

# Photonics in Europe



## Economic Impact





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**Photonics** is driving innovation in Europe. This bold statement is based on the findings presented in this market study “Photonics in Europe”. It spotlights the enormous competitive potential of photonics that has already enabled progress in communications, entertainment, healthcare, manufacturing, environmental sensing, lighting and biosciences, to name but a few. It reveals just how crucial photonics is for the future

economic development of the European Union. “Photonics in Europe” headlines some key indicators about the current state of Europe’s Photonics industry.

These include:

- The revenue of the European photonics industry grew by 12% to 49 billion in 2006. European photonics production is now equivalent to that of microelectronics in Europe and is expected to exceed it soon, underlining how important photonics is for Europe’s overall economy.
- Photonics employs 246,000 people in Europe, not including subcontractors. Well over 5,000 companies are involved in manufacturing of photonics, most of them small and medium-sized enterprises.
- Europe has 19% of the overall worldwide photonics production volume and leads in many key sectors such as lighting, measurement and automated vision, production technology, medical technology and life sciences, defence photonics and optical components and systems. In these areas the European share ranges from 25% to 45%.

For the period 2005 to 2015, the study predicts an annual growth rate of 7.6% for the world photonics market.

Europe is in a strong position in many other areas of photonics, including vital technologies for the future such as advanced high efficiency lighting and photovoltaic energy production. We need to make sure that we exploit these strengths and capitalise on the competitive advantage photonics offers us. Mastering disruptive photonic technologies will give us the opportunity to regain leadership in other application areas such as displays.

To do this we need a strong coordinated effort by all the relevant players, at European and national level. We also need to ensure close cooperation between the research community and industry. Although Europe has already made great progress in the last few years with the European technology platform Photonics<sup>21</sup> playing a significant role, there are still many challenges and much work to be done.

*Viviane Reding,  
European Commissioner for Information Society and Media*

The study in hand was inspired by a survey on the photonics market in Germany which was published in September 2007 by the German Federal Ministry of Education and Research. Optech Consulting, and the European Commission together with Photonics21 have taken the initiative to have this market study extended to cover all of Europe.

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# Summary

The European photonics industry accounted in 2005 for revenues of EUR 43.5 billion<sup>1,2</sup>. The industry sector employs 246 000 persons in Europe, not including employment with subcontractors.

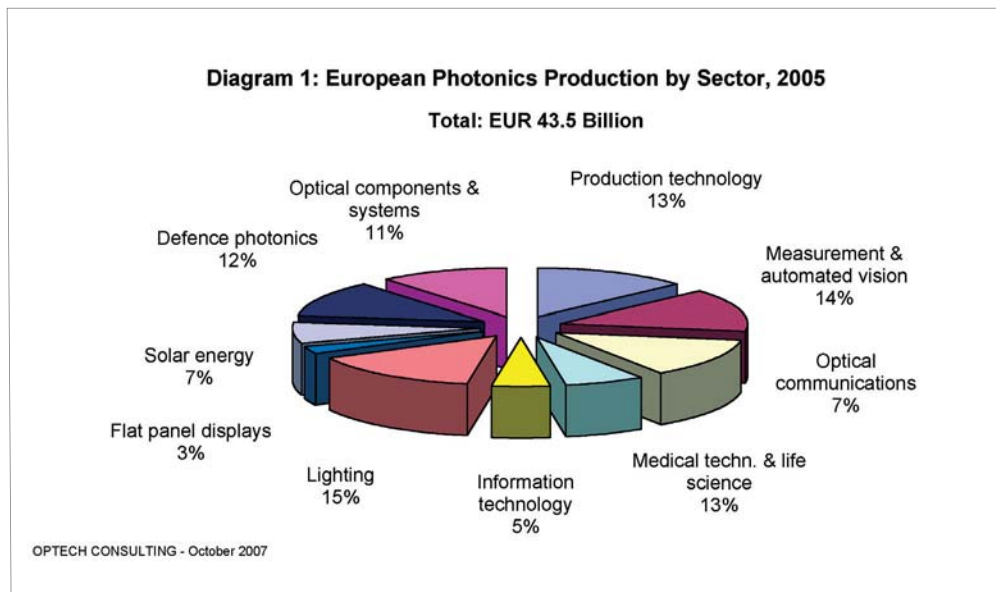
In 2006, revenues increased to about EUR 49 billion, corresponding to a growth rate of 12%. The growth is substantially higher than the GDP growth of 3% (nominal growth 5%) for the EU25 countries [2]. Photonics is a growth industry.

**Table 1: Photonics Sectors and Segments**

<b>Production Technology</b> Laser Materials Processing Systems Lithography Systems (IC, FPD, Mask) Lasers for Production Technology Objective Lenses for Wafer Steppers	<b>Lighting</b> Lamps LEDs OLEDs
<b>Optical Measurement and Machine Vision</b> Machine Vision Systems and Components Spectrometers and Spectrometer Modules Binary Sensors Meas. Systems for Semiconductor Industry Meas. Systems for Optical Communications Meas. Systems for Other Applications	<b>Flat Panel Displays</b> LCD Displays Plasma Displays OLEDs and Other Displays Display Glass and Liquid Crystals
<b>Medical Technology and Life Science</b> Lenses for Eyeglasses and Contact Lenses Laser Systems for Medical Therapy and Cosmetics Endoscope Systems Microscopes and Surgical Microscopes Medical Imaging Systems (only Photonics-Based Systems) Ophthalmic and Other in Vivo-Diagnostic Systems Systems for In-Vitro-Diagnostics, Pharmac. & Biotech R&D	<b>Solar Energy</b> Solar Cells Solar Modules
<b>Optical Communications</b> Optical Networking Systems Components for Optical Networking Systems	<b>Defence Photonics</b> Vision and Imaging Systems, Including Periscopic Sights Infrared and Night Vision Systems Ranging Systems Munition / Missile Guiding Systems Military Space Surveillance Systems Avionics Displays Image Sensors Lasers
<b>IT: Consumer Electronics, Office Automation, Printing</b> Optical Disk Drives Laser Printers and Copiers, PODs, Fax and MFPs Digital Cameras and Camcorders, Scanners Barcode Scanners Systems for Commercial Printing Lasers for IT Sensors (CCD, CMOS)	<b>Optical Systems and Components</b> Optical Components and Optical Glass Optical Systems ("Classical" Optical Systems) Optical & OE Systems & Components Not Elsewhere Classified

