologies, medicine, consumer market (wearable devices), quantum cryptography, IoT
III-V epitaxy: semiconductor materials	MOCVD, Aixtron G4	18ths wafers per year	EUR 800-4,500	Increasing data transmission efficiency, throughput in optical communications, gas detection, 3D scanning, access to energy sources without energy infrastructure, reduction of battery consumption in computer mice, elimination of microwave limitations for automotive radars, control of autonomous vehicles, electrical powering of satellites and strategic drones	Data transfer, 3D detection, microelectronics, imaging, telecommunications, automotive industry (LIDAR), medicine, quantum photonics

Source: Company data, WOOD Research

Advantages and high quality of VIGO's products

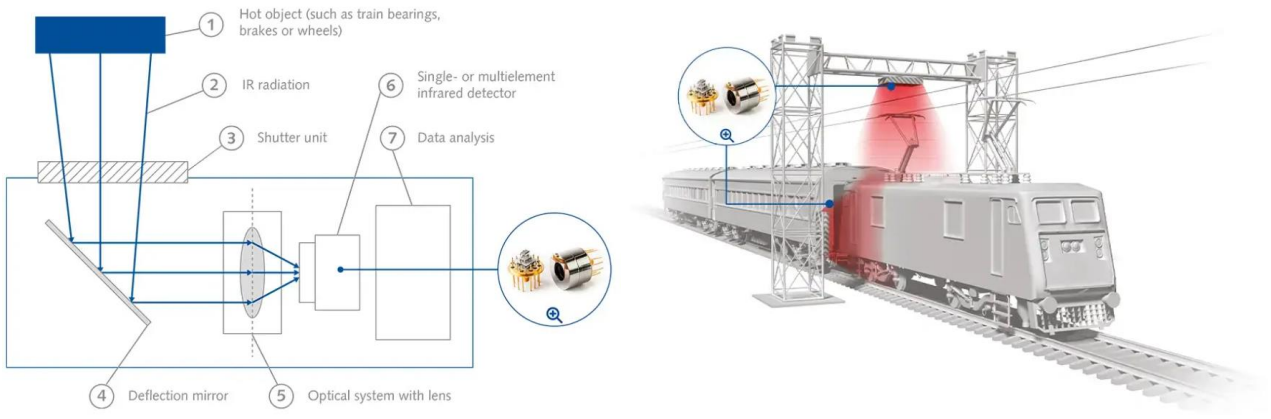
VIGO's detectors work in an ambient temperature or are cooled using thermoelectric coolers, based on the company's proprietary technology. Thanks to this, they are cheaper, easier to operate, offer faster cooling and warming times than cryocooling and consume less energy. On the other hand, the cryocooled detectors (utilising liquid nitrogen or helium cooling system) can offer better sensitivity and detectivity than thermoelectric-cooled detectors, particularly in the long-wave infrared region. Nevertheless, VIGO claims that, in the mid-wavelength spectrum, its detectors offer best-in-class quality in terms of the detectivity ratio compared to the competition. The proof of VIGO's products' quality is their use in the NASA and European Space Agency exploration programmes.

Applications of VIGO's products

The detectors manufactured by VIGO have a wide range of applications, such as:

- **Railway traffic safety:** failure detection systems in in the running gear of high-speed rail systems and fire detection systems. Temperature measurement, combined with gas analysis, makes it possible to detect leaks of gases or technical liquids, and prevent fires and explosions. Thermal monitoring is the way to minimise unscheduled breakdowns of all undercarriage elements, and prevent costly failures and downtime. The scanning system is integrated with a signalling system, enabling the automatic stopping of trains whenever hazardous defects are detected, without the intervention of the operator. The most efficient solutions for temperature measurement in railway industry are infrared HgCdTe detectors.

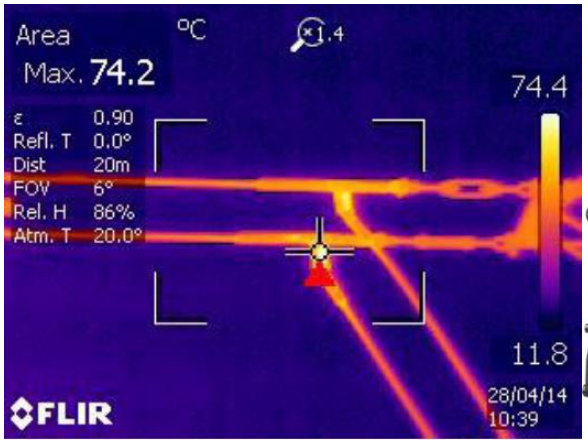
VIGO Photonics: thermal scanning system with VIGO's infrared detection modules



Source: Company data, WOOD Research

- **Environmental protection:** measurement of the threat to the environment posed by harmful chemical substances, the monitoring of emissions of hazardous substances into the air, air quality surveillance, and real-time water quality control.
- **Industrial applications:** industrial scanners for temperature distribution, industrial automation equipment, automotive sensors (analysis of temperature distribution in fast moving objects, engine emissions' monitoring and control, fuel quality assessment), industrial IR sensors (laser power control and calibration, mid-infrared spectroscopy, gas analysis), utilities (monitoring the technical condition of the transmission infrastructure).

Infrared thermography of transmission power lines using drones

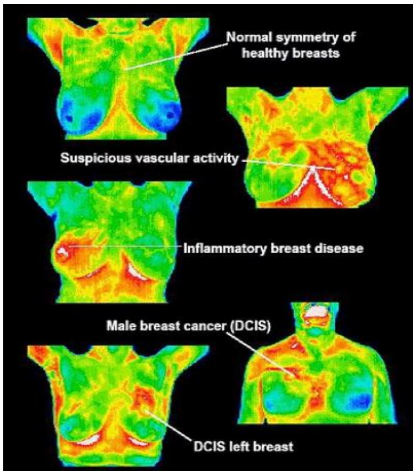


Rosemount™ X-STREAM Enhanced XEFD Continuous Gas Analyzer

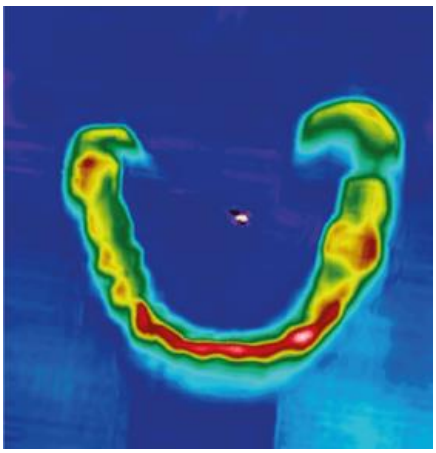
Source: scanpro.com.au, emerson.com

- **Research and science:** the measurement of high-temperature plasma parameters for thermonuclear fusion research, the measurement of ultra-short pulses of infrared radiation emitted by lasers and synchrotrons, and spectrometers for measuring extremely low concentrations of substances.
- **Medicine:** currently, infrared detectors are used in medicine primarily for the precise imaging of the temperature distribution on the surface of a patient's (or animal's) body. The physiological features of the human body related to warm-bloodedness and the emissivity of tissues in the mid- and far-infrared ranges make the human body an excellent object in thermovision studies. The visualisation of the temperature distribution on the surface of the human body is valuable diagnostic information. Increased temperature indicates the development of inflammation in a given place, which is characteristic of many diseases, e.g., cancer, or blockages in superficial blood vessels. The company's products are also used in diagnosing skin diseases and in aesthetic dermatology. In addition, infrared detectors have found an application in dentistry, in devices capable of detecting caries at a very early stage of development, allowing for non-invasive treatment only, with the use of pharmacological agents.

Breast thermography



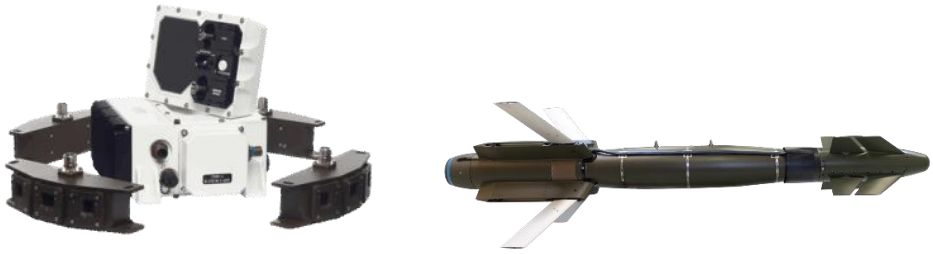
Thermography occlusion visualisation



Source: serenityhealthcarecenter.com, *oatext.com*

- **Security** (the detection of explosive and hazardous substances, prevention systems against terrorist activities, systems for checking the contents of passengers' luggage).
- **Space industry:** laser communications in open space, measurement equipment for space applications. Infrared detectors produced by VIGO were used in the Mars Curiosity Rover, which landed on the Red Planet on 6 August 2012 as part of the NASA programme, and the subsequent detection of traces of methane on Mars in December 2014 with the use of these detectors. The company's detectors were also used by the European Space Agency as part of the Exomars mission. In October 2016, the Schiaparelli landing module, equipped with VIGO System's detectors, attempted a landing on Mars.
- **Military applications:** laser-beam vehicle-tracking alert systems, missile guidance systems. VIGO's biggest client in 2021 was Safran, which used VIGO's detectors in its smart munition products. Safran's Hammer AASM (Armement Air-Sol Modulaire, in French) is a modular air-to-ground guided missile family produced by French Safran (for more details, click here).

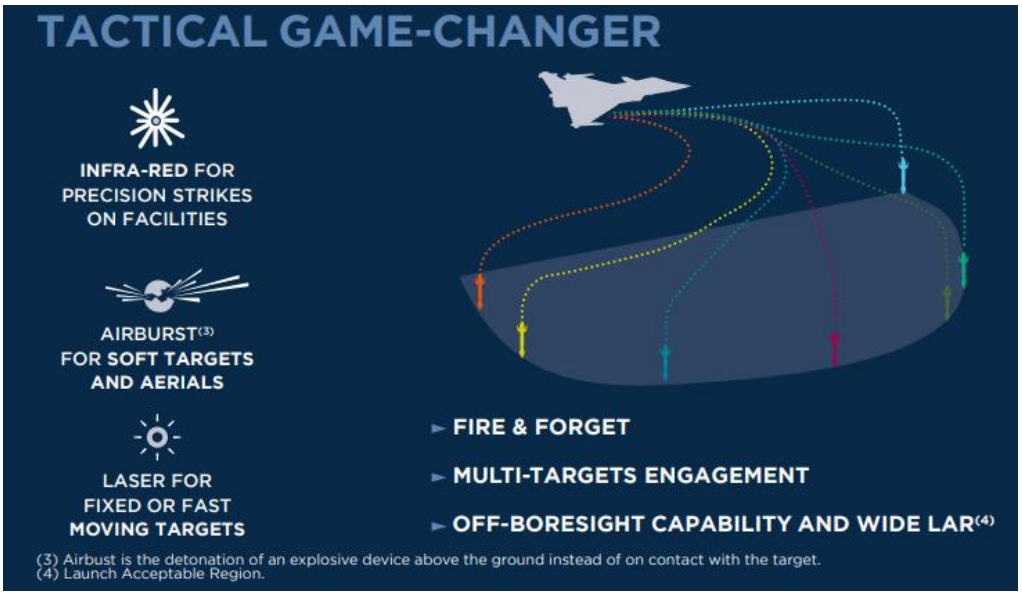
SSP-1 Obra-3 Vehicle Self-Shielding System AASM HAMMER™ – Highly Agile Modular Munition Extended Range



Source: pcosa.com.pl, safran-group.com

As an all-weather smart munition, with an extended stand-off range, Hammer is equipped with multiple guidance systems (such as infrared homing, laser, INS and GPS guidance), giving it the capability to operate under electronic warfare conditions. Hammer is the primary strike weapon of France's new generation Dassault Rafale jets and is also integrated in the earlier generation French (Mirage-2000, Mirage F-1) and Lockheed Martin's F16 jets. The weapon system was combat proven over the past 15 years and had a 99% successful hit rate during the NATO operations in Afghanistan and Libya. Due to its modular feature and low lifecycle cost, Hammer has been exported to multiple countries. For instance, in addition to the French Air Force and Naval Aviation, the air forces of India, Morocco, Egypt and Qatar.

Safran: Hammer guided missile

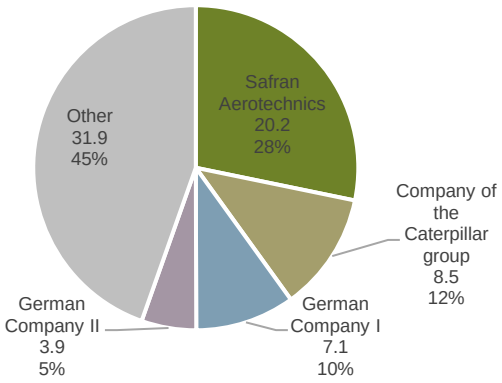


Source: Safran

VIGO supplies global corporations and space agencies

VIGO's products are used by some global industry, security and defence systems manufacturers. The company lists the following clients among the biggest ones: Safran (VIGO's detectors are used in smart munitions production); Emerson (industrial gas analysers); Caterpillar (railway safety systems); and TRUMPF (industrial lasers). VIGO's detectors are also used by space agencies: NASA (VIGO's detectors were used in the Mars Curiosity Rover and the Orion spaceship); and the European Space Agency (Exomars mission). In 2021, Safran, VIGO's biggest client, contributed PLN 20.2m to its sales (28.23% of total sales), and Caterpillar PLN 8.5m (11.8% of sales), while the two other biggest clients (both German companies, not specified by VIGO) generated PLN 11m in revenue (15.4% of sales). In total, its four biggest clients generated 55.4% of VIGO's sales in 2021 (vs. 48% in 2020).

VIGO Photonics: sales structure by clients in 2021 (PLN m, %)



VIGO Photonics: selected customers

Source: Company data, WOOD Research

VIGO's 2026 strategy: PLN 100m in revenues and PLN 40m in EBITDA in 2023E

In June 2021, VIGO Photonics adopted a new strategy for 2021-23. The strategy assumes development in the market segments in which the company is present currently and the expansion of its operations to new areas.

In terms of financials, the company's ambition is to maintain the growth rate of revenues at 20-30% annually and high profitability of the core operating activities, including the gross margin on sales above 60% and EBITDA profitability above 40%. VIGO's financial targets include:

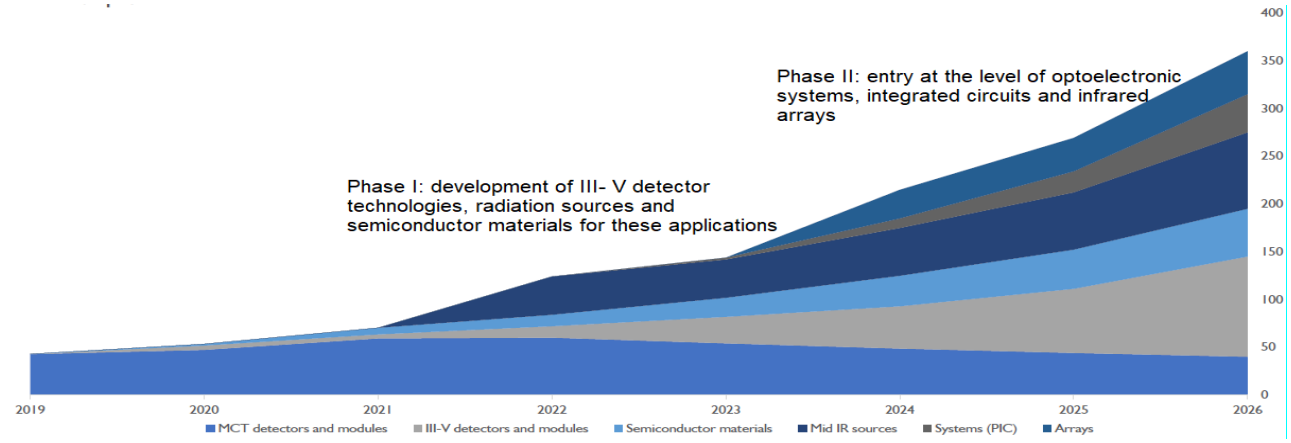
- PLN 67m in revenues and PLN 29.5m in EBITDA in 2021 (delivered).

- PLN 80m in revenues and PLN 33.5m in EBITDA in 2022 (not delivered: VIGO's sales reached PLN 67.3m in 2022).

- PLN 100m in revenues and PLN 40m in EBITDA in 2023E.

In order to achieve its goals, VIGO plans to spend PLN 30-40m in capex annually (both R&D and infrastructure) in 2021-23E, financed from own funds and public funding for R&D. In order to deliver on the growth rates assumed in the strategy, the management board has recommended no dividend payouts and the full reinvestment of the generated profits in the strategy period. The dividend policy will be subject to periodic review by the board.

VIGO Photonics: portfolio of growth initiatives – assumed development paths (PLN m)



Source: Company data

Strategy execution: delivering financial targets unlikely, in our view. The execution of VIGO's strategy is going as planned regarding the capex and R&D, as well as geographic expansion, as the company is strengthening its presence outside Europe. However, it failed in terms of the delivery of its financial targets in 2022. The company reported preliminary sales of PLN 67.3m in 2022 (vs. the PLN 80m target), down 6% yoy, due to lower revenues from the military application, and lower than previously assumed revenues from applications for industry and transport, as a result of the lower availability of some components and the disrupted supply chains. Considering the supply chain issue, which lasted into 4Q22, achieving that the goal of PLN 100m in revenues in 2023E could be in danger as well, in our view: in our model, we conservatively assume sales expansion of 27% yoy, to PLN 87.5m. Despite the company perhaps not being able to deliver on its ambitious targets, assumed in the strategy, we believe in a strong long-term growth outlook, stemming from an increase in the demand for current products (especially in the industry and military segments) and new initiatives. We see potential especially in the infrared arrays project (considering the hike in the Polish army's budget) and believe that the project might cause some potential positive surprises for our forecasts: in our model, we conservatively assume 300 units sold annually from 2026E (vs. VIGO's current production capacity of 500 units and the volume of 1,000 units targeted by the company).

VIGO: guidance vs. WOOD's forecasts (PLN m, %)

	2021	2022E	2023E
Guidance			
Sales	67	80	100
Adj. EBITDA	29.5	33.5	40
Actual/WOOD forecasts			
Sales	71.5	67.3	87.5
Adj. EBITDA	29.1	14.2	28.2
Difference (%)			
Sales	7%	-16%	-13%
Adj. EBITDA	-1%	-57%	-29%

Source: Company data, WOOD Research

Strategy details. The management board has identified a number of potential business opportunities for the company, considering the following initiatives the most promising ones:

1) Exploration of the MCT (HgCdTe) detector market, including expansion (geographical, segmental) in market areas not covered by regulations excluding the use of mercury and cadmium in detectors (RoHS).

2) The development of technology for detectors and infrared modules made of materials based on compounds from groups III and V of the periodic table, compliant with the Restriction of Hazardous Substances (RoHS) directive.

3) The development of the epitaxy of III-V semiconductor materials and the production of near-infrared sources (VCSEL lasers).

4) The development of the technology of infrared sources.

5) The development of the technology of optoelectronic systems and photonic integrated circuits for medium and short infrared.

6) The development of the technology of infrared detector arrays.

The implementation of the VIGO 2026 strategy is divided into two stages. In the first stage, covering 2021-23, the company intends to focus on: the continuation of the ongoing development projects, including the technology of photonic integrated circuits, detectors from III-V materials, epitaxy of semiconductor materials, infrared source technology, and the development of the technological base and technology, common to key pro-growth initiatives through investments in R&D and universal infrastructure, based on the effects of R&D projects, the analysis of the market situation, the selection of the most promising growth initiatives, and the preparation of the investment plan necessary for their implementation .

In the second stage, the company will focus on implementing the most promising growth initiatives.

VIGO also intends to continue its expansion into new geographic and product markets, including investing in the development of its own sales structures in key markets.

New initiatives: mid-infrared sources, PICs, infrared arrays

In its strategy, the company sees three new potential areas of growth:

- **Mid-infrared sources:** laser or diode chips and modules that provide infrared radiation sources, manufactured from III-V semiconductor materials. The company targets acquiring ICL, QCL and MIRLED technologies through the development of proprietary technology or the acquisition of an existing player. Mid-infrared sources can be applied to monitoring and measurement equipment manufacturers of high-performance sensory systems. In its strategy, VIGO is aiming for target volumes of over 1m chips/year.

- **Optoelectronic systems and photonic integrated circuits (PIC):** a miniaturised system consisting of multiple optical and electronic components with different functionalities integrated on a common substrate (usually semiconductor) – on a single chip. The development of PICs would mean moving up the value stream for VIGO, i.e., developing off-the-shelf sensory systems that can be integrated into everyday consumer devices. If VIGO developed PIC technology for the MIR range (MIRPIC), it would be the first manufacturer in the world of mid-infrared integrated circuits. The R&D project was launched in April 2021, with a lead time of three years and a budget of PLN 29.3m (of which PLN 26.6m in co-financing). The project is being realised in cooperation with the Warsaw University of Technology and the Institute of Microelectronics and Photonics. In its strategy, VIGO is aiming for target volumes of over 10m sensors/year.

- **Infrared arrays:** infrared detector arrays containing hundreds of thousands or millions of active pixels used in the construction of thermal imaging cameras for space and military applications, and having a

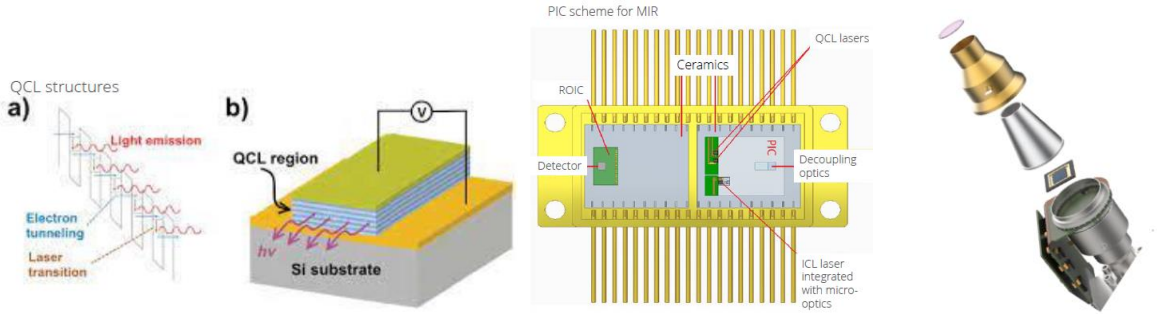
semiconductor layer made of III-V materials (InAsSb - MWIR, LWIR, or InGaAs - SWIR). Infrared arrays can be applied to imaging cameras for military and space applications. The company estimates its annual production capacity of infrared arrays at 500 units; while, in its strategy targets, volumes of 1,000 pieces/year.

VIGO Photonics: new initiatives

Product	Production method	Price:	Applications	Sectors
Mid-infrared sources	MOCVD or MBE	USD 6,000 - 9000/unit	Gas analysis, examination of the spatial distribution of temperature, precise determination of the direction of the infrared radiation source, scanning of larger areas for the detection of substances, gases and temperature changes, sorters on production lines	Environment protection, medicine, robotics, military industry, property protection, industry (automotive, manufacturing), consumer market (wearable devices)
Optoelectronic systems and photonic Integrated Circuits (PIC)	Different components made using different technologies	EUR 10/piece	Analyses of the chemical composition of gases, analysis of impurities in liquids, gas detection, FSO (free space communication), analyses related to medicine and telemedicine: blood analysis	Industry and transport, environment protection, food industry, biomedicine, telecom, protection and security, medicine, automotive, IOT, space industry
Infrared array	MBE (InAsSb) or MOCVD (InGaAs).	EUR 30,000/unit	Detectors for thermal imaging cameras	Military industry, space industry

Source: Company data, WOOD Research

VIGO Photonics: mid-infrared sources (QCL structures), PIC scheme, infrared array



Source: Company data

In our forecasts for VIGO, out of the new initiatives, we include only the infrared arrays as it is existing technology (unlike MIRPICs, which has to be developed by VIGO) and does not require a potential acquisition. We present our assumptions regarding the contribution of infrared arrays to VIGO's results in the forecasts section of this report.

Incentive scheme aligned with the strategy

In September 2021, VIGO adopted an incentive scheme for its managers and key employees, with the targets aligned with the financial goals assumed in the strategy. According to the scheme's rules, the company might distribute up to 29,160 warrants (40% to the management board, 60% to other key employees) in 2021-23 (20% annually in 2021-22, 60% in 2023), assuming that the company reaches adjusted EBITDA of PLN 29.5m in 2021 and PLN 33.5-40m in 2022-23E. Each 1% below the EBITDA target cuts the potential payout for incentive scheme participants by 4% of the warrants, with the condition that the realisation of less than 85% of the EBITDA target means no payout at all. Based on our forecasts, the warrants are unlikely to be issued in 2023E.

M&A in the photonic industry: VIGO can be either an acquirer or a target

VIGO Photonics may be interested in potential acquisitions as, according to its strategy, this could accelerate its entry into new product segments: the company has noted especially manufacturers of mid-infrared sources. We, however, also believe that VIGO Photonics could become an acquisition target, as it holds a unique, hard to copy technology, high-quality products and a global presence. The company has noted that it observed levered investment activity in the photonics industry in 2018-22, in terms of both M&A and SPO/IPOs, driven by consolidation and vertical integration around market leaders – VIGO noted the trend of business investors (especially from the automotive industry) purchasing entities from photonics (biosensors and LIDARs producers). Moreover, we note that the recent crisis in the chip market shows the weakness of the semiconductor industry in the EU and the model, which is based on fabless manufacturing, i.e., outsourcing chip production to players in Asia. This can be especially risky, considering the current political tensions in the region; therefore, we believe that a need to move the production chain back to the Western markets might arise and drive demand for the local players. Due to a potential conflict between China and Taiwan, a country that now accounts for >50% of semiconductor production worldwide, Western governments want to build up their own production capacity in these key industries.

Based on the data from Mergermarket, we identified 55 M&A in the broad global photonics industry in 2018-22. In the table below, we present seven selected M&A, for which we have managed to find/calculate transaction multiples. In the selected group, the median transaction EV/sales stood at 2.5x, while the EV/EBITDA at 14.5x.

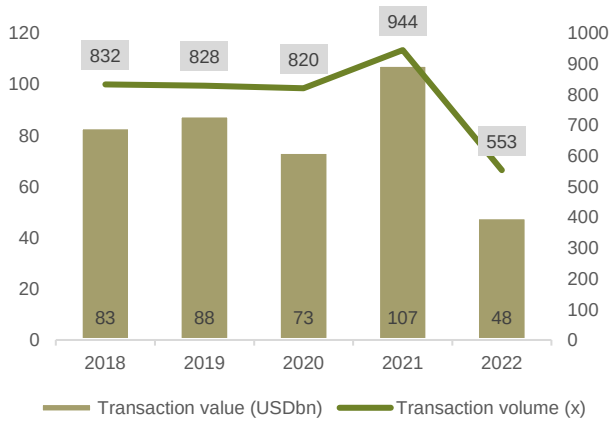
Selected M&A in photonics in 2018-22

Date	Bidder	Target	Implied EV (USDbn)	EV/sales	EV/EBITDA	Target description
Jul-22	II–VI Inc.	Coherent	6.6	4.4	n.a.	Laser manufacturer
May-21	Teledyne Technologies	FLIR Systems	8.2	4.3	19.9	Producer of infrared thermal imaging systems.
Jul-20	Materion	Optics Balzers	0.2	2.4	12.3	Liechtenstein-based provider of customised optical thin-film coatings and components for the photonics industry.
Jul-20	ams	Osram	4.9	1.2	27.7	Germany-based company engaged in the field of lighting fixtures.
Mar-20	TE Connectivity	First Sensor	0.3	2.0	14.5	Germany-based company manufacturing sensors, detectors and emitters.
Sep-19	II–VI Inc.	Finisar	3.2	2.5	n.a.	Manufacturer of optical communication components and subsystems.
Mar-18	Lumentum Holdings	Oclaro	1.8	3.0	12.9	Producer of optical components and modules for the long-haul, metro, and data centre markets.
Median				**2.5**	**14.5**	

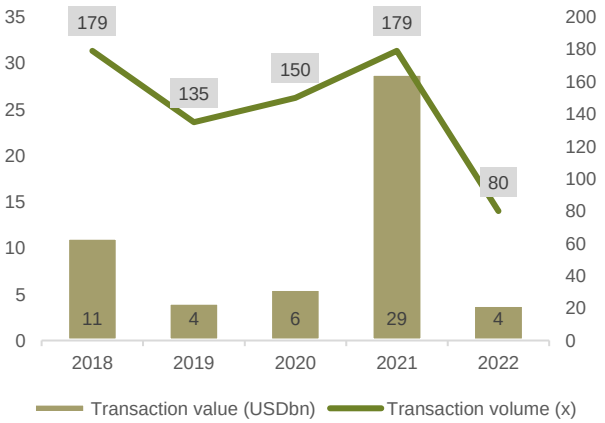
Source: Mergermarket, WOOD Research

According to CERES research, on M&A, the global photonics market saw a slowdown in 2022 vs. previous years due to macro uncertainty (inflation and rapid interest rate hikes), geopolitical instability in Europe and China, losses in both the equity and bond markets, supply chain risk and labour shortages. In the whole of the 2022 global M&A market, the company identified 49,633 announced transactions (down 14% yoy) worth USD 3.1trn (down 33% yoy). Of this, CERES identified 553 transactions (down 41% yoy), with a reported value of USD 48bn (down 55% yoy) in the photonics industry and vertical markets employing photonics technologies as core differentiators. In the pure photonics industry, according to CERES data, there were 80 transactions in 2022, worth USD 4bn.

M&A in photonics and related industries*



M&A in the photonics segment



*Source: Ceres "2022 Mergers & Acquisitions in Photonics", WOOD Research; *Photonics, IT, Energy, Defense Security and Sensing, Biophotonics, Advanced Manufacturing*

Based on CERES data and our estimates, the average transaction EV/EBITDA in the broad photonics and related industries market stood at 13.4x in 2018-22 (based on 108 deals, in which the majority stake was acquired and the details regarding the financials and the transaction prices were known); while, in the pure photonics segment, 14.4x (based on 23 deals).

The highest multiples for acquisitions of 100% shares in the broad photonics market were: Oxford Instruments (27.1x), provider of atomic force microscopy, optical imaging, spectrometer, nuclear magnetic resonance, scientific camera and x-ray source products (UK); CyberOptics Corporation (17.9x), supplier of high precision sensing technology metrology solutions (US); Yunex GmbH (17.6x), provider of hardware, software, Internet of Things devices and advanced modular traffic management solutions (Germany); Maxar Technologies Inc. (NYSE:MAXR) (14.2x), provider of earth intelligence and space infrastructure solutions (US); and Tower Semiconductor Ltd. (NasdaqGS:TSEM) (12.2x), an independent semiconductor foundry providing customisable process technologies, including CMOS image sensors (Israel).

Market outlook: infrared detectors global sales to expand at 7-10% CAGR

According to five different market research sources (detailed in the table below), the value of the global infrared detector market is estimated at around USD 0.5bn, while its long-term CAGR is expected to reach 7-10%. The market is a niche one: according to Fact.MR, the global sensors market value stood at USD 180bn in 2020, while the IR detectors share accounted for only 0.23%, but the company expects this share to increase going forward. VIGO Photonics is focused on an even narrower niche of mid-wave infrared detectors, which contribute c.20-25% of the global IR detectors market (based on the company's estimates and external research). In its niche, VIGO competes with three other main mid-infrared detectors providers: Teledyne Judson, Infrared Associates, and Hamamatsu (for details, please see Appendix 2 at the end of this report).

Global infrared detectors market value forecasts

Source	Research date	Forecast period	Current market value (USDm)	Target market value (USDm)	CAGR (%)
IMARC Group	Jan, 2023	2023-2028	483 (2022)	806 (2028)	8.90%
Knowledge Sourcing Intelligence	Aug, 2022	2021-2027	507 (2020)	837 (2027)	7.44%
Emergen Research	Jun, 2022	2022-2030	441 (2021)	785 (2030)	6.60%
Fact.MR	Jan, 2022	2022-2031	463 (2021)	968 (2031)	7.70%
Maximize Market Research (MMR)	Jan, 2023	2022-2029	422 (2021)	892 (2029)	9.80%

Source: WOOD Research

According to Transparency Market Research (publication from March 2023), the global mid-infrared laser market should record a CAGR of 9.6% from 2023 to 2031E, and reach USD 2.2bn by 2031E (from c.USD 1bn in 2022). The company sees demand for compact mid-infrared laser instruments with a broad spectral range in high-end IR applications, especially medical, defence and aerospace.

The global photonic integrated circuits market (based on P&S Intelligence research from July 2022) should expand from USD 7.6bn in 2021 to USD 41.0bn in 2030E (a 20.5% CAGR), driven by demand from telecommunications, biomedical, data centre facilities, a shift towards automation in various industries and autonomous vehicles, and the miniaturisation of electronic devices.