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- 1 This comprises the revenues of production plants located in Europe, whether owned by Europe or overseas headquartered companies. Revenues of production plants outside Europe are not included.
- 2 The base year of the present report is 2005. That year has been chosen because a detailed report on Germany "Optische Technologien – Wirtschaftliche Bedeutung in Deutschland" [1] also uses the base year 2005. That report forms an important database for the present analysis.



Photonics is a cross-sectoral technology, which comprises ten sectors, and more than 40 major product segments (Table 1). Diagram 1 shows the breakdown of European Photonics production volume by the ten sectors.

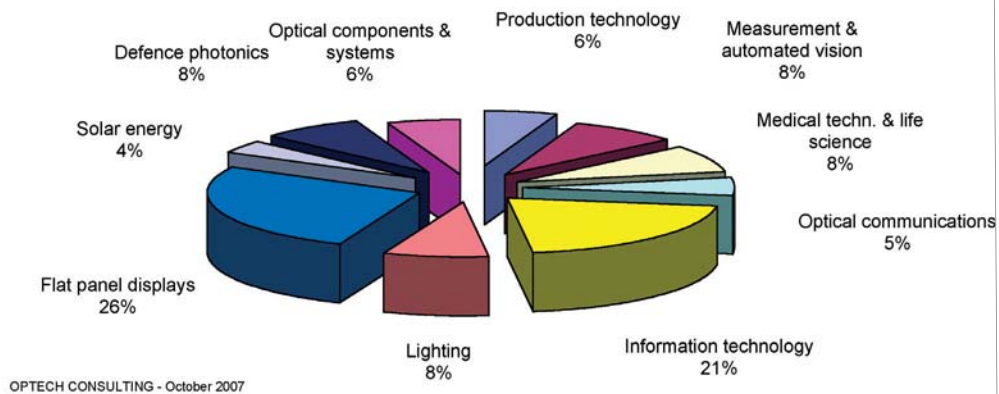
Six sectors account for a share of more than 10% of the total European production volume: lighting (15%), measurement & automated vision (14%), production technology (13%), medical technology & life science (13%), defence photonics (12%), optical components & systems (11%). The other four sectors account for a share of less than 10%: optical communications (7%), solar energy (7%), information technology (5%), flat panel displays (3%).

The world market for Photonics accounted in 2005 for EUR 228 billion<sup>3</sup>. The segmentation of the world market differs from the segmentation of the European production volume. Notably, the sectors of flat panel displays and information technology dominate in the world market (Diagram 2).

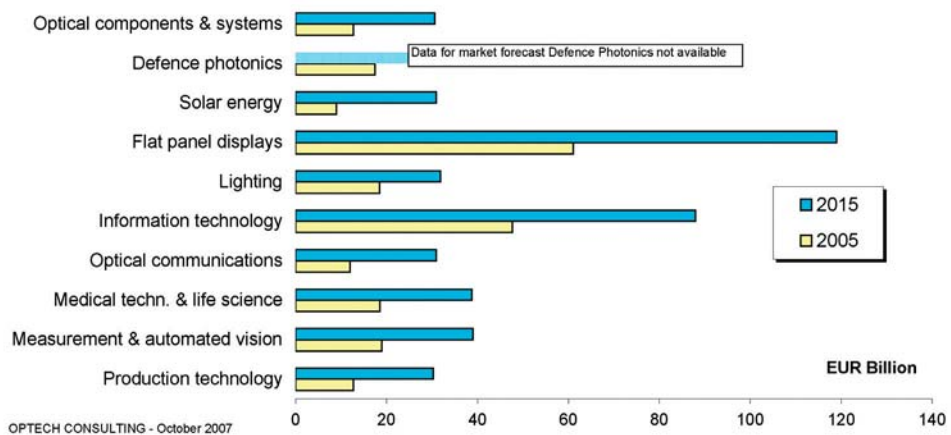
<sup>3</sup> In the report "Optische Technologien – Wirtschaftliche Bedeutung in Deutschland" [1] the world market is estimated at EUR 211 billion. The difference is mainly due to the defence photonics sector, which is not included in the report on Germany.