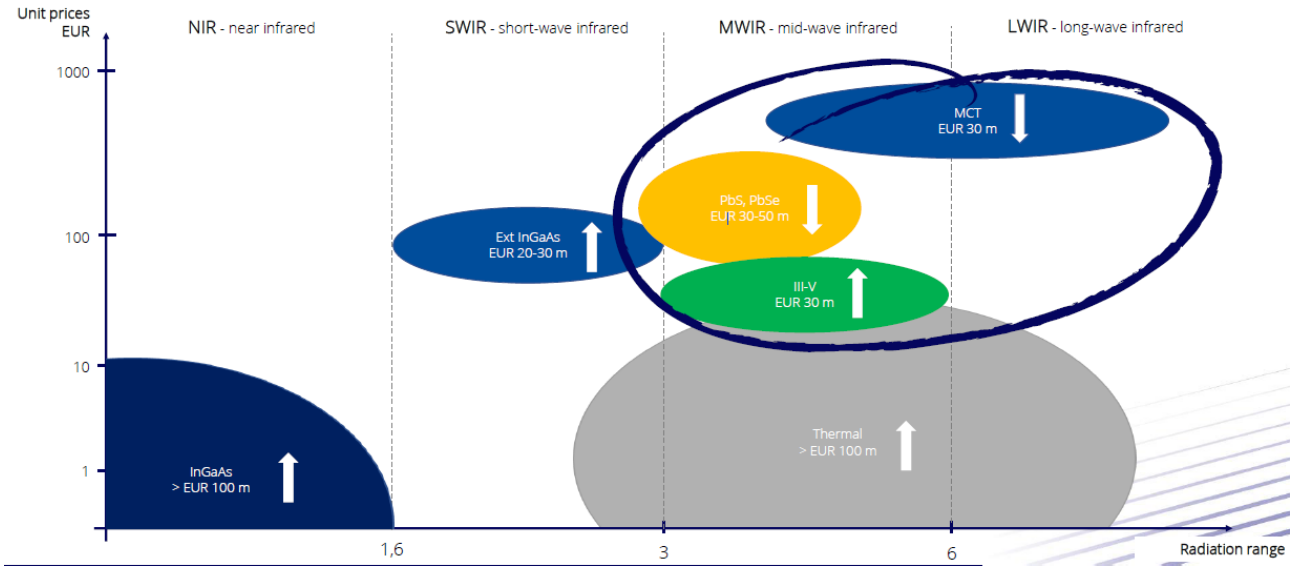
The expected long-term growth rates in the studied research pieces broadly match (or are slightly below) the growth rates quoted/estimated by the company for its specific product lines. We present the company's expectations in the table below.

VIGO Photonics: market size and competitive environment per segment (new initiatives highlighted with grey)

Product	Market value*	Market growth potential*	Competition
MCT detectors and detection modules	USD 40m	9% CAGR	Teledyne Judson, Infrared Associates, Hamamatsu
III-V InAsSb detectors and detection modules	USD 30m	>20% CAGR	Hamamatsu, Teledyne Judson, Asahi Kasei
III-V InGaAs detectors and detection modules	USD 150m whole market, USD 30m extended InGaAs market	>10% 2021-25E CAGR	Hamamatsu, Teledyne Judson, Laser Components, Thorlabs, OSI Optoelectronics
III-V epitaxy: semiconductor materials	USD 2.6bn	13% 2020-2027 CAGR	IQE, AMS, II-VI Inc., Intelli Epi
Mid-infrared sources	USD 61m	10% 2020-2026 CAGR	Hamamatsu, Thorlabs, Nanoplus, Daylight Solutions, Mirsense, Alpes Laser
Optoelectronic systems and photonic Integrated Circuits (PIC)	USD 1.5bn	12% CAGR	Redfinch, CEA-LETI, Picpair, Rockley, Brolis, NeoSpectra, Hamamatsu
Infrared array	EUR 15m (PL market)	n.d.	Lynred, Irnova, Hamamatsu, large armaments companies

*Source: Company data, WOOD Research; *Mid-Infrared Photodetectors and Systems: Market Study, 2018; Epitaxial Wafer Market For Compound Semiconductor, Allied Research, 2020, *Interband & Quantum Cascade Lasers Technologies, Market Trends And Application, Tematys, 2020, company estimates*

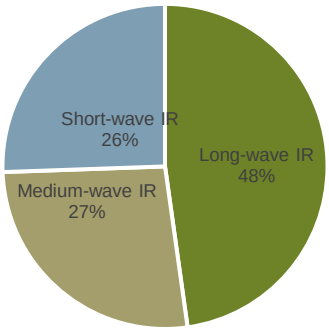
IR detectors global market structure



Source: VIGO Photonics

Based on the spectral range, the Infrared Detector Market is segmented into long-wave IR, medium-wave IR (in which VIGO Photonics is present), and short-wave IR. According to MMR, long-wave IR is expected to hold the maximum market share due to the high demand for long-wave IR from the defence and military industries for security and surveillance application. Moreover, the cost of long-wave IR products is lower than short-wave and medium-wave. According to an Allied Market Research report from December 2016, long-wave IR detectors dominated the global market, due to their ability to sense thermal signs and provide excellent detection capability in low-light-level conditions.

IR detectors market by spectral range, 2021 (%)

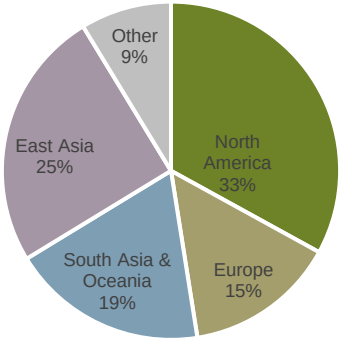


Source: WOOD Research, maximizemarketresearch.com (Infrared Detector Market – Global Industry Analysis and Forecast (2022-29))

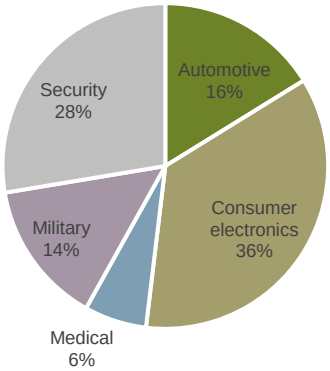
In terms of geographic split, Fact.MR estimates North America to be the largest IR detector segment (contributing to c.33% of the global market value), due to the rising demand in the US, followed by Asia (mainly China, which Fact.MR expects to dominate the global market in terms of the volume of exports, due to high production volumes and low pricing) and Europe.

In terms of industries, the biggest components of the global IR detectors market are consumer electronics (36%), followed by automotive (16%) and security (28%).

IR detectors market by region, 2021 (%)



IR detectors market by industry, 2021 (%)



Source: WOOD Research, maximizemarketresearch.com (Infrared Detector Market – Global Industry Analysis and Forecast (2022-2029))

All the research companies see increasing demand for motion- and people-sensing devices, smart home solutions, IOT devices, as well as increasing product utilisation in the military industry, industrial plants and the automotive industry as the main drivers of the market:

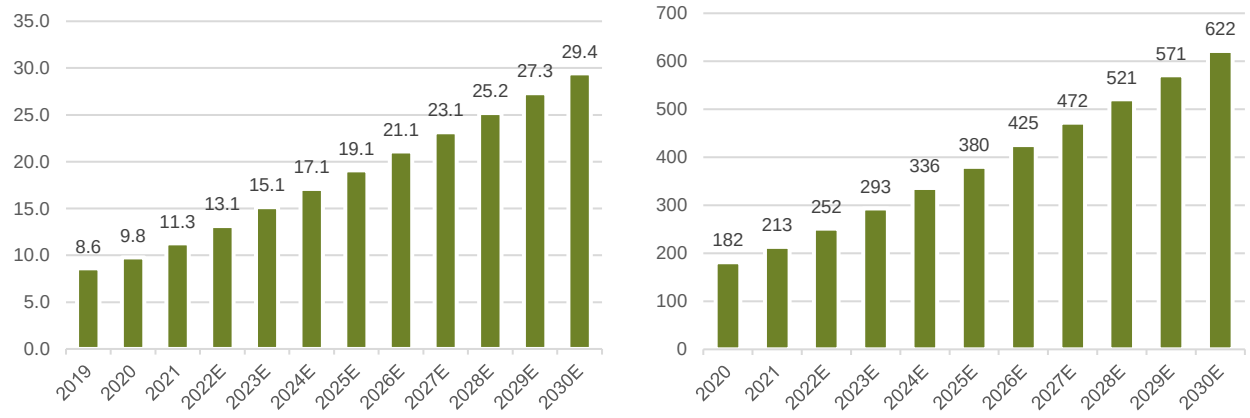
- **Wearable devices:** infrared motion sensors are being used in wearable devices, such as bands and smartwatches, to track heart rate, steps, and oxygen levels, to aid personal health monitoring. The company sees the development of wearable lab-on-chip (device able to measure glucose, lactic acid, and ethanol levels) as a potential driver for the infrared detectors market growth. The current solutions are based on the visible spectrum and short infrared; according to VIGO, the development of MIR PICs will boost the possibilities of the devices significantly.
- **Automotive:** the growing adoption of autonomous cars should drive demand for IR detectors, especially new generation LIDAR sensors, thermographic cameras, and in-cab sensors.
- **Defence:** the current geopolitical situation may influence the need for increased security in countries including those in Western Europe – the company expects growing interest in detectors from the defence sector.
- **IOT market:** IR detectors are used in various IoT devices for detecting the presence of objects, measuring temperature, and detecting motion. The growth of the IOT market should drive the demand for IR detectors.

IOT market growth outlook: 13% CAGR by 2030E

According to Statista's data (research published in July 2022), the number of Internet of Things devices worldwide should almost triple from 9.8bn in 2020 to more than 29bn in 2030E. According to Statista's research, the value of the global IOT market should expand from USD 181.5bn in 2020 to USD 621.6bn in 2030E (a 13% 2020-30E CAGR).

Major industry verticals, with currently more than 100m connected IoT devices, are electricity, gas, steam and A/C, water supply and waste management, retail and wholesale, transportation and storage, and government. The total number of IoT devices across all industry verticals is forecast by Statista to grow to more than 8bn by 2030E. The most important use case for IoT devices in the consumer segment is consumer internet and media devices, such as smartphones, where the number of IoT devices is forecast to grow to more than 17bn by 2030E. Other use cases with more than 1bn IoT devices by 2030E are connected (autonomous) vehicles, IT infrastructure, asset tracking and monitoring, and the smart grid. Statista expects the consumer segment value share in the global IOT market to expand from 35% in 2020 to 45% in 2030E.

Global IOT market forecasts by volume (lhs, bn units) and sales value (rhs, USD bn)



Source: Statista in cooperation with Transforma Insights (July 2022), WOOD Research

Polish army modernisation plan to drive demand for infrared detectors

According to the Polish army modernisation plan for 2021-35, approved in 2019 and later updated by the Homeland Defence Act in 2022: from 2023, Poland is to spend at least 3% of its GDP on defence; in 2021-35, it plans to spend PLN 524bn on new military equipment, and it has set a target of doubling the size of the armed forces from 150,000 to 300,000 personnel. In 2023, Poland will spend a total of PLN 137bn (c.4.2% of the GDP, according to the government's estimates).

In the plan, the Polish government assumes the purchase of 96 KRABs (a self-propelled tracked gun-howitzer), 672 K9s (a 155mm self-propelled tracked gun-howitzer), 1,400 BORSUK infantry fighting vehicles, 64 RAK self-propelled mortars, 1,000 K2 tanks, and 70 remotely controlled ZSSW-30 turret systems integrated with the SPIKE-LR anti-tank guided missile launcher for the purposes of integration with the ROSOMAK wheeled armoured personnel carriers.

The agreement regarding the purchase of equipment from Korea (the K2 tanks and the K9 gun-howitzers) includes the transfer of technology, as a result of which industrial capabilities will be established in the area of armoured technology, which will allow for the acquisition of service competences in the first stage and the final launch of the production of K2 tanks and K9 gun-howitzers in Poland, and thus the polonisation of the spare parts and supply chains.

We note that all the tanks and armoured vehicles can be equipped with the OBRA-3 Laser warning system, which utilises infrared detectors for the detection of vehicles and military objects' radiation from impulse rangefinders or laser illuminators.

Apart from the demand from the Polish army, we expect VIGO to benefit from increased spending on army modernisation in Western countries. We note that, in its annual report, Safran, VIGO's biggest client, pointed out that 2022 brought sharp increases in defence and space budgets in Europe and internationally, against the backdrop of the war in Ukraine and the global geopolitical tensions: for example, the US, the largest defence spender, announced a budget of nearly USD 800bn for 2023 (up 8% yoy), and France a EUR 400bn budget for the French army for the 2024-30 period.

According to Jane's Defense (24 January 2023), Indonesia is in talks with Safran for the potential acquisition and domestic assembly of Hammer missiles (Indonesia ordered France 42 Rafale fighters in 2022, in a USD 8.1bn deal). In our view, future defence exports by the French Dassault and Safran groups may result in further sensor and detector orders for VIGO.

RoHS directive limits usage of MCT detectors in the EU

VIGO's performance and strategy is affected by regulations, especially the RoHS directive (Directive 2011/65/EU of 8 June 2011), who phases out certain uses of some hazardous substances in electrical and electronic equipment placed on the EU market. Among the hazardous substances are mercury and cadmium, which are contained in cadmium mercury telluride (HgCdTe), a basic semiconductor material for uncooled mid-infrared detectors.

In order to minimise the possible negative implications of the regulations, VIGO has diversified its portfolio with III-V infrared detectors that are RoHS compliant. Moreover, the company wants to keep developing sales of the old type MCT detectors in geographies (US, Asia) and industries (military, space) that are RoHS exempt.

Pursuant to the RoHS directive, mercury and cadmium in infrared detectors are exempt from the restrictions of the directive:

- Until 21 July 2021 for medical devices.

- Until 21 July 2023 for in vitro diagnostic medical devices.

- Until 21 July 2024 in the case of control and measuring equipment for industrial use.

The directive does not cover military or space applications.

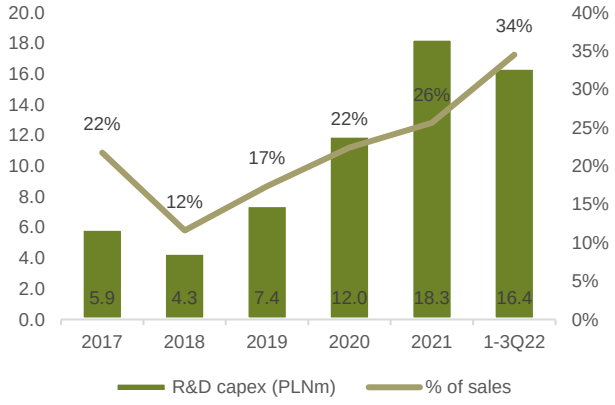
The directive provides for the possibility to apply to the European Commission for an extension of the above deadlines in the event that technical progress does not render it possible to find reliable substitutes for the above substances. VIGO has applied to the EC for an extension of the transition period for medical devices. Similar requests have also been made by other manufacturers of equipment using HgCdTe detectors. The applications are being examined currently. In March 2022, a report commissioned by the European Commission was published, assessing the applications submitted for extending the transition periods. According to this report, the consultant recommends extending the possibility of using HgCdTe detectors in all three of the above applications until 21 July 2028.

Further R&D co-financing likely, due to supportive regulatory framework

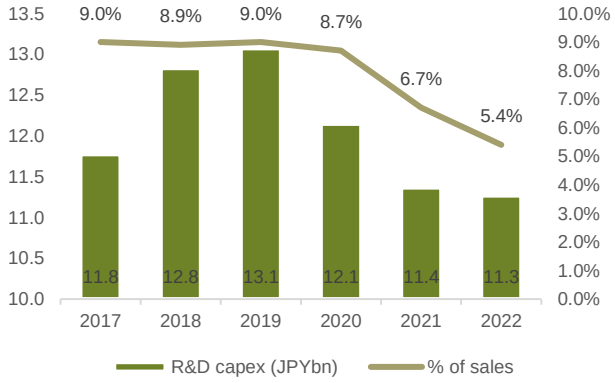
VIGO benefits materially from the subsidies/co-financing of R&D. As a technological company, VIGO invests a substantial share of its total capex in R&D: in 2021, the company spent PLN 18.3m on R&D, i.e., 26% of sales/36% of total capex. In 2021, VIGO's R&D department was the second-largest in the company – it employed a team of 56 scientists.

To compare, one of its closest peers, Hamamatsu, in the financial year ending September 2022, spent JPY 11.3bn (5.4% of sales); while, according to its 2021 report, Hamamatsu employed 5,279 people, out of which the R&D personnel share stood at c.10% (i.e., over 500 people). A significant part of VIGO's R&D expenses are covered by subsidies: the average co-financing contribution to the R&D capex stood at 80% in 2017-21.

VIGO Photonics: R&D capex evolution

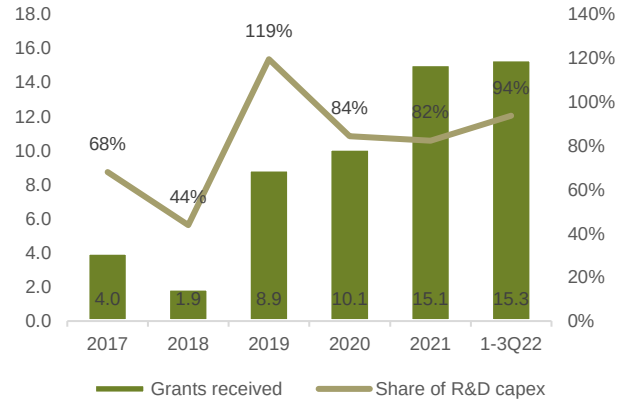


Hamamatsu: R&D capex evolution*

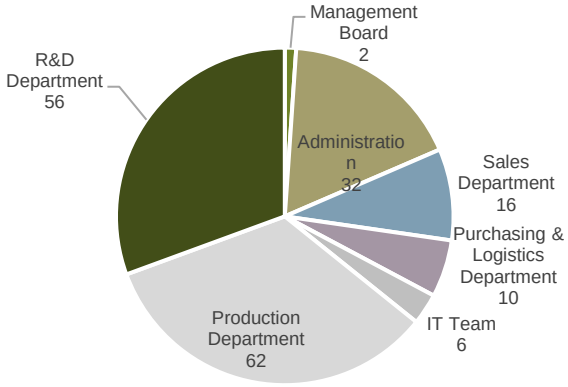


*Source: VIGO Photonics, Hamamatsu, WOOD Research; *financial years ending in September*

VIGO Photonics: grants received



VIGO Photonics: employment structure in 2021



Source: Company data, WOOD Research

Further R&D co-financing likely, due to the supportive regulatory framework. The global chip shortage, which started in 2020 during the COVID-19 lockdowns, has pushed Western economies towards considering supporting the development of local semiconductor supply chains in order to avoid potential shortages in the future. We see this as an opportunity for VIGO to secure further financing for its production capacity development and R&D projects.