**Diagram 2: Photonics World Market by Sector, 2005**

Total: EUR 228 Billion

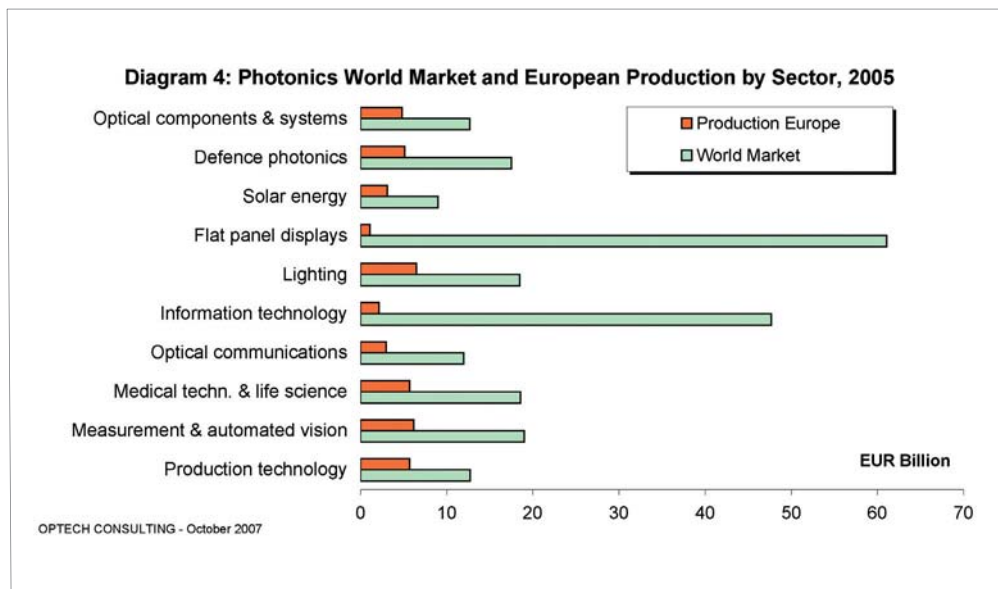


**Diagram 3: Photonics World Market, Forecast**



An average annual growth rate of 7.6% is expected for the Photonics world market for the ten years period of 2005 through 2015 [1]<sup>4</sup>. The highest growth rate (13.2%) is expected for the solar energy sector (Diagram 4). Demand in that sector is mainly determined by the size of legal incentives. Strong growth of 9% to 10% per year is also expected for the sectors of production technology, optical components & systems, and optical communications. Growth for the sectors of measurement & automated imaging, medical technology & life science, information technology, and flat panel displays is expected at 6% to 7% annually, while 5.5% is expected for the lighting sector.

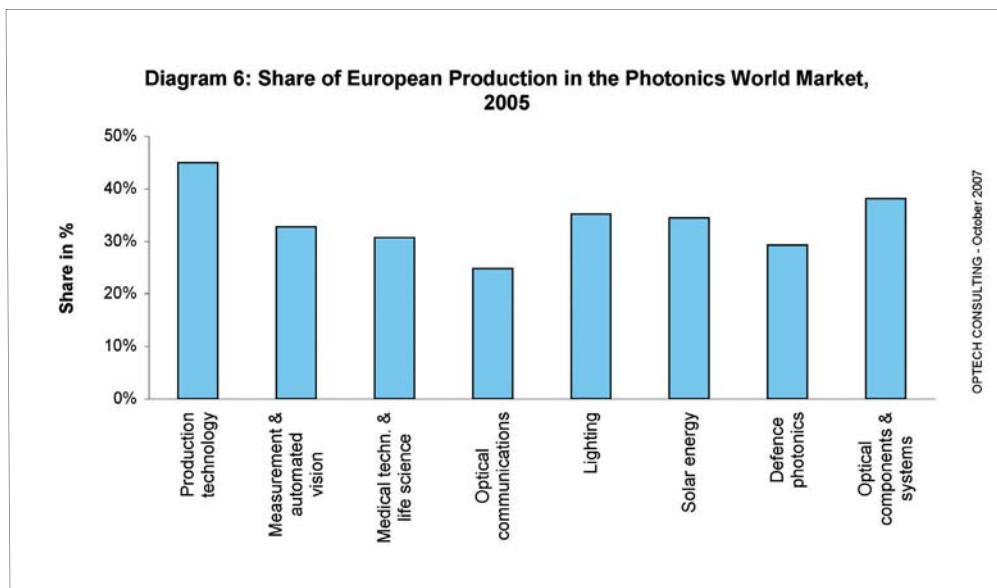
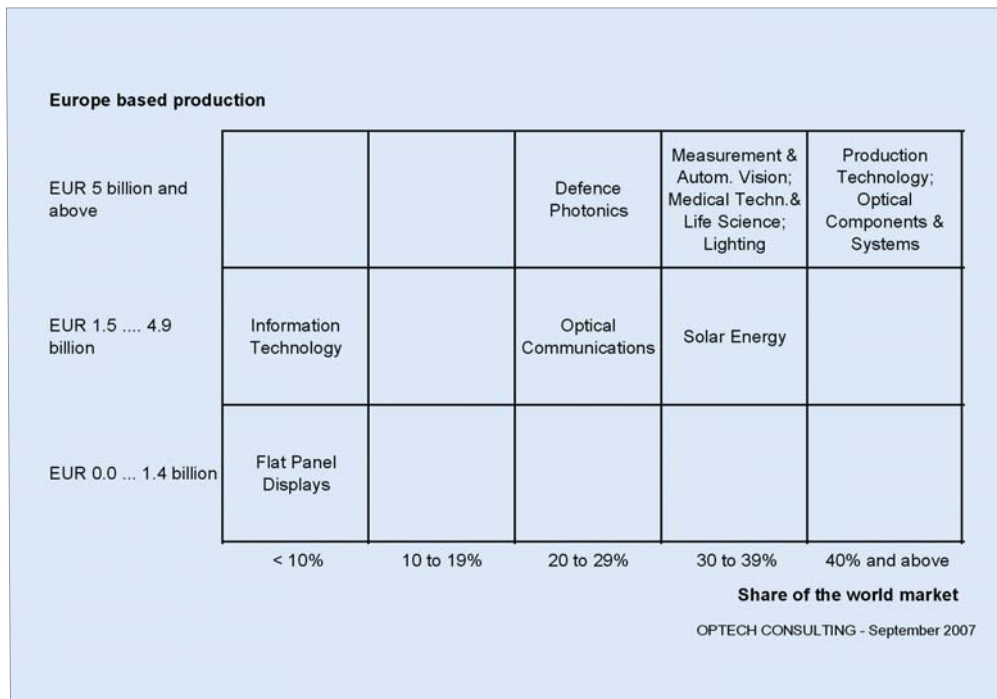
The European production volume of EUR 43.5 billion corresponds to 19% of the world market<sup>5</sup>. The European industry has a weak position in the sectors of information technology and flat panel displays (Diagram 4 and Diagram 5). For Photonics without information technology and flat panel displays, the European share in the world market is in average 35%, and ranges from 25% to 45% for the single sectors (Diagram 6).