In February 2023, the EU Parliament set its negotiating position on two draft bills: one on the "Chips Act", which aims to bolster technological capacity and innovation in EU chips; and a second on the Chips Joint Undertaking, to increase investments for developing this type of European presence. The next steps will consider negotiations with the Council on both acts.

Currently, according to EC data, on average, almost 80% of suppliers to European firms operating in the semiconductor industry are headquartered outside the EU, while only 10% of the global production capacity is located in Europe.

The main aim of the Chips Act is to double the European global market share in semiconductors from 10% currently to at least 20% by 2030E, in order to ensure the EU's future technological sovereignty.

The act also aims to strengthen Europe's research and technology leadership towards smaller and faster chips, build and reinforce capacity to innovate in the design, manufacturing and packaging of advanced chips, develop an in-depth understanding of the global semiconductor supply chains, address the skills shortage, attract new talent and support the emergence of a skilled workforce.

In order to achieve that, the act proposes:

- Investments in next-generation technologies.

- Providing access across Europe to design tools and pilot lines for the prototyping, testing and experimentation of cutting-edge chips.

- Certification procedures for energy-efficient and trusted chips to guarantee quality and security for critical applications.

- A more investor-friendly framework for establishing manufacturing facilities in Europe.

- Support for innovative start-ups, scale-ups and SMEs to access equity finance.

- Fostering skills, talent and innovation in microelectronics.

- Tools for anticipating and responding to semiconductors shortages and crises to ensure security of supply.

- Building semiconductor international partnerships with like-minded countries.

The Chips Act assumes the mobilisation of more than EUR 43bn of policy-driven investments, and setting measures to prepare, anticipate and swiftly respond to any future supply chain disruptions, together with Member States and international partners.

The Chips Act, according to the EC, should result in additional public and private investments of more than EUR 15bn, complementing existing programmes, and action in research and innovation in semiconductors, such as Horizon Europe and the Digital Europe programme, as well as announced support from Member States.

The semi-conductor industry is also supported by national investment plans in other geographies:

- In June 2021, the US administration approved a USD 52bn investment plan for domestic semiconductor manufacturing.

- South Korea has approved up to USD 65bn in support for the semiconductor supply chain by 2030E, with an ambition to attract more than USD 450bn of investment from the private chip sector. The support also includes tax incentives and relaxed regulations.

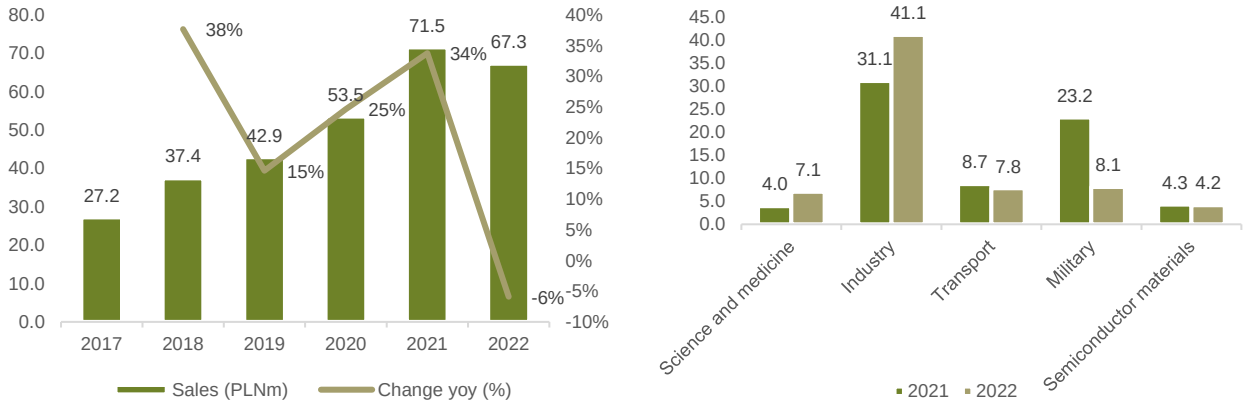
- China has increased its investments in semiconductors (in 2020, China's investments into semiconductor companies reached RMB 227.6bn, or c.USD 35.2bn, based on EC data).

IPCEI on microelectronics. Another, older project, which supports semi-conductor producers in Europe is IPCEI (Important Projects of Common European Interest) on microelectronics. The project initiated by France, Germany, Italy and the UK in 2018 is aimed at stimulating the research and development of innovative technologies and components (e.g., chips, integrated circuits, and sensors). Initially, the project assumed EUR 1.75bn of public support and was aimed at unlocking an additional EUR 6bn in private investment.

2022 results harmed by supply chain issues and a lack of orders from Safran

In 2022, VIGO Photonics reported sales of PLN 67.3m, down 6% yoy. The weakness was driven by two main factors: 1) supply chain issues; and 2) a lack of contracts from its biggest client – Safran. Both issues, however, are temporary and, from 2023E, we expect the company to record a results expansion, driven by strong demand for both industrial and military detectors, as well as the price hikes implemented by VIGO in October 2022.

VIGO Photonics: sales evolution (PLN m, %)



Source: Company data, WOOD Research

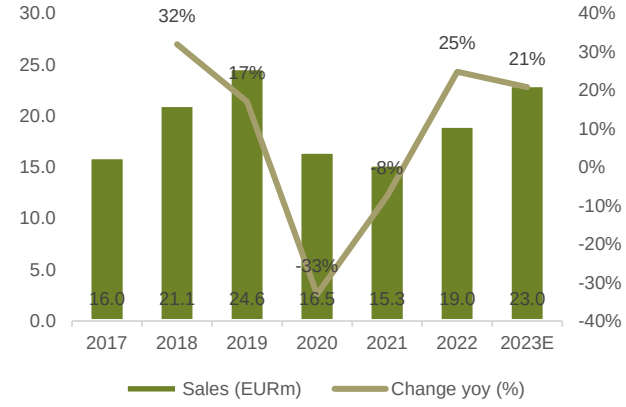
We note that, since 2020, the global economy has faced a chip shortage crisis, as the demand for semiconductor chips has exceeded the supply materially. The crisis was driven by the upsurge in people working from home (demand for work-from-home technology increased dramatically), bottlenecks in the supply chains (particularly in South Asia), and strong demand from the automotive sector, which has been shifting towards electric vehicles and automation (and, as a result, required more chips).

The supply chain issue risk materialised for VIGO in 2022. In October 2022, VIGO's CFO (as quoted by PAP) stated that the limited availability concerned c.10-20% of the electronic components, only for the production of detection modules for transport and industrial applications. According to the company's estimates (presented along with the 4Q22 sales results), the difficulties in the availability of certain electronic components reduced its full-year contracting in 2022 by approximately 5%.

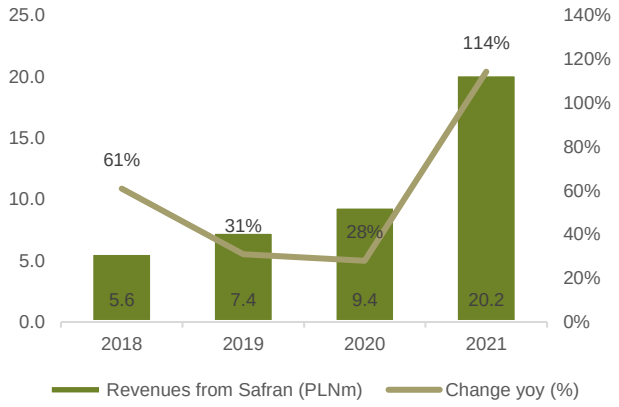
The company has also faced issues with supply related to components manufactured in the Russian Federation. The value of components imported from Russia amounted to PLN 7.3m in 2021. The company has taken steps to find alternative suppliers and has completed the qualification of a new supplier successfully. In addition, the existing supplier has relocated its production outside of Russia. The company does not see any significant problems, at this stage, with the availability of components that were purchased previously from the Russian market.

In terms of the demand from Safran: the company has not yet provided the exact sales for 2022 but, considering the sales structure of 2021 (in which Safran was the biggest VIGO client, contributing PLN 20.2m to sales, 28% of total sales), we believe that the 65% yoy drop in the military segment revenues in 2022 was driven mainly by a decline in the volume of orders from Safran. We believe that that the slowdown in revenues from Safran is temporary and might be related to the strong stocking up in 2021: we note that, in 2021, VIGO generated PLN 20.2m of sales from Safran, more than double 2020 (PLN 9.4m) and almost triple 2019 (PLN 7.4m). Considering the solid outlook for Safran's defence segment, in which the company expects to benefit from levered Western countries' army budgets, we believe that the demand for VIGO's products should return soon.

Safran: revenues evolution (EUR bn, %)*



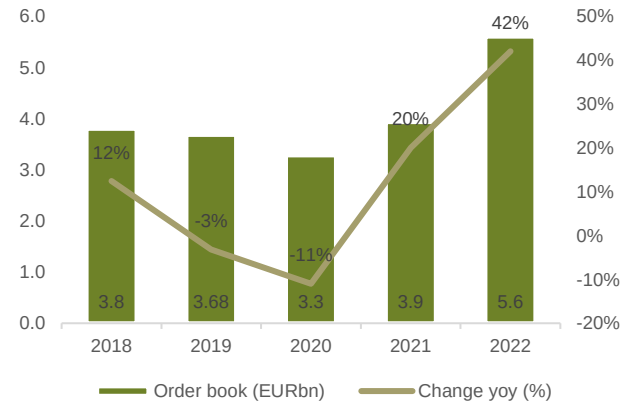
VIGO Photonics: revenues from Safran



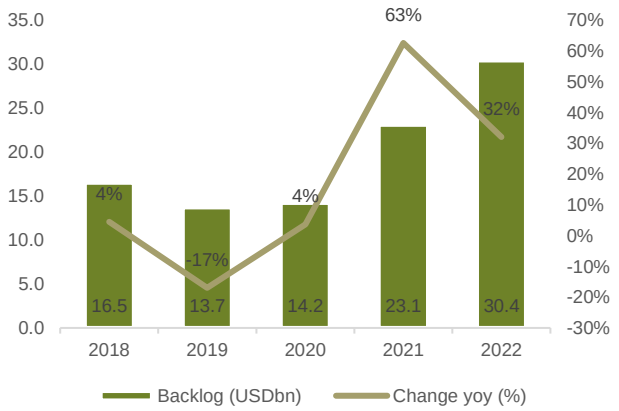
*Source: Safran, VIGO Photonics, WOOD Research; *Safran outlook for 2023E assumes revenues of at least EUR 23.0bn*

Apart from Safran, we also see potential solid demand from VIGO's other key clients, at least looking at their promising backlogs – Caterpillar (second-biggest client in 2021) recorded a backlog of USD 30.4bn as of end-2022 (up 32% yoy), while TRUMPF EUR 5.6bn as of the end of the financial year ending in June 2022 (up 42% yoy).

TRUMPF: order book evolution*



Caterpillar: backlog evolution



*Source: TRUMPF, Caterpillar, WOOD Research;*financial year ending in June*

Valuation – price target (PT) at PLN 629/share

We initiate coverage of VIGO Photonics with a BUY rating and a price target (PT) of PLN 629/share, implying 18% upside potential. Our PT is the average of our comparative valuation (implying a PT of PLN 662.1/share) and our DCF valuation (implying a PT of PLN 595.8/share). We assign equal 50% weights to both methods.

VIGO Photonics: valuation summary

Method	Valuation	Weight
Comparative valuation	662.1	50%
DCF	595.8	50%
Price target (PLN/share)	**629.0**	
Current price (PLN/share)	532.0	
Upside (%)	**18%**	

Source: WOOD Research

DCF

We base our DCF valuation on the following assumptions:

- ✓ A risk free rate of 6.25%, as a proxy for the 10-year maturity Polish government bond yield.
- ✓ An unlevered beta of 1.1x, based on Damodaran's unlevered EM beta for electronics.
- ✓ An equity risk premium (ERP) of 4.5%.
- ✓ A debt risk premium of 2.0%, based on VIGO's effective cost of debt.
- ✓ A terminal growth rate of 3.0%.

VIGO Photonics: DCF valuation (PLN m)

	2023E	2024E	2025E	2026E	2027E	2028E	2029E	2030E	2031E	2032E	>2032E
Revenues	87.5	107.2	134.7	173.5	181.7	190.4	199.8	209.8	220.6	231.8	231.8
EBITDA	31.5	43.4	56.3	78.5	82.0	85.8	90.0	94.4	99.3	104.2	104.2
EBITDA margin	*36.0%*	*40.5%*	*41.8%*	*45.2%*	*45.2%*	*45.1%*	*45.0%*	*45.0%*	*45.0%*	*45.0%*	45.0%
EBIT	19.3	29.5	40.8	61.2	64.8	68.7	74.0	79.2	84.4	89.4	89.4
EBIT margin	*22.0%*	*27.5%*	*30.3%*	*35.2%*	*35.7%*	*36.1%*	*37.0%*	*37.8%*	*38.2%*	*38.6%*	38.6%
Cash tax on EBIT	-3.7	-5.6	-7.8	-11.6	-12.3	-13.1	-14.1	-15.1	-16.0	-17.0	-17.0
NOPAT	15.6	23.9	33.1	49.5	52.5	55.6	59.9	64.2	68.4	72.4	72.4
D&A	12.2	13.9	15.5	17.4	17.3	17.1	16.0	15.2	14.9	14.8	14.8
Change in WC	-13.2	-14.5	-12.6	-15.7	-7.2	-7.4	-7.6	-7.8	-8.0	-8.1	
Capex*	-35.3	-48.7	-14.0	-14.0	-12.0	-12.0	-12.0	-12.0	-12.0	-12.0	-24.6
FCFF	**-20.6**	**-25.3**	**21.9**	**37.2**	**50.5**	**53.4**	**56.3**	**59.6**	**63.3**	**67.2**	**62.6**
Discount factor (%)	90%	81%	73%	65%	59%	53%	48%	43%	39%	35%	
PV	-19	-20	16	24	30	28	27	26	24	23	
PV 2023-32E	159										
TV growth rate (%)	3.0%										
PV TV	265										
EV 2022E	**425**										
Minorities 2022E	0										
Net debt 2022E	56										
Equity-accounted investees and other LT financial assets 2022E	8										
Equity value end-2022E (PLN m)	**377**										
Number of shares, m	0.73										
Fair value per share as of end-2022E (PLN)	517.5										
12-month price target (PLN)	**595.8**										

*Source: WOOD Research; *capex including grants received and excluding capex on financial investments*

Comparative valuation

We base our comparative approach on the 2023-25E EV/EBITDA and P/E multiples, using our forecasts for VIGO Photonics and the Bloomberg consensus median multiples for its peers. Our comparative valuation implies a PT of PLN 662.1/share for VIGO, and we assign a 50% weighting to this in our final PT for the company.

We see VIGO's valuation as relatively attractive as, on our forecasts, it trades at EV/EBITDAs of 16.6-12.5x for 2024-25E, at 14-31% discounts vs. its peers, while offering a stronger growth outlook – we expect VIGO to generate a 49% 2022-25E EBITDA CAGR vs. the 10% peers median. In the 2021-25E

period (2022E is not representative due to a temporary issue with supply chain), we estimate VIGO's EBITDA CAGR of 16%, still above the peers' median.

Comparative valuation (PLN m)*

	P/E (x)			EV/EBITDA (x)		
	2023E	2024E	2025E	2023E	2024E	2025E
VIGO multiple	37.6	22.7	13.9	16.6	12.5	8.6
Peers median	23.7	22.4	18.6	16.3	14.6	12.5
VIGO premium (discount)	59%	1%	-25%	2%	-14%	-31%
Company results	10	17	28	28	39	54
EV implied	325	489	600	459	576	676
Net debt	81	106	81	81	106	81
Minorities	0	0	0	0	0	0
Equity value implied	244	382	519	378	469	596
Multiple weight	17%	17%	17%	17%	17%	17%
Equity value (PLNm)	431					
Fair value/share (PLN)	591.9					
12M PT (PLN)	**662.1**					

*Source: WOOD Research; *the current multiples calculations are based on WOOD's forecasts for VIGO Photonics and the Bloomberg consensus for its other peers*

VIGO Photonics: peer multiples*

	Country	MCap (USDm)	P/E (x)			EV/EBITDA (x)		
			2023E	2024E	2025E	2023E	2024E	2025E
VIGO Photonics	**Poland**	**90**	**37.6**	**22.7**	**13.9**	**16.6**	**12.5**	**8.6**
Hamamatsu Photonics	Japan	8,531	24.5	24.1	22.9	13.4	12.5	11.6
Teledyne Technologies	USA	20,479	22.8	21.0	20.6	16.3	14.6	13.4
Visual Photonics Epitaxy	Taiwan	607	37.2	24.3	18.6	20.9	14.6	n.a.
Coherent	USA	4,771	9.3	7.9	7.1	6.6	5.6	5.2
Ipg Photonics	USA	5,537	22.8	19.9	17.9	n.a.	n.a.	n.a.
Optex Group	Japan	554	11.8	10.5	9.1	n.a.	n.a.	n.a.
Nippon Ceramic	Japan	519	16.1	14.7	13.3	n.a.	n.a.	n.a.
Focused Photonics Hangzhou	China	1,810	44.4	28.3	n.a.	n.a.	n.a.	n.a.
Visual Photonics Epitaxy	Taiwan	607	37.2	24.3	18.6	20.9	14.6	n.a.
Amphenol	USA	46,516	26.1	23.7	21.8	16.2	14.9	14.2
Median			**23.7**	**22.4**	**18.6**	**16.3**	**14.6**	**12.5**
VIGO premium (discount)			**59%**	**1%**	**-25%**	**2%**	**-14%**	**-31%**

*Source: Bloomberg, WOOD Research; *the current multiples calculations are based on WOOD's forecasts for VIGO Photonics and the Bloomberg consensus for its other peers*

VIGO Photonics: peers' key indicators*

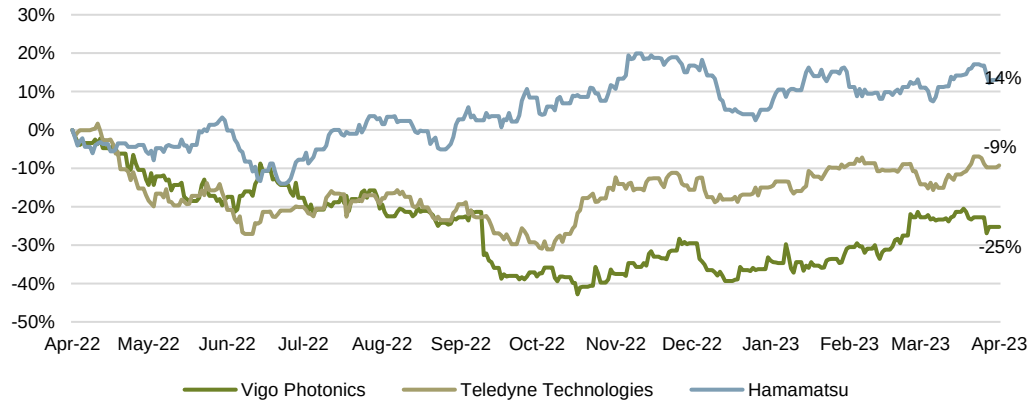
	CAGR 2022-25E		ND/EBITDA	FCF yield		Dividend yield		EBITDA margin		NI margin	
	NI	EBITDA	2023E	2023E	2024E	2023E	2024E	2023E	2024E	2023E	2024E
VIGO Photonics	**38%**	**49%**	**2.6**	**-5%**	**-6%**	**0.0%**	**0.0%**	**36%**	**41%**	**15%**	**19%**
Hamamatsu Photonics	5%	10%	-1.6	2%	3%	1.1%	1.2%	32%	32%	19%	18%
Teledyne Technologies	8%	7%	1.7	4%	5%	n.a.	n.a.	24%	25%	16%	16%
Visual Photonics Epitaxy	19%	20%	0.4	3%	5%	2.3%	2.9%	34%	36%	19%	22%
Coherent	17%	23%	2.4	-11%	-11%	0.0%	0.0%	26%	27%	12%	12%
Ipg Photonics	9%	8%	n.a.	2%	6%	0.0%	0.0%	27%	29%	17%	18%
Optex Group	10%	n.a.	n.a.	n.a.	n.a.	2.2%	2.3%	n.a.	n.a.	10%	10%
Nippon Ceramic	-10%	11%	n.a.	n.a.	n.a.	4.1%	4.5%	25%	25%	15%	15%
Focused Photonics Hangzhou	n.a.	n.a.	n.a.	0%	2%	0.6%	0.9%	12%	13%	5%	7%
Visual Photonics Epitaxy	19%	20%	0.4	3%	5%	2.3%	2.9%	34%	36%	19%	22%
Amphenol	5%	5%	0.9	4%	4%	1.1%	1.1%	24%	24%	15%	15%
Median	**9%**	**10%**	**0.6**	**2%**	**4%**	**1.1%**	**1.2%**	**26%**	**27%**	**15%**	**16%**

*Source: Company data, Bloomberg, WOOD Research; *estimates based on our forecasts for VIGO and Bloomberg consensus for its peers*

VIGO's share price has underperformed its main listed peers (Teledyne and Hamamatsu) in the past 12 months: it dropped 25% vs. Teledyne's 9% decline and Hamamatsu's 14% appreciation. The underperformance (apart from local market weakness – the WIG dropped 9% in LTM) was driven by VIGO's soft financials (sales down 6% yoy) in 2022, caused by (temporary) issues with the supply chain, while its peers delivered solid growth (Teledyne's sales increased 18% yoy in 2022, while Hamamatsu reported 23.5% sales growth in the fiscal year that ended in September 2022). Due to a EBITDA

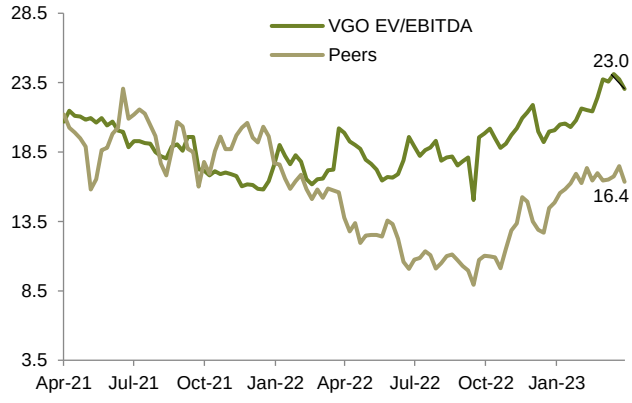
contraction, VIGO's LTM EV/EBITDA expanded to 23.0x, implying a 41% premium vs. the peer median of 16.4x (vs. the average 27% premium in the past two years).

VIGO Photonics vs. peers' share price performance

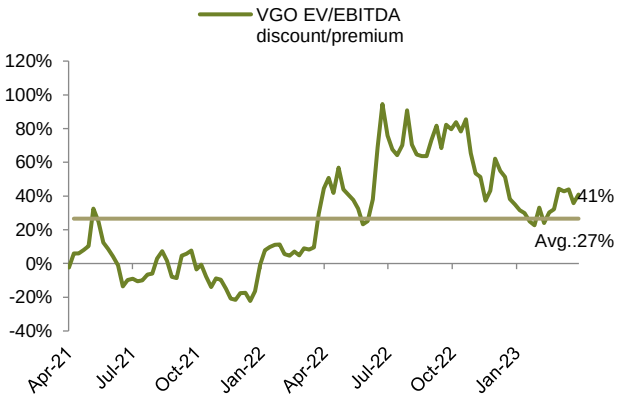


Source: Bloomberg, WOOD Research

VIGO Photonics vs. peers
Average LTM EV/EBITDA



LTM EV/EBITDA discount/premium



Source: Bloomberg, WOOD Research

Scenario analysis for the infrared arrays project

Out of the three new initiatives assumed in VIGO's strategy, we have pencilled only the infrared arrays project into our model, as we believe its realisation is the most probable. In our forecasts, we assume that VIGO will conclude an agreement with the Polish army and reach a target production volume of 300 infrared arrays/year from 2026E. In this scenario, the project adds PLN 117/share to our PT for VIGO – excluding the project, our PT for VIGO would reach PLN 512/share (i.e., 19% below our base-case scenario PT).

However, we note that our assumptions are conservative compared to the company's plans: VIGO estimates its annual production capacity of the infrared arrays at 500 units, and volumes of 1,000 pieces/year in its strategy. If we pencil in volumes of 500 units/annually to our model, our PT would increase to PLN 705/share (12% above our base-case PT), while the annual contribution to sales would increase from the PLN 42m assumed in our base case scenario, to PLN 71m.

VIGO Photonics: infrared arrays scenario analysis

	PT	Contribution to 2026E sales (PLN m)
Bull case	705	71
Base case	629	42
Bear case	512	0

Source: WOOD Research

Financial forecasts

Sales 2022-25E CAGR of 26%. The company has reported its sales numbers for 2022 already – the company recorded total sales of PLN 67.3m, down 6% yoy. A yoy drop was recorded in both the detection modules (6% yoy) and semiconductor materials segments (down 3% yoy). The decline was driven by weakness in the demand from the military industry (due to the lack of an order from Safran, VIGO's biggest client, which generated 28% of the company's sales in 2021) and supply chain issues, related to the limited availability of c.10-20% of the electronic components used for the production of detection modules for transport and industrial applications. According to the company's estimates (presented along with the 4Q22 sales results), the difficulties in the availability of certain electronic components reduced its full-year contracting by approximately 5% in 2022.

In 2023-24E, we expect VIGO's sales to expand by 30-23%, to PLN 87.5-107.2m, driven by an increase in demand from the industry sub-segment (we expect 16-25% yoy growth in 2023-24E, with a deceleration vs. 2022, related to the uncertain macro environment) and a military segment sales acceleration – we expect a return of orders from Safran and demand stemming from the programme of Polish army modernisation (described in a separate paragraph in this report). The sales volumes should also be supported by VIGO's expansion into new geographies – we note that, in 4Q22, VIGO's sales in the Asian market almost doubled yoy, to PLN 4.5m, from PLN 2.4m in 4Q21.

We also note that, from 2023E, VIGO's sales should be supported by the price hikes implemented by the company in October 2022 (by 25-30%), which are reflected in 4-19% increases in the average prices in 2022-23E in our model.

From 2025E, we also expect the revenues from the military industry to be supported by the launch of VIGO's new initiative – infrared arrays. In our forecasts, we expect volumes of 100-300 in 2025-26E, respectively, and sales of PLN 14.1-42.4m.

VIGO Photonics: sales forecasts

	2018	2019	2020	2021	2022E	2023E	2024E	2025E	2026E
Science and medicine	2.8	3.1	7.8	4.0	7.1	9.2	11.1	12.7	14.0
Other	0.4	0.4	0.4	0.3	0.5	0.8	0.9	1.0	1.1
Industry	20.3	25.4	23.6	31.1	41.1	47.5	59.3	68.3	75.1
Transport	5.8	5.8	6.2	8.7	7.8	7.8	9.0	9.9	10.9
Military	8.1	8.1	13.4	23.2	8.1	16.3	19.5	33.6	61.9
Semiconductor materials	0.0	0.2	1.9	4.3	4.2	5.9	7.3	9.1	10.5
Revenues (PLN m)	**37.4**	**42.9**	**53.5**	**71.5**	**67.3**	**87.5**	**107.2**	**134.7**	**173.5**
Change yoy									
Science and medicine	12%	11%	153%	-50%	78%	31%	20%	15%	10%
Other	-43%	-1%	8%	-35%	99%	51%	10%	10%	10%
Industry	30%	25%	-7%	31%	32%	16%	25%	15%	10%
Transport	66%	0%	7%	41%	-10%	1%	15%	10%	10%
Military	69%	-1%	67%	73%	-65%	101%	20%	72%	84%
Semiconductor materials	n.a.	n.a.	1101%	124%	-3%	41%	25%	25%	15%
Revenues (PLNm)	38%	15%	25%	34%	-6%	30%	23%	26%	29%
EUR/PLN average	**4.3**	**4.3**	**4.4**	**4.6**	**4.7**	**4.7**	**4.7**	**4.7**	**4.7**
Revenues (EUR m)	**8.8**	**10.0**	**12.0**	**15.7**	**14.4**	**18.6**	**22.8**	**28.6**	**36.8**
Change yoy	38%	14%	21%	30%	-8%	29%	23%	26%	29%
Sales volume of detector modules (ths)	**7.6**	**7.2**	**8.4**	**12.2**	**11.0**	**11.7**	**14.1**	**15.9**	**17.5**
Change yoy	40%	-6%	16%	46%	-10%	7%	20%	13%	10%
Average price (EUR 000s)	**1.1**	**1.4**	**1.4**	**1.3**	**1.3**	**1.6**	**1.6**	**1.8**	**2.1**
Change yoy	-1%	21%	4%	-11%	4%	19%	2%	11%	17%

Source: WOOD Research

Adjusted EBITDA margin to contract from 41% in 2021 to 37% in 2024E. We expect VIGO's adjusted EBITDA to drop to PLN 14.2m in 2022E and then rebound to PLN 28.2-39.4m in 2023-24E, implying an adjusted EBITDA margin contraction from 41% in 2021 to 21% in 2022E and 32-37% in 2023-24E. The profitability contraction (which VIGO has faced in 1-3Q22 already, when its adjusted EBITDA margin reached 20%, vs. 45% in 1-3Q21) is likely to be driven by a hike in the costs of materials and energy, as well as increasing employee-related expenses, due to the team expansion (including the development of VIGO's branches abroad) and pressure on salaries. From 2023E, we expect the adjusted EBITDA margin to rebound, due to the price hikes implemented by VIGO, and the assumed stabilisation of components (due to the partially solved supply chain issues) and energy prices in Poland. Assuming a one-off related to the settlement of grants of PLN 2.9m in 2022E and PLN 3.3-4.0m in 2023-24E, we expect the reported EBITDA to reach PLN 17.2m in 2022E and 31.5-43.4m in 2023-24E.

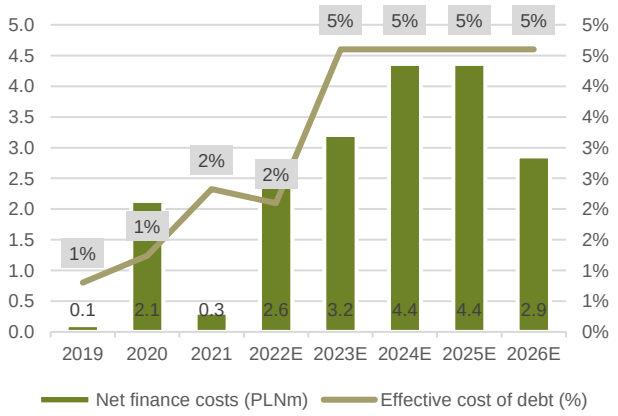
VIGO Photonics: operating profitability forecasts

	2018	2019	2020	2021	2022E	2023E	2024E	2025E	2026E
Depreciation	-3.5	-4.6	-6.2	-6.7	-9.4	-12.2	-13.9	-15.5	-17.4
Consumption of materials and energy	-6.4	-8.5	-9.4	-12.8	-18.8	-21.0	-24.7	-26.3	-33.0
Third-party services	-2.2	-3.0	-4.1	-6.1	-15.5	-17.1	-20.9	-25.6	-33.0
Taxes and charges	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
Employee-related expenses	-9.6	-10.5	-12.5	-15.8	-19.9	-22.0	-24.0	-27.4	-29.9
Other costs by type	-0.4	-0.5	-0.3	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
Total costs by type. of which:	-26.8	-32.5	-39.0	-49.1	-64.3	-72.9	-84.1	-95.5	-114.0
Change in products	0.0	2.1	2.0	-0.9	0.0	0.0	0.0	0.0	0.0
Selling costs (negative figure)	2.2	2.4	3.4	4.3	11.8	14.1	15.8	16.4	17.8
General administrative expenses (negative figure)	7.7	12.2	15.9	20.0	21.5	20.9	24.9	28.3	31.2
Cost of products and services sold	-16.9	-15.9	-17.8	-25.7	-31.0	-37.9	-43.5	-50.9	-65.0
Gross profit (loss) on sales	**20.5**	**27.0**	**35.6**	**45.1**	**36.3**	**49.6**	**63.7**	**83.8**	**108.6**
EBIT	**12.8**	**14.0**	**20.2**	**24.7**	**7.7**	**19.3**	**29.5**	**40.8**	**61.2**
EBITDA	**16.2**	**18.6**	**26.5**	**31.5**	**17.2**	**31.5**	**43.4**	**56.3**	**78.5**
One-offs*	0.0	0.0	-2.0	-2.3	-2.9	-3.3	-4.0	-2.0	-2.0
EBITDA adjusted	**16.2**	**18.6**	**24.5**	**29.1**	**14.2**	**28.2**	**39.4**	**54.3**	**76.5**
Margins (%)									
Gross profit (loss) on sales	55%	63%	67%	63%	53%	57%	59%	62%	63%
EBIT	34%	33%	38%	35%	11%	22%	28%	30%	35%
EBITDA	43%	43%	50%	44%	25%	36%	41%	42%	45%
EBITDA adjusted	43%	43%	46%	41%	21%	32%	37%	40%	44%

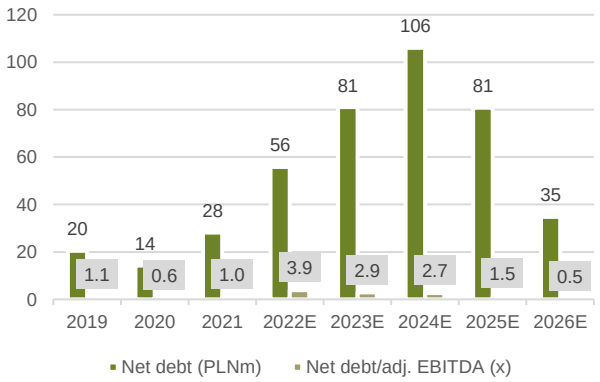
Source: Company data, WOOD Research

Net profit to hit its low, at PLN 11.3m, in 2022E and to rebound to PLN 13.0-20.4m in 2023-24E. We expect VIGO's net finance costs to expand from PLN 0.3m in 2021 to PLN 2.6m in 2022E and PLN 3.2-4.4m in 2023-24E. Apart from a hike in EURIBOR (on which most of the company's interest on debt is based), we expect an increase in the company's leverage, considering the relatively low cash balance (PLN 2.1m as of end-3Q22) and the capex outlays related to the infrared arrays R&D and production line and other organic capex that we expected. In the results, we expect VIGO to record negative FCF in 2022-24E and a return to cash generation in 2025E. From 2023E, we also assume VIGO's effective income tax rate to stand at 19% (vs. 0% or a positive result related to deferred tax asset creation in previous years). We expect VIGO's net profit adjusted for one-offs (related mainly to gains on subsidies and tax assets creation) to rebound from PLN 2.7m in 2022E to PLN 10.3m in 2023E and PLN 17.1m in 2024E.