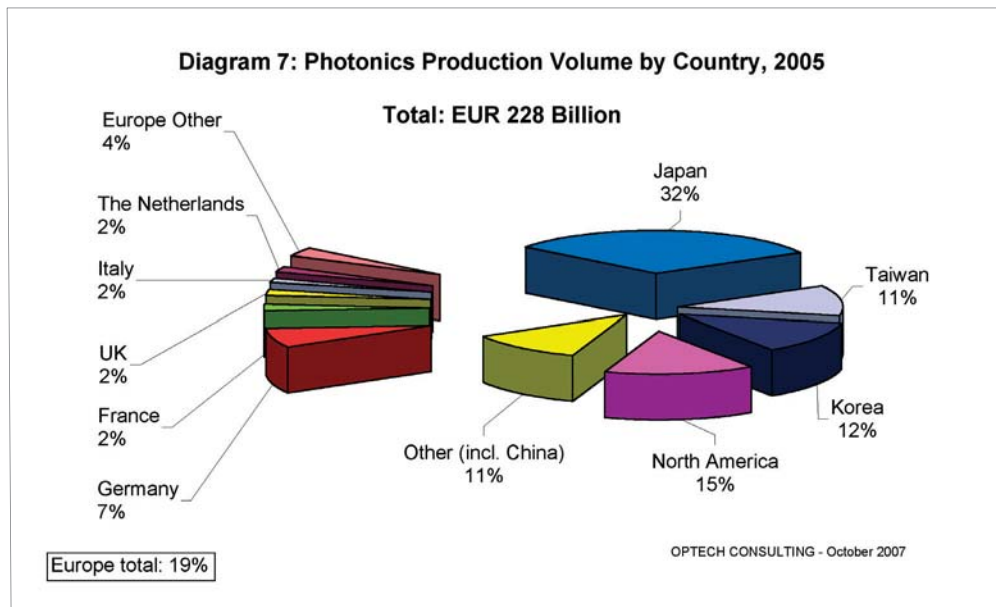


<sup>4</sup> The growth rate refers to the Photonics world market excluding the defence photonics sector, for which no market forecast data was available.

<sup>5</sup> Note that "European revenues" include products, parts and service, while the world market includes products only. For details see the Appendix on methodology and definitions.

**Diagram 5: Photonics by Sector, European Production Volume and Share in the World Market**





The Photonics world market is larger than the semiconductor world market, which accounted for a volume of EUR 200 billion (USD 247.7 billion) in 2006, according to the Semiconductor Industry Association (SIA). Also, the Photonics market grows faster than the semiconductor market (according to SIA, the USD-based average annual growth rate of the semiconductor market from 1996 to 2006 was 6.5%). The European production volume in Photonics (EUR 43.5 billion) is larger than for semiconductors (estimated at EUR 30 billion corresponding to a share 15% of the worldwide production). Although the two markets are not fully comparable<sup>6</sup> the data underlines the growth dynamics of the Photonics market, and its importance for the European economy.

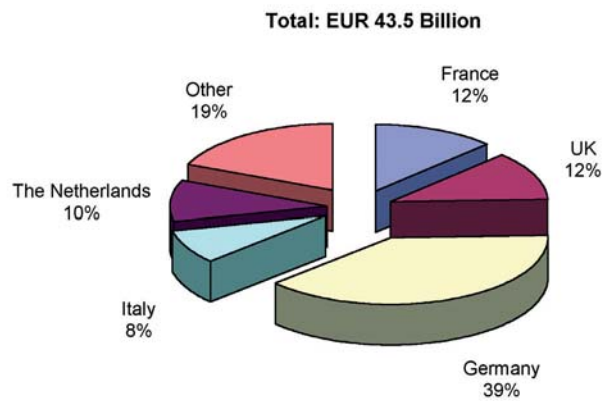
Diagram 7 shows the production volume by country<sup>7</sup>. Europe accounts for 19% of the worldwide production volume. Photonics production is dominated by Asia, notably Japan, Korea, and Taiwan. China is catching up, hosting production facilities of overseas producers and Electronic Manufacturing Services (EMS). Also locally owned companies in China play an increasing role. North America hosts an estimated 15% of the worldwide production volume<sup>8</sup>.

<sup>6</sup> The semiconductor market comprises components only, while the Photonics market comprises components and systems, i.e. a higher level of integration.

<sup>7</sup> For the European countries, the revenues of the production facilities in these countries are included, comprising products, parts and service (see Appendix on methodology and definitions).

<sup>8</sup> The estimate of the North American production volume is complicated by the fact that American companies have outsourced a large amount of manufacturing to subsidiaries abroad and EMS.

**Diagram 8: Photonics, European Production Volume by Country, 2005**



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Germany accounts for 39% of the European production volume (Diagram 8). France and the UK follow with 12%, each, the Netherlands with 10%, and Italy with 8%. The other countries account for the balance of 19%. Among these Switzerland accounts for the largest volume, followed by Spain. It should be noted that the share of the countries varies substantially by sector and product. Per capita, the Netherlands account for the largest Photonic production volume, followed by Germany and Switzerland.

A detailed analysis, as given in the following chapters of this report, shows that the single regions and countries in Europe are focused on parts of the Photonics product spectrum. One reason for this is specialization, emerging e.g. from industry history. Other factors are labour content of the products, and labour cost of the region. Countries with low labour cost often host high volume manufacturing, involving a substantial amount of manual work. This includes manufacturing and assembly plants operated by large companies headquartered elsewhere. Countries with high labour cost preferably host the manufacturing of high value-added products, involving a small amount of manual work.

Overall, the number of companies in Photonics manufacturing in Europe is estimated to well exceed 5,000. Several of the Photonics sectors are dominated by a few, large producers. This is true for the sectors of lighting, production technology, communications, and defence photonics. Note that also in these sectors SME add to the European production. In other sectors, both large companies and SME contribute to a substantial extent to the production volume, e.g. in the sectors of medical technology & life science, solar energy, and optical systems & components. The sector of measurement & automated vision is dominated by SME, with a limited contribution of large companies.

During the discussions for this report the question was raised if the European Photonics industry is too fragmented. As for many other questions the answer needs differentiation between the sectors and product segments. In some product areas the European industry is more fragmented than the counterparts in Japan and North America. This is true e.g. for the sector of solar energy. Also, in the segment of spectrometers large units have emerged in Japan and in the USA, while the units in Europe are smaller. The solar energy sector is in the phase of rapid growth, while the spectrometer segment is mature. It is also important to note that some segments are fragmented worldwide, such as automated vision. One advantage of larger companies is their competitiveness in the rapidly growing overseas markets e.g. in Asia.

The analysis for the present report has been focused on the present status of the European Photonics industry. Data on the world market and market forecast has been taken from the detailed report on Germany [1]. That report analyzes many additional issues, including employment, employment forecast, export volumes, and R&D quotas for Germany. Technology issues are dealt with in the Photonics21 Agenda [3]. The set of data leads to noteworthy aspects, the discussion of which is beyond the scope of this report.

# 1. European Photonics by Sector

## 1.1 Production Technology

### Segments and major products

- Lithography
  - Wafer steppers
  - Laser mask writers
  - Projection scanners for flat panel displays
  - Objective lenses for wafer steppers
  - Lasers for wafer steppers
- Laser materials processing
  - Machines / systems
  - Lasers

### European industry and world market

The European industry holds a strong position in the sector of production technology, with a production volume of EUR 5.8 billion. This compares to a worldwide market volume of EUR 12.8 billion<sup>9</sup>.

**Table 1.1/1: Production Technology –  
World Market and Revenues of the European Industry, 2005**  
in EUR billion

	World market	Revenues European industry
Lithography	6.8	> 3
Laser Materials Processing	6.0	~ 2.5
<b>Total</b>	<b>12.8</b>	<b>~ 5.8</b>

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In the lithography segment European companies have a strong position regarding wafer steppers (ASML), and objective lenses for the wafer steppers (Zeiss). Further products include laser mask writers (Micronic and other European companies). The European industry is not involved in the segment of projection scanners for flat panel displays. Also, it is not involved in excimer lasers for wafer steppers.

<sup>9</sup> Note that the production volume includes parts and service, while the world market refers to products only.  
For further details please refer to the Appendix on methodology and definitions.

Laser materials processing comprises the subsegments of

- Macro processing (mainly including cutting, welding, and marking).
- Micro processing (processes for manufacturing of semiconductors, flat panel displays, printed circuit boards, solar cells).

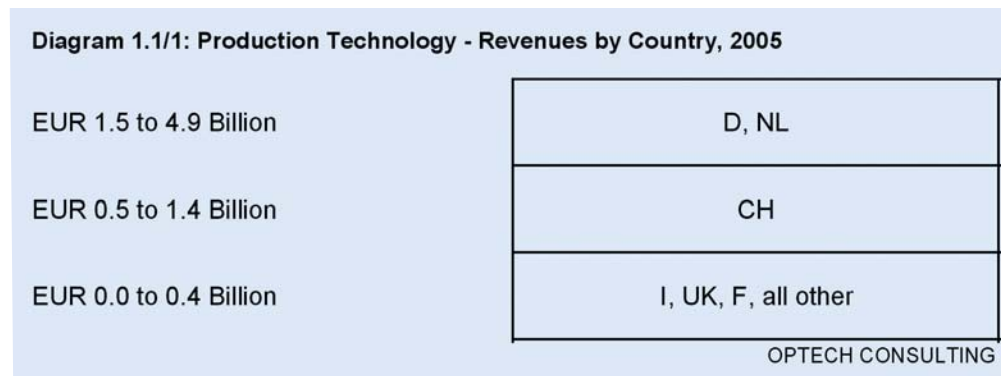
In the larger segment of macro processing European companies have a worldwide leading position regarding systems and lasers [4]. In the segment of micro processing companies from North America and Japan dominate. In the emerging field of solar cell processing European manufacturers are well positioned.

#### Production volume by country

Diagram 1.1/1 shows the production volume (EUR billion) in the sector of production technology in Europe.

Lithography: The Netherlands are home to ASML, the world market leader for wafer steppers. Revenues of ASML accounted for ~ EUR 2.5 billion in 2005 [5]. The objective lenses for the ASML wafer steppers are manufactured by Zeiss, Germany [6]. Further activities include laser mask writing systems (Micronic of Sweden [7]), as well as minor activities for laser writing systems by companies in Germany.

Laser materials processing: Germany accounts for about half of the European production volume (systems and lasers). The next largest manufacturer is Switzerland, followed by Italy [4].



#### Structure of European industry

In the production technology sector the major three companies account for more than 50% of the production volume, the major ten companies account for more than 80%. The number of smaller companies exceeds 100.

**Table 1.1/2: Production Technology – Structure of the European Industry, 2005**

Revenue class *)	Companies (major countries of production)	Total revenues in EUR billion
> EUR 500 Mio	ASML (NL), Trumpf (D, CH), Zeiss (D)	3 ... 4 **)
EUR 50 ... 500 Mio	< 10 companies: Rofin Sinar (D), Bystronic (CH), Prima Industry (I), Jenoptik (D), Micronic (S); examples, list not complete	1 ... 2
< EUR 50 Mio	> 100 companies	< 1
<b>Total</b>		<b>5.8</b>

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\*) Not including revenues of manufacturing facilities outside Europe.

\*\*) Precise estimate not given for confidentiality reasons.