VIGO Photonics: net finance costs forecasts (PLN m, %)

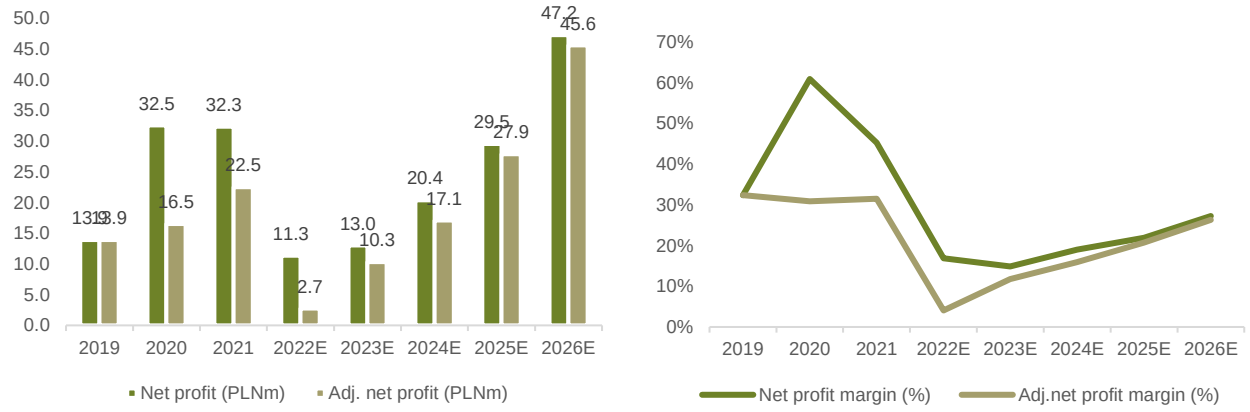


VIGO Photonics: indebtedness forecasts (PLN m, %)



Source: Company data, WOOD Research

VIGO Photonics: net profit forecasts (PLN m, %)



Source: Company data, WOOD Research

VIGO Photonics: P&L forecasts (PLN m)

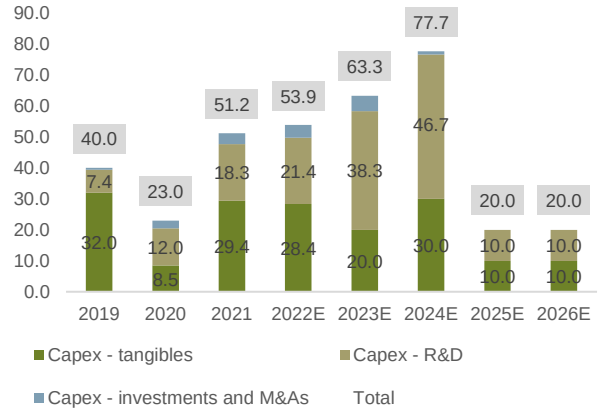
	2018	2019	2020	2021	2022E	2023E	2024E	2025E	2026E
Net revenues	**37.4**	**42.9**	**53.5**	**71.5**	**67.3**	**87.5**	**107.2**	**134.7**	**173.5**
COGS	-16.9	-15.9	-17.8	-26.4	-31.0	-37.9	-43.5	-50.9	-65.0
Gross profit (loss) on sales	**20.5**	**27.0**	**35.6**	**45.1**	**36.3**	**49.6**	**63.7**	**83.8**	**108.6**
Selling costs	-2.2	-2.4	-3.4	-4.3	-11.8	-14.1	-15.8	-16.4	-17.8
General and administrative costs	-7.7	-12.2	-15.9	-20.0	-21.5	-20.9	-24.9	-28.3	-31.2
Other operating revenues	2.8	2.7	4.4	5.9	8.2	8.1	9.9	5.0	5.0
Other operating expenses	-0.7	-1.1	-0.6	-1.9	-3.4	-3.4	-3.4	-3.4	-3.4
Profit (loss) on operating activities	**12.8**	**14.0**	**20.2**	**24.7**	**7.7**	**19.3**	**29.5**	**40.8**	**61.2**
Financial revenues	0.3	0.1	0.0	0.5	0.1	0.1	0.1	0.1	0.1
Financial expenses	-0.1	-0.3	-2.2	-0.8	-2.7	-3.3	-4.4	-4.4	-2.9
Gross profit (loss)	**13.0**	**13.9**	**18.1**	**24.4**	**5.1**	**16.0**	**25.1**	**36.4**	**58.3**
Income tax	0.0	0.0	14.5	7.9	6.2	-3.0	-4.8	-6.9	-11.1
Net profit	**13.0**	**13.9**	**32.5**	**32.3**	**11.3**	**13.0**	**20.4**	**29.5**	**47.2**
EBIT	**12.8**	**14.0**	**20.2**	**24.7**	**7.7**	**19.3**	**29.5**	**40.8**	**61.2**
EBITDA	**16.2**	**18.6**	**26.5**	**31.5**	**17.2**	**31.5**	**43.4**	**56.3**	**78.5**
EBITDA adjusted	**16.2**	**18.6**	**24.5**	**29.1**	**14.2**	**28.2**	**39.4**	**54.3**	**76.5**
Net profit (loss) adjusted for tax gains	**13.0**	**13.9**	**18.1**	**24.3**	**5.1**	**13.0**	**20.4**	**29.5**	**47.2**
Net profit adjusted for one-offs	**13.0**	**13.9**	**16.5**	**22.5**	**2.7**	**10.3**	**17.1**	**27.9**	**45.6**

Source: Company data, WOOD Research

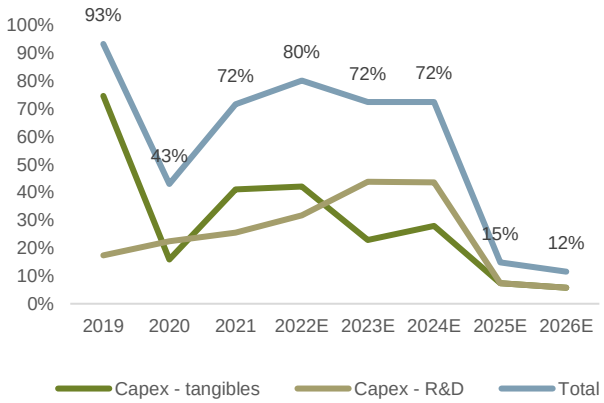
Capex to reach its peak in 2024E, dividends on hold. We expect VIGO's capex to reach PLN 54m in 2022E and PLN 63-78m in 2023-24E. We expect the increase in the total capex level to be driven mainly by the development of the infrared arrays initiative that we assume, i.e., R&D expenses and investment in the production line, which should be fully operational by end-2024E, on our assumptions. We also pencil in investment of another PLN 5m in VIGO Ventures in 2023E. Due to the expected levered capex outlays, we expect the company to record negative FCF in 2022-24E. As a result, we see no space for dividend payouts; however, this is in line with the company's strategy, which assumes no dividend payouts and the full reinvestment of earnings until the end of 2026E.

In our forecasts, we assume that a significant part of the R&D expenses will be supported by subsidies – the average co-financing contribution to the R&D capex in 2017-21 stood at 80%; while, in our forecasts, we conservatively expect the share to fall to 60%.

VIGO Photonics: capex forecasts (PLN m)

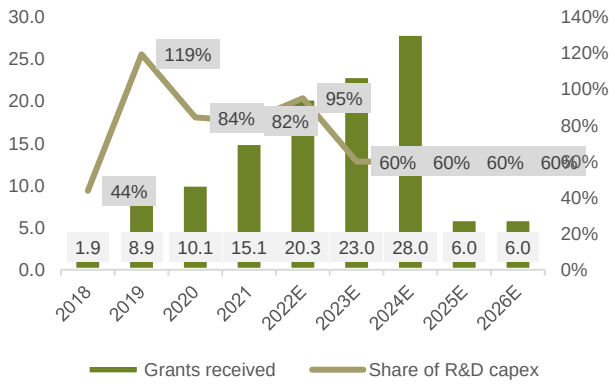


VIGO Photonics: capex/sales forecasts (%)

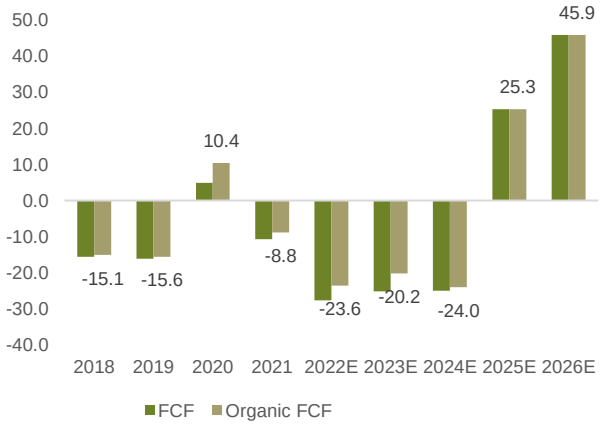


Source: Company data, WOOD Research

VIGO Photonics: subsidies forecasts (PLN m, %)



VIGO Photonics: FCF forecasts (PLN m)



Source: Company data, WOOD Research

VIGO Photonics: FCF reconciliation (PLN m)

	2018	2019	2020	2021	2022E	2023E	2024E	2025E	2026E
Net cash flows from operating activities	9.1	15.4	21.2	24.1	6.8	18.4	29.1	43.8	62.9
Net cash flows from investing activities	-24.6	-31.1	-15.9	-34.6	-33.6	-40.3	-49.7	-14.0	-14.0
Interest and commissions	-0.1	-0.4	-0.4	-0.3	-1.0	-3.3	-4.4	-4.4	-2.9
FCF	**-15.6**	**-16.1**	**4.9**	**-10.7**	**-27.7**	**-25.2**	**-25.0**	**25.3**	**45.9**
Investments and M&As	0.5	0.6	5.5	1.9	4.1	5.0	1.0	0.0	0.0
Organic FCF	**-15.1**	**-15.6**	**10.4**	**-8.8**	**-23.6**	**-20.2**	**-24.0**	**25.3**	**45.9**
FCF yield	-4%	-4%	1%	-3%	-7%	-6%	-6%	7%	12%
Organic FCF yield	-4%	-4%	3%	-2%	-6%	-5%	-6%	7%	12%

Source: Company data, WOOD Research

4Q22E results preview (due on 18 April)

VIGO Photonics: 4Q22E results preview

(PLN m)	3Q21	4Q21	1Q22	2Q22	3Q22	4Q22E	qoq	yoy
Net revenues	**16.7**	**22.3**	**11.7**	**19.0**	**16.8**	**19.7**	**17%**	**-11%**
COGS	-5.1	-9.6	-3.1	-9.0	-8.8	-10.1	15%	5%
Gross profit (loss) on sales	**11.6**	**12.7**	**8.6**	**10.0**	**8.0**	**9.6**	**20%**	**-24%**
SG&A	-5.8	-7.4	-7.7	-9.9	-7.8	-8.0	3%	9%
Other operating income&costs	1.4	0.5	0.6	1.6	1.3	1.2	-11%	164%
Adj. EBITDA	**8.3**	**6.9**	**2.8**	**3.3**	**3.3**	**4.8**	**43%**	**-31%**
EBITDA	**8.9**	**7.5**	**3.3**	**4.1**	**4.2**	**5.6**	**33%**	**-25%**
EBIT	**7.2**	**5.8**	**1.6**	**1.7**	**1.6**	**2.8**	**74%**	**-51%**
Net finance costs	-0.4	0.0	-0.5	-0.1	-1.3	-0.7	-51%	n.a.
Pre-tax profit (loss)	**6.8**	**5.7**	**1.0**	**1.7**	**0.3**	**2.2**	**674%**	**-62%**
Income tax	1.8	5.6	2.6	0.9	2.8	0.0	n.a.	n.a.
Net profit (loss)	**8.6**	**11.3**	**3.6**	**2.5**	**3.0**	**2.2**	**-29%**	**-81%**
Margins								
Gross profit (loss) on sales	69.6%	56.9%	73.6%	52.6%	47.8%	48.8%	1.0pp.	-8.1pp.
Adj. EBITDA	49.6%	31.2%	23.9%	17.5%	19.8%	24.2%	4.4pp.	-7.0pp.
EBITDA	53.5%	33.5%	28.3%	21.4%	24.9%	28.3%	3.4pp.	-5.3pp.
EBIT	43.3%	25.9%	13.3%	9.1%	9.7%	14.3%	4.6pp.	-11.6pp.
Net profit (loss)	51.7%	50.9%	30.8%	13.3%	18.1%	10.9%	-7.2pp.	-40.0pp.

Source: Company data, WOOD Research

Risks

Competition. Despite being one of the global leaders in terms of product quality, the company is up against competition with a similar global reach, which are improving their offers constantly. We also note that, in such a specialised market niche as the one in which VIGO is operating, the sale process starts along with the process of the development of a new product on the client's side. As the project of the product is created based on specific components, the loyalty of customers is relatively high, so it might be difficult for VIGO to win market share from the competition. We also note the high barriers (technology, R&D process length and cost, capex on production facility) to entry and the relatively low number of competitors in VIGO's niche of mid-infrared detectors.

New initiatives failure. Out of the three new initiatives assumed in VIGO's strategy, we have pencilled only the infrared arrays project into our model, as we believe its realisation is the most probable. In our forecasts, we assume that VIGO will conclude an agreement with the Polish army and reach a target production volume of 300 infrared arrays/year from 2026E. In this scenario, the project adds PLN 117/share to our PT for VIGO – excluding the project, our PT for VIGO would reach PLN 512/share (i.e., 19% below our base-case scenario PT). We believe our assumptions are conservative (as VIGO sees current annual production capacity of 500 units and target production volumes of 1000 units), but we see a risk of failure in terms of concluding the contract with the Polish army (it might decide to use foreign components).

Macro risks. A macro slowdown might limit the demand for VIGO's products. On the other hand, the current inflationary trends might put pressure on the company's profitability (in terms of energy costs, salaries, production resources and equipment prices).

High concentration of sales. VIGO's four biggest clients generated as much as 55% of the company's sales in 2021. Losing one of its key clients is a risk for VIGO's future results development. However, we note the high quality of VIGO's products and that the switching process for its clients is a difficult one, so customer loyalty is relatively high.

Lack of new orders from Safran. VIGO's 2022 sales weakness was, to a large extent, caused by limited demand from Safran, its biggest client, which contributed PLN 20.2m to sales, 28% of total sales, in 2021. We believe that that the slowdown in revenues from Safran is temporary and might have been related to strong stocking up in 2021: we note that, in 2021, VIGO generated PLN 20.2m in sales on Safran, more than double 2020 (PLN 9.4m) and almost triple 2019 (PLN 7.4m). In our forecasts, we expect a rebound in military revenues, driven mainly by a return of demand from Safran, which we believe is likely, considering the strong outlook for Safran's defence segment. However, if orders from Safran are limited again, or if Safran decides to change its supplier, we would see it as a major risk for our forecasts.

New technology replacing IR detectors. We see a risk of new technology emerging, which could be cheaper or perform better than IR detectors.

Risk related to key staff members. Experienced managers and employees are one of the company's key strengths and competitive advantages. The loss of key employees is a risk for VIGO.

Lack of skilled labour force. VIGO needs high-skilled specialists for its R&D and production departments. There is a risk that a lack of these in the Polish labour market could limit the company's growth pace, or it might have to look abroad for specialists, implying higher labour force costs in the future.

Potential share issue. In our forecasts, we expect VIGO's growth to be financed by operating cash flow and debt, but we see a risk of the company looking for an equity raising in order to accelerate its growth, especially in the new areas, i.e., mid-infrared sources, PICs and infrared arrays. The company has also flagged that it might enter the mid-infrared sources segment through M&A.

Supply chain issues. For the purpose of the detector production, the company purchases thermoelectric cooler, substrates, electronic circuits and some amounts of chemical elements (including cadmium, mercury, tellurium, antimony, arsenic, and indium).

We note that, since 2020, the global economy has faced a chip shortage crisis, as the demand for semiconductor chips exceeded the supply materially. The crisis was driven by the upsurge in people working from home (demand for work-from-home technology increased dramatically), bottlenecks in the supply chains (particularly in South Asia), and strong demand from the automotive sector, which has been shifting towards electric vehicles and automation (and, as a result, required more chips).