## 1.2 Measurement & Automated Vision

### Segments and major products

- Automated vision
  - Systems (incl. Software)
- Components: cameras, illumination, etc.
  - Measurement
  - Binary sensors
  - Measurement systems
  - Measurement systems for the semiconductor industry
  - Measurement systems for optical networking
  - Spectrometers and spectrometer modules
  - Measurement systems for construction industry, geodetic measurement systems
  - Other measuring systems: for geometry, dynamics, particles, etc.

### European industry and world market

The world market accounts for a volume of EUR 18.9 billion, with contributions from automated vision (EUR 6.7 billion)<sup>10</sup>, binary sensors (EUR 5.2 billion), and other measurement systems (EUR 7.0 billion).

<sup>10</sup> Note that the 2005 world market for automated vision is estimated at EUR 6.7 billion due to new information. I.e. the former estimate of EUR 7.4 billion [1] has been revised downward by about 10%, mainly due to a reduced estimate for Europe.

The share of the European industry in the world market is about 42% (binary sensors), 30% (automated vision), and 34% (other measurement systems). European companies are well represented in the sub-segments of geometrical & dynamic measurement, and geodetic measurement / measurement in the construction sector. The representation is weaker in the subsegments of spectrometers, and weak in the area of measurement systems for the semiconductor industry and measurement systems for optical networking.

**Table 1.2/1: Measurement & Automated Vision –  
World Market and Revenues of European Industry, 2005**  
in EUR billion

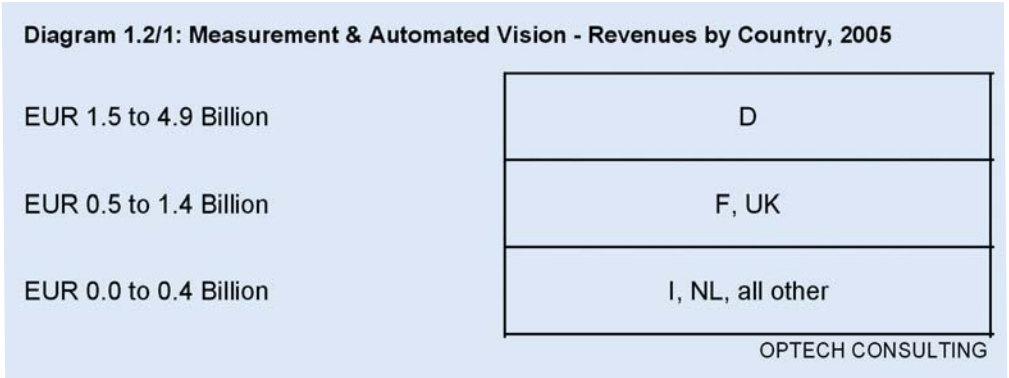
	World market	Revenues European industry
Automated vision systems and components	6.7	2.0
Binary sensors	5.2	2.2
Other measurement systems	7.0	2.4
<b>Total</b>	<b>18.9</b>	<b>6.6</b>

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**Production volume by country**

In the segment of automated vision Germany holds a share of ~50% of the European production. Further regions with major production are France, the UK, Italy, the Benelux, and Scandinavia.

In the segment of binary sensors Germany dominates with a two third share of European production, followed by France.



For the other measurement systems the German share is estimated at 29%, with activities in the area of spectrometers and optical measuring systems for geometry and dynamics. Major activities in other European countries include spectrometers (France, UK), and measurement systems for the construction industry / geodetic measurement systems (Switzerland and other). The, relatively weak, European activities in the area of measurement systems for the semiconductor industry are located in France and Germany.

#### Structure of European industry

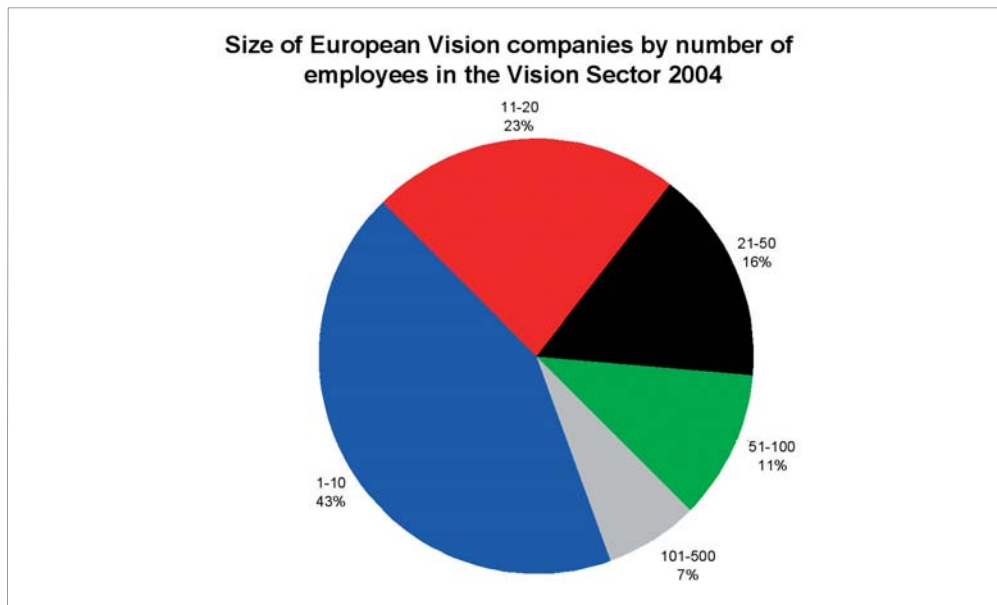
There are about 10 companies with revenues exceeding EUR 100 million, making up for a total of about EUR 2.5 billion. These bigger companies are mainly active in the segments with standard products, such as e.g. binary sensors and spectrometers.

The majority of the companies, however, accounts for revenues of less than EUR 100 million, and most of them for much less than that amount. The revenues of these more than 1,000 companies add up to ~EUR 4 billion.

For the automated vision segment, company size in Europe has been analyzed by the EMVA (European Machine Vision Association) [8]. The data in Diagram 1.2/2 below is based on 80 companies from 16 countries reporting to the EMVA statistics. The companies all have less than 500 employees working in the area of automated vision. Some of the major companies are public (e.g. Basler, Isra, and Viscom in Germany). The annual sales of major European automated vision companies are in the range of EUR 50 million.

**Diagram 1.2/2: European Automated Vision Companies by Size**

Source: European Machine Vision Association (EMVA)



**Table 1.2/2: Measurement & Automated Vision – Structure of the European Industry, 2005**

Revenue class	Number of companies	Companies in EUR billion	Total revenues
> EUR 50 Mio	~ 20	see text	~ 2.5
< EUR 50 Mio	> 1000		~ 4
<b>Total</b>			<b>6.6</b>

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In the segment of binary sensors leading companies achieve annual sales exceeding EUR 100 million. In addition, there are many smaller companies in the segment. Note that many companies in the binary sensor segment also produce related products such as automated vision systems and other (optical) sensors and measuring systems. European manufacturers include Sick (D), Siemens (D), Balluf (D), Leuze (D), IFM (D), and Automelec (F).

In the segments of spectrometers, as well as measurement systems for semiconductor manufacturing, and measurement systems for fibre optic networking, big companies dominate on a worldwide scale. The world market leaders are located outside Europe, and the size of the activities in Europe is small to medium size.

In the segment of other optical measuring system (for geometry, dynamics, particles, etc.), small companies dominate. The biggest companies in this segment typically account for revenues in the range of a few ten million Euros.

## 1.3 Medical Technology & Life Science

### Segments and major products

The segment of medical technology comprises medical therapeutic systems, and diagnostic systems for invivo and invitro diagnostics. The segment of life science includes R&D systems, and especially systems for drug development (pharmaceutical and biotech R&D).

Major products include:

- Endoscopes and accessories
- Spectacle lenses and contact lenses
- Therapeutic laser systems
- Medical imaging systems: CR systems (computed radiography), DR systems (digital radiography), fluorescence diagnostics systems, optical coherence tomography systems, other diagnostic systems for ophthalmology. Not included are non-photonic medical imaging systems such as Xray and NMR systems.
- Microscopes and surgical microscopes
- Capillary electrophoresis systems, DNA sequencers, cell sorters
- Plate and array readers

Note that pulse oximetry systems are not included in this report as their photonic content is small.

### European industry and world market

The revenues of European companies of EUR 5.7 billion correspond to 33% of the world market. The European market share is especially high in the segments of microscopes (nearly 50%). The European market share is about 35% in the segments of spectacle lenses / contact lenses. In all other segments the European market share is under 30%, e.g. for endoscopes and therapeutic laser systems. It is lower than 20% for in-vitro diagnostic systems (e.g. plate and array readers, capillary electrophoresis systems, DNA sequencers, cell sorters), and for medical imaging systems (CR and DR).

**Table 1.3/1: Medical Technology & Life Science –  
World Market and Revenues of European Industry, 2005**  
in EUR billion

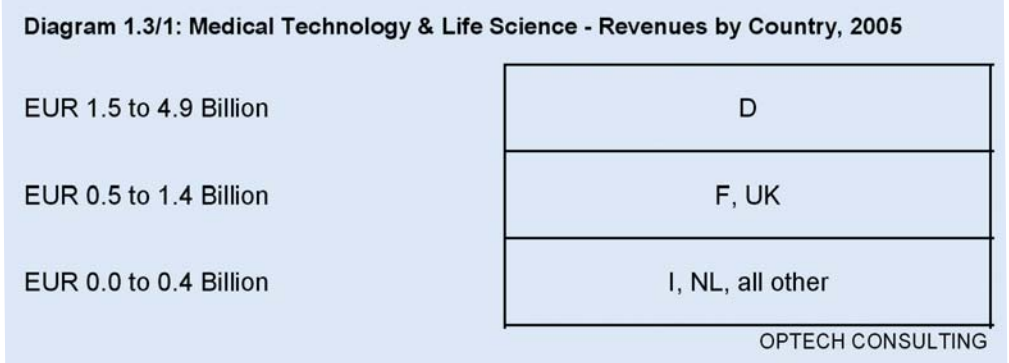
	World market	Revenues European industry
Spectacle lenses and contact lenses	7.8	2.7
Other	9.7	3.0
<b>Total</b>	<b>17.5</b>	<b>5.7</b>

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**Production volume by country**

Spectacle lenses / contact lenses, with EUR 2.7 billion, account for nearly half of the European production volume. The major producers are Germany, the UK, and France. Note that the world market leader, Essilor, is headquartered in France. However, Eurostat data suggests that Essilor’s production facilities are to a substantial extent located in other countries. Spectacle lenses / contact lenses are also produced in Italy, the Netherlands, and to a smaller extent in several other European countries.

Microscopes / surgical microscopes are the next important European products. The dominating producer is Germany. Surgical microscopes are also produced in Switzerland. Therapeutic laser systems are mainly produced in Germany (ophthalmic systems) and Italy. Endoscopes are mainly produced in Germany (Eurostat: EUR 324 million; note that the present report includes accessories (cameras, video documentation systems). Small quantities of endoscopes are also produced in the UK, Bulgaria, Hungary, Poland, Lithuania and Estonia.



Overall, Germany accounts for about 50% of the European production volume in the sector. Microscopes, endoscopes, and spectacle lenses / contact lenses are the major products. Smaller contributions originate from medical imaging systems, ophthalmic diagnostic systems, and therapeutic medical laser systems.