The supply chain issue risk materialised for VIGO in 2022. In October 2022, VIGO's CFO (as quoted by PAP) stated that the limited availability concerned c.10-20% of the electronic components, only for the production of detection modules for transport and industrial applications. According to the company's

estimates (presented along with the 4Q22 sales results), the difficulties in the availability of certain electronic components reduced its full-year contracting in 2022 by approximately 5%.

The company has also faced issues with supply related to components manufactured in the Russian Federation. The value of components imported from Russia amounted to PLN 7.3m in 2021. The company has taken steps to find alternative suppliers and has completed the qualification of a new supplier successfully. In addition, the existing supplier has relocated its production outside of Russia. The company does not see any significant problems, at this stage, with the availability of components that were purchased previously from the Russian market. However, due to disruptions in global supply chains in the electronic components market, this risk cannot be excluded completely.

FX risk. The company generates the vast majority of its revenues in EUR, while it incurs a large part of its opex in PLN (labour force costs, which are mostly PLN-denominated, contributed 47% of the opex in 2021). To some extent, VIGO hedges the FX through debt: most of the company's loans are EUR-denominated (87% as of end-2021).

Risk of lower co-financing amount. In our forecasts, we assume that VIGO's R&D expenses will be supported by public subsidies. In the past five years, the average support has reached as much as 80% of the R&D expenses (on our estimates); while, in our model, we conservatively assume a 60% rate. We, however, see a risk of a lower subsidies level in the future, which could either mean higher capex for VIGO financed from own sources, or limited R&D activity, and the risk of losing its technological advantage over the competition.

Financials

Sales forecasts

	2018	2019	2020	2021	2022E	2023E	2024E	2025E	2026E
Science and medicine	2.8	3.1	7.8	4.0	7.1	9.2	11.1	12.7	14.0
Other	0.4	0.4	0.4	0.3	0.5	0.8	0.9	1.0	1.1
Industry	20.3	25.4	23.6	31.1	41.1	47.5	59.3	68.3	75.1
Transport	5.8	5.8	6.2	8.7	7.8	7.8	9.0	9.9	10.9
Military	8.1	8.1	13.4	23.2	8.1	16.3	19.5	33.6	61.9
Semiconductor materials	0.0	0.2	1.9	4.3	4.2	5.9	7.3	9.1	10.5
Revenues (PLNm)	**37.4**	**42.9**	**53.5**	**71.5**	**67.3**	**87.5**	**107.2**	**134.7**	**173.5**
Change yoy									
Science and medicine	12%	11%	153%	-50%	78%	31%	20%	15%	10%
Other	-43%	-1%	8%	-35%	99%	51%	10%	10%	10%
Industry	30%	25%	-7%	31%	32%	16%	25%	15%	10%
Transport	66%	0%	7%	41%	-10%	1%	15%	10%	10%
Military	69%	-1%	67%	73%	-65%	101%	20%	72%	84%
Semiconductor materials	n.a.	n.a.	1101%	124%	-3%	41%	25%	25%	15%
Revenues (PLNm)	38%	15%	25%	34%	-6%	30%	23%	26%	29%
EUR/PLN average	**4.3**	**4.3**	**4.4**	**4.6**	**4.7**	**4.7**	**4.7**	**4.7**	**4.7**
Revenues (EURm)	**8.8**	**10.0**	**12.0**	**15.7**	**14.4**	**18.6**	**22.8**	**28.6**	**36.8**
Change yoy	38%	14%	21%	30%	-8%	29%	23%	26%	29%
Sales volume of detector modules (ths)	**7.6**	**7.2**	**8.4**	**12.2**	**11.0**	**11.7**	**14.1**	**15.9**	**17.5**
Change yoy	40%	-6%	16%	46%	-10%	7%	20%	13%	10%
Average price (EUR 000s)	**1.1**	**1.4**	**1.4**	**1.3**	**1.3**	**1.6**	**1.6**	**1.8**	**2.1**
Change yoy	-1%	21%	4%	-11%	4%	19%	2%	11%	17%

Source: WOOD Research

Operating profitability forecasts

	2018	2019	2020	2021	2022E	2023E	2024E	2025E	2026E
Depreciation	-3.5	-4.6	-6.2	-6.7	-9.4	-12.2	-13.9	-15.5	-17.4
Consumption of materials and energy	-6.4	-8.5	-9.4	-12.8	-18.8	-21.0	-24.7	-26.3	-33.0
Third-party services	-2.2	-3.0	-4.1	-6.1	-15.5	-17.1	-20.9	-25.6	-33.0
Taxes and charges	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
Employee-related expenses	-9.6	-10.5	-12.5	-15.8	-19.9	-22.0	-24.0	-27.4	-29.9
Other costs by type	-0.4	-0.5	-0.3	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
Total costs by type. of which:	-26.8	-32.5	-39.0	-49.1	-64.3	-72.9	-84.1	-95.5	-114.0
Change in products	0.0	2.1	2.0	-0.9	0.0	0.0	0.0	0.0	0.0
Selling costs (negative figure)	2.2	2.4	3.4	4.3	11.8	14.1	15.8	16.4	17.8
General administrative expenses (negative figure)	7.7	12.2	15.9	20.0	21.5	20.9	24.9	28.3	31.2
Cost of products and services sold	-16.9	-15.9	-17.8	-25.7	-31.0	-37.9	-43.5	-50.9	-65.0
Gross profit (loss) on sales	**20.5**	**27.0**	**35.6**	**45.1**	**36.3**	**49.6**	**63.7**	**83.8**	**108.6**
EBIT	**12.8**	**14.0**	**20.2**	**24.7**	**7.7**	**19.3**	**29.5**	**40.8**	**61.2**
EBITDA	**16.2**	**18.6**	**26.5**	**31.5**	**17.2**	**31.5**	**43.4**	**56.3**	**78.5**
One-offs*	0.0	0.0	-2.0	-2.3	-2.9	-3.3	-4.0	-2.0	-2.0
EBITDA adjusted	**16.2**	**18.6**	**24.5**	**29.1**	**14.2**	**28.2**	**39.4**	**54.3**	**76.5**
Margins (%)									
Gross profit (loss) on sales	55%	63%	67%	63%	53%	57%	59%	62%	63%
EBIT	34%	33%	38%	35%	11%	22%	28%	30%	35%
EBITDA	43%	43%	50%	44%	25%	36%	41%	42%	45%
EBITDA adjusted	43%	43%	46%	41%	21%	32%	37%	40%	44%

Source: Company data, WOOD Research

Segment results forecasts (PLN m)

	2018	2019	2020	2021	2022E	2023E	2024E	2025E	2026E
Sales revenue	**37.4**	**42.9**	**53.5**	**71.5**	**67.3**	**87.5**	**107.2**	**134.7**	**173.5**
Detection modules	37.4	42.7	51.5	67.2	63.1	81.6	99.9	125.6	163.0
Semiconductor materials	0.0	0.2	1.9	4.3	4.2	5.9	7.3	9.1	10.5
Gross profit on sales	**20.5**	**27.0**	**35.6**	**45.1**	**36.3**	**49.6**	**63.7**	**83.8**	**108.6**
Detection modules	20.5	26.9	34.8	43.3	34.4	46.9	60.4	79.7	103.8
Semiconductor materials	0.0	0.1	0.8	1.8	1.9	2.6	3.3	4.1	4.7
Profit (loss) on operating activities	**12.8**	**14.0**	**20.2**	**24.7**	**7.7**	**19.3**	**29.5**	**40.8**	**61.2**
Detection modules	12.8	14.3	19.6	24.2	7.1	18.1	28.0	38.8	58.8
Semiconductor materials	0.0	-0.3	0.7	0.5	0.7	1.1	1.5	2.0	2.4
Net profit/ (loss)	**13.0**	**13.9**	**32.5**	**32.3**	**11.3**	**13.0**	**20.4**	**29.5**	**47.2**
Detection modules	13.0	14.1	34.1	31.3	11.7	12.3	19.3	28.1	45.5
Semiconductor materials	0.0	-0.2	-1.6	0.6	-0.3	0.7	1.1	1.5	1.7
EBITDA	**16.2**	**18.6**	**26.5**	**31.5**	**17.2**	**31.5**	**43.4**	**56.3**	**78.5**
Detection modules	16.2	18.8	25.5	30.7	16.3	30.2	41.7	53.9	75.8
Semiconductor materials	0.0	-0.3	1.0	0.8	0.8	1.3	1.8	2.3	2.8

Source: WOOD Research

P&L forecasts (PLN m)

	2018	2019	2020	2021	2022E	2023E	2024E	2025E	2026E
Net revenues	**37.4**	**42.9**	**53.5**	**71.5**	**67.3**	**87.5**	**107.2**	**134.7**	**173.5**
COGS	-16.9	-15.9	-17.8	-26.4	-31.0	-37.9	-43.5	-50.9	-65.0
Gross profit (loss) on sales	**20.5**	**27.0**	**35.6**	**45.1**	**36.3**	**49.6**	**63.7**	**83.8**	**108.6**
Selling costs	-2.2	-2.4	-3.4	-4.3	-11.8	-14.1	-15.8	-16.4	-17.8
General and administrative costs	-7.7	-12.2	-15.9	-20.0	-21.5	-20.9	-24.9	-28.3	-31.2
Other operating revenues	2.8	2.7	4.4	5.9	8.2	8.1	9.9	5.0	5.0
Other operating expenses	-0.7	-1.1	-0.6	-1.9	-3.4	-3.4	-3.4	-3.4	-3.4
Profit (loss) on operating activities	**12.8**	**14.0**	**20.2**	**24.7**	**7.7**	**19.3**	**29.5**	**40.8**	**61.2**
Financial revenues	0.3	0.1	0.0	0.5	0.1	0.1	0.1	0.1	0.1
Financial expenses	-0.1	-0.3	-2.2	-0.8	-2.7	-3.3	-4.4	-4.4	-2.9
Gross profit (loss)	**13.0**	**13.9**	**18.1**	**24.4**	**5.1**	**16.0**	**25.1**	**36.4**	**58.3**
Income tax	0.0	0.0	14.5	7.9	6.2	-3.0	-4.8	-6.9	-11.1
Net profit	**13.0**	**13.9**	**32.5**	**32.3**	**11.3**	**13.0**	**20.4**	**29.5**	**47.2**
EBIT	**12.8**	**14.0**	**20.2**	**24.7**	**7.7**	**19.3**	**29.5**	**40.8**	**61.2**
EBITDA	**16.2**	**18.6**	**26.5**	**31.5**	**17.2**	**31.5**	**43.4**	**56.3**	**78.5**
EBITDA adjusted	**16.2**	**18.6**	**24.5**	**29.1**	**14.2**	**28.2**	**39.4**	**54.3**	**76.5**
Net profit (loss) adjusted for tax gains	**13.0**	**13.9**	**18.1**	**24.3**	**5.1**	**13.0**	**20.4**	**29.5**	**47.2**
Net profit adjusted for one-offs	**13.0**	**13.9**	**16.5**	**22.5**	**2.7**	**10.3**	**17.1**	**27.9**	**45.6**

Source: Company data, WOOD Research

Balance sheet forecasts (PLN m)

	2018	2019	2020	2021	2022E	2023E	2024E	2025E	2026E
Tangible fixed assets	45.0	67.5	70.7	99.2	121.9	134.4	156.4	158.3	159.6
Intangible assets and expenditures on development projects	21.1	29.0	39.6	53.9	71.6	105.1	145.9	148.5	149.8
Deferred tax assets	0.0	0.0	14.5	22.4	28.6	25.6	20.8	13.9	2.8
Other	1.3	2.3	4.3	8.2	12.4	17.4	18.4	18.4	18.4
Fixed assets	**67.4**	**98.8**	**129.1**	**183.7**	**234.4**	**282.5**	**341.4**	**339.0**	**330.6**
Inventory	4.1	6.9	9.2	6.9	12.5	15.2	17.6	22.1	28.5
Trade and other receivables	5.6	7.1	9.9	14.4	12.2	15.8	19.4	24.4	31.4
Cash and cash equivalents	9.3	12.8	13.2	6.5	3.0	2.8	2.8	3.1	9.1
Other	3.7	2.1	5.6	6.6	3.5	3.5	3.5	3.5	3.5
Total current assets	**22.8**	**28.9**	**38.0**	**34.3**	**31.2**	**37.4**	**43.3**	**53.2**	**72.5**
Total assets	**90.2**	**127.7**	**167.1**	**218.0**	**265.6**	**319.9**	**384.8**	**392.2**	**403.1**
Equity	**54.2**	**68.1**	**100.6**	**131.2**	**144.9**	**157.9**	**178.2**	**207.7**	**255.0**
Long term debt	5.5	26.8	24.1	22.2	33.7	58.7	83.7	58.7	38.7
Deferred income	12.0	19.6	25.3	35.1	48.2	63.1	81.2	82.2	83.2
Other long-term liabilities	0.4	0.7	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Long-term liabilities	**17.9**	**47.1**	**49.6**	**57.5**	**82.1**	**122.0**	**165.1**	**141.1**	**122.1**
Short term debt	7.9	6.5	6.4	12.5	25.3	25.3	25.3	25.3	5.3
Trade payables	7.0	1.6	1.7	8.1	4.6	6.0	7.4	9.3	12.0
Deferred income	1.3	1.4	2.9	2.4	2.4	2.4	2.4	2.4	2.4
Other current liabilities	1.9	3.1	5.7	6.4	6.4	6.4	6.4	6.4	6.4
Total current liabilities	**18.1**	**12.5**	**16.9**	**29.3**	**38.6**	**40.0**	**41.4**	**43.3**	**26.0**
Total equity and liabilities	**90.2**	**127.7**	**167.1**	**218.0**	**265.6**	**319.9**	**384.8**	**392.2**	**403.1**

Source: Company data, WOOD Research

Cash flow forecasts (PLN m)

	2018	2019	2020	2021	2022E	2023E	2024E	2025E	2026E
Gross profit (loss)	**13.0**	**13.9**	**18.1**	**24.4**	**5.1**	**16.0**	**25.1**	**36.4**	**58.3**
Depreciation	3.5	4.6	6.2	6.8	9.4	12.2	13.9	15.5	17.4
Exchange gains (losses)	-0.2	-0.2	2.2	0.0	2.3	0.0	0.0	0.0	0.0
Interest and share in profits (dividends)	0.0	0.0	0.4	0.3	1.0	3.3	4.4	4.4	2.9
Change in accruals	0.8	0.7	2.2	0.4	0.0	0.0	0.0	0.0	0.0
Change in inventories	-0.7	-2.8	-2.3	2.3	-5.6	-2.8	-2.4	-4.5	-6.4
Change in receivables	-5.8	0.8	-3.1	-8.0	5.2	-3.7	-3.6	-5.0	-7.0
Change in liabilities. except credit and loans	0.5	0.4	0.3	2.5	-3.5	1.4	1.4	1.9	2.7
Change in prepayments	-0.1	0.0	0.7	-0.4	0.0	0.0	0.0	0.0	0.0
Change in deferred revenue	-1.5	-1.3	-3.6	-5.4	-7.2	-8.1	-9.9	-5.0	-5.0
Result of entities accounted for using the equity method	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Income tax (paid)/received	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other adjustments	-0.5	-0.7	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Net cash flows from operating activities	**9.1**	**15.4**	**21.2**	**24.1**	**6.8**	**18.4**	**29.1**	**43.8**	**62.9**
Grants received	1.9	8.9	10.1	15.1	20.3	23.0	28.0	6.0	6.0
Purchase of intangible assets and tangible assets	-21.6	-32.0	-8.5	-29.4	-28.4	-20.0	-30.0	-10.0	-10.0
Expenses for the purchase of shares	-0.5	-0.6	-2.5	-3.5	-4.1	-5.0	-1.0	0.0	0.0
Investment Funds	0.0	0.0	-3.0	3.0	0.0	0.0	0.0	0.0	0.0
Expenditure on unfinished research&development projects	-4.3	-7.4	-12.0	-18.3	-21.4	-38.3	-46.7	-10.0	-10.0
Loans granted	0.0	0.0	0.0	-1.4	0.0	0.0	0.0	0.0	0.0
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Net cash flows from investing activities	**-24.6**	**-31.1**	**-15.9**	**-34.6**	**-33.6**	**-40.3**	**-49.7**	**-14.0**	**-14.0**
Changes in debt	13.3	19.7	-4.7	3.4	24.2	25.0	25.0	-25.0	-40.0
Dividends and other payments to owners	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Interest and commissions	-0.1	-0.4	-0.4	-0.3	-1.0	-3.3	-4.4	-4.4	-2.9
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Net cash flows from financing activities	**13.3**	**19.2**	**-5.1**	**3.1**	**23.3**	**21.7**	**20.6**	**-29.4**	**-42.9**
Total net cash flows	**-2.2**	**3.5**	**0.2**	**-7.4**	**-3.5**	**-0.2**	**0.0**	**0.3**	**5.9**
Cash opening balance	**11.6**	**9.3**	**12.9**	**13.0**	**6.5**	**3.0**	**2.8**	**2.8**	**3.1**
Cash closing balance	**9.3**	**12.9**	**13.0**	**6.5**	**3.0**	**2.8**	**2.8**	**3.1**	**9.1**

Source: Company data, WOOD Research

Appendix 1: glossary

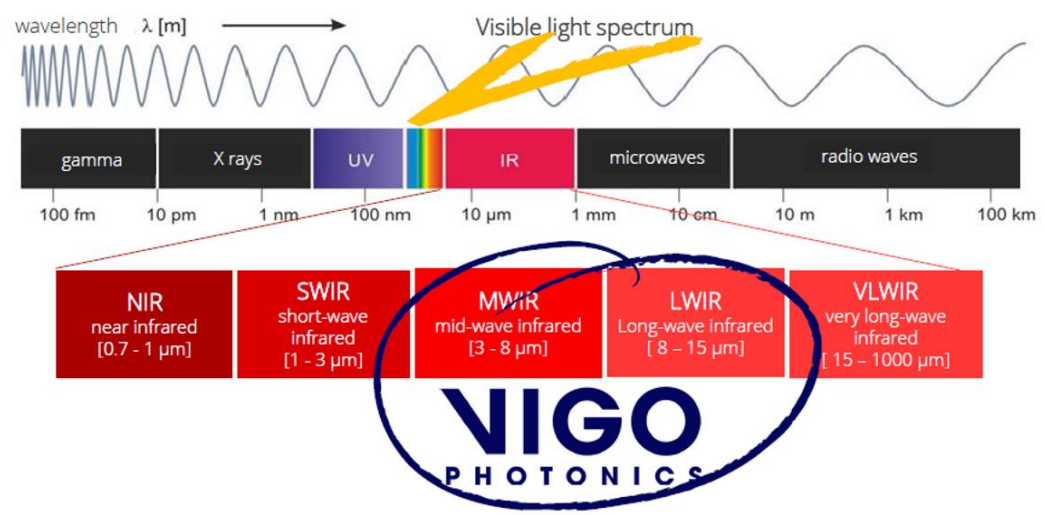
Photonics: photonics is a field of science and engineering that deals with the study and application of light. It involves the use of light (photons) to manipulate, transmit, and store information. Photonics is a multidisciplinary field that draws upon various areas of physics, materials science, electrical engineering, and optics. Photonics has a wide range of applications, including telecommunications, information processing, sensing, imaging, lighting, agriculture, medicine, manufacturing, transportation, and aerospace. Examples of photonics devices include fibre optic cables, lasers, LED lights, photodetectors, and optical filters.

Infrared radiation (IR): a type of electromagnetic radiation, with wavelengths longer than those of visible light, but shorter than those of radio waves. It is invisible to the human eye, but can be detected by specialised sensors and cameras. Infrared radiation is generated by thermal radiation from objects that are at a temperature above absolute zero, which means that almost all objects emit some level of infrared radiation. Infrared radiation is often referred to as "heat radiation", because it is associated with the sensation of warmth. It is used in a variety of applications, including thermal imaging cameras, remote controls, and some types of medical imaging.

Infrared radiation is divided into five categories: near infrared (700 nanometers to 1000 nanometers), short-wave infrared (1-3 micrometers), mid-wave infrared (3-8 micrometers), long-wave infrared (8-15 micrometers) and very long-wave infrared (15-1000 micrometers), based on the range. Near infrared and short-wave infrared radiation are the closest to visible light and are often used in applications such as fibre-optic communication, spectroscopy, and imaging. Mid-infrared radiation is used in applications such as chemical sensing and thermal imaging. Long-wave infrared radiation is associated with thermal radiation from objects at low temperatures and is used in applications such as astronomy and materials science.

VIGO Photonics is focused on IR detectors operating in any wavelength from 2 to 16 µm.

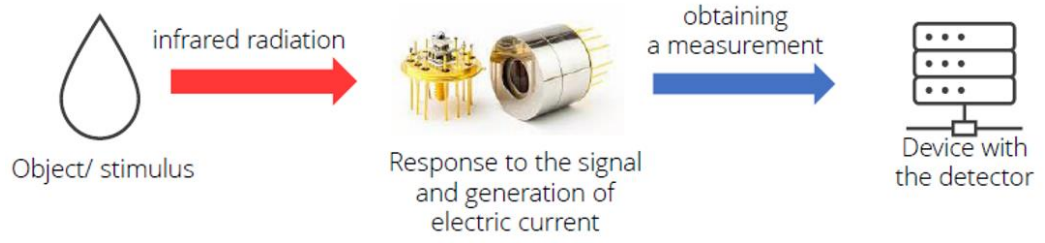
Optical radiation diagram



Source: VIGO Photonics

Infrared detector: an electronic component made up of semiconductors that allows the conversion of infrared radiation energy into an electrical signal. The device is capable of detecting and measuring the levels of infrared radiation emitted by objects in its field of view. Infrared detectors are used in a variety of applications, including remote sensing, thermal imaging, and non-contact temperature sensing.

Simplified general operating diagram of the infrared detector



Source: VIGO Photonics

There are two main infrared detectors categories: thermal, whose operation is based on the use of changes in resistance or voltage as a result of the thermal effect of radiation; and photon, operating as a result of the conversion of radiant energy into thermal energy.

Thermal detectors are typically used for applications that require high sensitivity and low cost, such as non-contact temperature measurement, motion detection, and TV remote controls. Photon detectors are typically used for applications that require high speed and a wide range of detectable wavelengths, such as telecommunications and imaging.

The key differences between thermal and photon infrared detectors are the following:

- **Sensitivity:** thermal detectors typically have higher sensitivity than photon detectors. They can detect very small changes in temperature, which can translate into very small changes in the amount of IR radiation detected. Photon detectors are less sensitive to small changes in radiation, but they can detect a wider range of wavelengths.
- **Response time:** thermal detectors typically have slower response times than photon detectors. This is because it takes time for the detector material to heat up or cool down in response to changes in radiation. Photon detectors can respond more quickly because the interaction of photons with the detector material is faster.
- **Temperature range:** thermal detectors can operate over a wider temperature range than photon detectors. This is because thermal detectors are based on temperature changes, which can occur at very high or very low temperatures. Photon detectors are typically limited to a narrower temperature range.
- **Cost:** thermal detectors are generally less expensive than photon detectors. This is because they are simpler in design and use less complex materials.

Semiconductor materials: materials with a crystalline structure whose electrical conductivity is between conductors (usually metals) and insulators (most ceramic materials). They have the unique property of being able to conduct electricity under certain conditions, such as when exposed to light or heat. Semiconductors are used extensively in electronic devices such as transistors, diodes, and integrated circuits. They are also used in solar cells, light-emitting diodes (LEDs), and other optoelectronic devices. The most commonly used semiconductors are silicon (Si) and germanium (Ge), which are both elements in the periodic table. Other semiconductors, such as gallium arsenide (GaAs) and indium phosphide (InP), are compound semiconductors made from combinations of different elements.

Infrared module: an integrated system containing an infrared photodetector, signal processing electronics, optics, heat dissipation systems and other components. The infrared module provides a complete and compact solution for detecting and measuring infrared radiation, with the added convenience of being ready to use out of the box. An infrared detector is a component that detects infrared radiation, while an infrared module is a packaged assembly of components that includes an infrared detector, along with other components, to provide a complete and convenient solution for detecting and measuring infrared radiation.

Substrates: the crystalline structure on which the proper layers are then grown. In the context of electronics and semiconductor technology, substrates are commonly used as the foundation or base layer for the fabrication of electronic devices. Substrates can be made from a wide range of materials, depending on the specific application. Commonly used substrate materials include silicon, gallium arsenide, sapphire, and various types of glass. In the semiconductor industry, substrates are used to grow thin films of semiconductor materials, such as silicon or gallium arsenide, through a process called epitaxy. The substrate acts as a template or seed for the growth of the semiconductor material. The properties of the substrate, such as its crystal structure and surface finish, can have a significant impact on the quality and properties of the grown semiconductor material.

Epitaxy: a process in which a thin layer of crystalline material is deposited on top of another crystalline material with a matching lattice structure, such that the deposited material takes on the same crystal orientation as the underlying material. In other words, epitaxy is a method for growing a crystal film with a specific crystallographic orientation on a substrate. The process of epitaxy is used extensively in the semiconductor industry to create thin films of materials such as silicon, gallium arsenide, and other compound semiconductors. These films are used in a variety of applications, such as in the production of computer chips, solar cells, and light-emitting diodes (LEDs). During the epitaxy process, the crystal structure of the deposited material aligns with that of the substrate, creating a single crystal structure.

There are several types of epitaxy, including molecular beam epitaxy (MBE), chemical vapor deposition (CVD), and metal-organic chemical vapor deposition (MOCVD). The choice of epitaxy technique depends on the specific material being grown and the desired properties of the resulting thin film.

Epitaxy III-V: epitaxy III-V refers to a process of growing thin layers of materials from the III-V group of elements (such as gallium arsenide, indium phosphide, or aluminium gallium arsenide) on top of a

substrate using a technique called epitaxy compared to I-II group elements (such as zinc sulfide or cadmium selenide).

Epitaxy III-V is commonly used in the semiconductor industry to create high-performance electronic and optoelectronic devices such as transistors, solar cells, LEDs, and laser diodes. The III-V materials offer several advantages over traditional silicon-based devices, including higher electron mobility, higher carrier concentration, and a wider bandgap, which allows them to operate at higher frequencies and temperatures.

By controlling the thickness and composition of the epitaxial layers, engineers can create complex structures with precise electrical and optical properties, which are essential for many advanced electronic and optoelectronic devices. Epitaxy III-V has enabled the development of many technologies, including high-efficiency solar cells, high-speed transistors, and high-brightness LEDs.

MCT detectors: MCT stands for Mercury Cadmium Telluride, which is a compound semiconductor material that is commonly used in the fabrication of infrared detectors. MCT detectors are a type of photoconductive detector that operates by converting incident infrared radiation into electrical current. MCT detectors have several advantages over other types of infrared detectors, such as high sensitivity, fast response time, and wide spectral range. They can detect radiation in the mid-wave infrared (MWIR) and long-wave infrared (LWIR) regions of the spectrum, which makes them suitable for a wide range of applications, such as thermal imaging, remote sensing, and spectroscopy.

RoHS: the Restriction of Hazardous Substances (RoHS) regulations restrict the use of certain hazardous substances in electronic products, including semiconductor devices. The substances covered by RoHS include lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBBs), and polybrominated diphenyl ethers (PBDEs). The goal of RoHS is to reduce the environmental and health hazards associated with these substances. The impact of RoHS on the semiconductor market has been significant. The regulations have forced semiconductor manufacturers to find alternative materials and manufacturing processes that are free from the restricted substances. This has led to the development of new materials and processes that are more environmentally friendly and less hazardous to human health.

Infrared array: an infrared array is a type of infrared detector that consists of an array of individual detector elements, each of which can detect infrared radiation in a specific wavelength range. The individual detector elements are typically arranged in a regular pattern, such as a square or rectangular grid, and are often fabricated using semiconductor manufacturing techniques.

Infrared arrays can be used in a variety of applications, including thermal imaging, gas detection, and spectroscopy. By detecting the infrared radiation emitted or absorbed by a sample, infrared arrays can provide information about its temperature, chemical composition, and other properties.

The performance of an infrared array is typically characterised by parameters such as its sensitivity, spatial resolution, and spectral range. In recent years, advances in infrared array technology have led to the development of high-performance detectors that are capable of detecting infrared radiation with high sensitivity and resolution, opening up new possibilities for applications such as medical imaging, environmental monitoring, and industrial process control.

VCSEL: Vertical-Cavity Surface-Emitting Laser. It is a type of semiconductor laser diode that emits light perpendicular to the surface of the wafer, as opposed to edge-emitting lasers that emit light parallel to the surface. VCSELs are commonly used in applications such as optical communication networks, sensing, and computer mice. They offer advantages such as low power consumption, high modulation rates, and ease of fabrication. They also have a circular output beam, which makes them easier to couple with optical fibres or other optical components.

Laser spectroscopy: a field of science that uses lasers to study the properties of matter. It involves using laser light to excite atoms, molecules, or solid-state materials and then analysing the resulting light emitted or absorbed by the sample. By studying the interaction between light and matter, laser spectroscopy provides information on the structure, composition, and dynamics of materials at the atomic and molecular level. Laser spectroscopy has applications in such as chemistry, physics, materials science, and biology.

ICL: Interband Cascade Laser technology, which is a type of semiconductor laser used in the mid-infrared wavelength range. ICL technology is based on a unique cascading design of multiple quantum wells, which allows for efficient and low-threshold operation in the mid-infrared region. This technology enables the development of compact, high-performance mid-infrared sources that can be used in a wide range of applications, such as sensing, spectroscopy, and medical diagnostics. The mid-infrared wavelength range is particularly useful for sensing and imaging applications because it can provide information about the chemical composition of materials, including gases and liquids.

QCL: Quantum Cascade Laser technology, a type of semiconductor laser used in the mid-infrared wavelength range. QCLs are made up of multiple layers of semiconductor materials, each layer only a few nanometers thick. The layers are carefully engineered to allow for the efficient and controllable movement of electrons through the structure, resulting in the emission of mid-infrared light. QCL technology has several advantages over other mid-infrared sources, such as ICLs. QCLs can be designed to emit at a wide range of wavelengths in the mid-infrared region, providing access to a broad range of chemical information. They also have high power output and can be operated at room temperature, making them more practical for many applications. QCLs have many potential applications, including trace gas sensing, medical diagnostics, and defence and security.

MIRLED: Mid-Infrared Light Emitting Diode, a type of semiconductor technology that allows for the efficient emission of mid-infrared (MIR) light from a light-emitting diode (LED). Traditionally, LEDs have been limited to emitting light in the visible or near-infrared (NIR) regions of the electromagnetic spectrum. However, MIRLED technology has been developed to extend the emission of LEDs into the MIR region. This is achieved by using new semiconductor materials and device structures that can efficiently emit light in the MIR region. MIRLED technology has several advantages over other MIR sources, such as QCLs and ICLs. MIRLEDs are compact and low-cost, making them suitable for portable and handheld devices. They are also more energy-efficient than other MIR sources, which can help to extend battery life in portable devices. On the other hand, MIRLED's output power and wavelength coverage are currently more limited than QCLs and ICLs. MIRLEDs have many potential applications, including chemical sensing, biomedical imaging, and environmental monitoring.

Appendix 2: peers descriptions

Hamamatsu Photonics is a leading global manufacturer of advanced photonic devices and systems, founded in 1953 in Hamamatsu, Japan. It offers devices for the generation and measurement of visible, infrared, and ultraviolet light. These devices include photomultipliers, photodiodes, infrared detectors, image sensors, scientific cameras, and light sources. The company also manufactures x-ray detectors and sources, as well as specialised photometric systems for semiconductor manufacturing, pharmaceutical development, non-destructive inspection, and academic research. Hamamatsu Photonics serves customers in more than 100 countries worldwide. In 2022, it generated revenues of almost USD 1,676m.

Teledyne Technologies was founded in 1960 and is headquartered in Thousand Oaks, California, providing electronic subsystems and instrumentation. Its products include digital imaging sensors, cameras and systems within the visible, infrared and X-ray spectra, monitoring and control instrumentation for marine and environmental applications, harsh environment interconnects, electronic test and measurement equipment, aircraft information management systems, and defence electronics and satellite communication subsystems. It also supplies engineered systems for defence, space, environmental and energy applications. In 2022, it generated revenues of almost USD 5,459m.

Coherent Corp is a global leader in materials, networking, and lasers for the industrial, communications, electronics, and instrumentation markets. The company is headquartered in Saxonburg, Pennsylvania. It was founded in 1971, to manufacture high-quality materials and optics for industrial lasers. Today, the company operates in more than 20 countries around the world.

IPG Photonics, founded in 1991, is a developer and manufacturer of high-performance fibre lasers and amplifiers, used in materials processing, communications, entertainment, medical, biotechnology, scientific and advanced applications, with many new products displacing traditional technologies. IPG operates globally, with manufacturing facilities in the US, Germany, Russia and Italy, and regional sales offices in China, Japan, Korea, Taiwan, India, Turkey, Brazil, Mexico, Singapore, Spain, Poland, the Czech Republic, Canada, and the United Kingdom.

OPTEX, founded in 1979, manufactures and markets infrared sensors used for security system, automatic doors, industrial automation, factory automation and environmental control. The company's products include passive infrared sensors, photoelectric sensors, and automatic transparency measurement systems.

NIPPON CERAMIC develops, manufactures, and sells various types of ultrasonic sensors and pyroelectric infrared sensors. The company also produces ferrite cores and gas sensors. Nippon Ceramic operates production facilities in Japan, the UK, and China, and markets its products in China, the UK, and the US.

Focused Photonics Hangzhou Incorporation develops, produces and sells instrumentations for environmental monitoring, industrial process analysis and safety monitoring. The company's main products are environmental monitoring systems, digital environmental protection information systems, industrial process analysis systems and security monitoring systems.

Visual Photonics Epitaxy, founded in 1996, with its HQ in Taiwan, develops, produces, and markets semiconductor epitaxy wafers, LEDs, photodetectors, and other optoelectronic devices, which are used in a variety of industries, including automotive, telecommunications, and consumer electronics.

Amphenol Corporation designs, manufactures, and markets electrical, electronic and fibre optic connectors, interconnect systems, and coaxial and flat-ribbon cable. The company's products are used in a variety of industries, including telephone, wireless, and data communications systems, cable television systems, and commercial and military aerospace electronics.

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