The UK accounts for a 14% share. The major products are spectacle lenses / contact lenses. Spectacle lenses / contact lenses are also the major product of France, which accounts for 11% of the European production volume. Other important producers are Switzerland (surgical microscopes, analytical systems) and Italy (spectacle lenses / contact lenses, medical laser systems).

### Structure of European industry

Major manufacturers in Europe are Zeiss (mainly microscopes, spectacle lenses / contact lenses), Essilor (spectacle lenses / contact lenses), and Leica Microsystems (microscopes). Medium size companies in the sector (EUR 50 ... 500 million) produce microscopes, spectacle lenses / contact lenses, ophthalmic diagnostic instruments, endoscopes, and analytical laboratory equipment. This includes e.g. Storz (D) and Wolf (D) in the endoscope segment, Zeiss Meditec (D) in the ophthalmic segment, Möller-Wedel (D) in the microscope segment, Rodenstock (D) in the spectacle lens / contact lens segment, and Tecan (CH) in the segment of analytical instrumentation. Besides, there are hundreds of smaller companies in the sector, accounting for revenues of less than EUR 50 million, each.

**Table 1.3/2: Medical Technology & Life Science – Structure of the European industry, 2005**

Revenue class	Number of companies	Companies (major countries of production)	Total revenues in EUR billion
> EUR 500 Mio	< 5	Zeiss (D), Leica Microsystems (CH, D), Essilor (F, others*)	~ 3
EUR 50 ... 500 Mio	10 ... 15	see text	1 ... 1.5
< EUR 50 Mio	>> 100		1 ... 1.5
<b>Total</b>			<b>5.7</b>

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\*) Essilor did not contribute information to the report.

## 1.4 Optical Communications

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### Segments and major products

- Optical networking systems
  - Mainly telecommunication systems, for trunk, metro, and access networks:  
WDM, Sonet / SDH, DCS / OCS equipment
  - CATV, CCTV, LAN systems
- Components and modules
  - Lasers, couplers, isolators, etc.
  - Transmitters, receivers
  - Fibre amplifiers

Fibre cables are not included in this report (cabling is not considered to be part of Photonics). Eurostat data on fibre cable production is provided in the box below.

### European industry and world market

Optical networking systems and components are produced in Europe, North America and Asia<sup>11</sup>. China has gained a substantial market share in recent years.

Eurostat gives the following figures for “Optical fibre cables made up of individually sheathed fibres whether or not assembled with electric conductors or fitted with connectors”:

- EU15: EUR 1.1 billion
- EU25: EUR 1.08 billion
- D: EUR 0.19 billion
- E: EUR 0.08 billion
- F: EUR 0.40 billion
- I: EUR 0.15 billion
- Smaller contributions (<EUR 0.1 billion) from the UK, S, FIN, A, DK, others
- NL: data blocked

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<sup>11</sup> Japan does not have a leading supplier position for optical networking equipment, as it has in most other Photonics sectors. This is remarkable as optical communications has received high attention by R&D funding in Japan, and the deployment of fibre optics has been pushed aggressively.

**Table 1.4/1: Optical Communications –  
World Market and Revenues of European Industry, 2005**  
in EUR billion

	World market	Revenues European industry
Systems	9.9	2.5 ... 3.0
Components	2.1	< 0.5
<b>Total</b>	<b>12.0</b>	<b>~ 3.0</b>

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The revenues of Europe based manufacturing plants are estimated at EUR 3.0 billion, i.e. about one quarter of the worldwide production volume.

#### **Production volume by country**

The worldwide market shares for optical networking systems in 2005, as estimated by a market research company, are shown in the box below.

The optical networking equipment industry has undergone substantial restructuring, in Europe and worldwide. The latest restructuring occurred after the burst of the telecom bubble in the year 2000. Today, the country of headquarters of the companies in the sector is not necessarily the country of major production. Alcatel-Lucent produces in France and in North America, as well as in other European and non-European countries. Ericsson produces mainly in the UK, in Italy, and in Sweden. Siemens (now Nokia Siemens) produces mainly in Germany. Mid size companies (e.g. Adva Optical from Germany), and an estimated ~ 50 small companies produce systems, modules, and components in Europe. Also subsidiaries of companies headquartered in North America and in Taiwan manufacture in Europe, while Europe headquartered companies produce to a substantial degree overseas.

#### **Worldwide market shares optical networking systems in 2005 \***

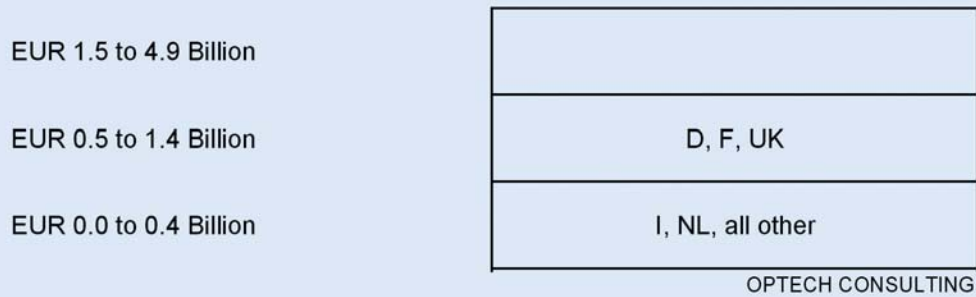
23% Alcatel-Lucent (F) #	6% Ericsson (S)
10% Huawei (China)	6% Siemens (D)
10% Nortel (Canada)	5% Cisco (USA)
9% Fujitsu (Japan)	5% NEC (Japan)
7% Tellabs (USA)	19% Other

\*) country of company headquarters in brackets

#) 16% were brought in by former Alcatel (F), and 7% by former Lucent (USA)

Source: RHK [9]

**Diagram 1.4/1: Optical Communications - Revenues by Country, 2005**



#### **Characterization of European industry**

Alcatel-Lucent, Ericsson-Marconi, and Nokia-Siemens dominate the production of optical networking systems in Europe. Adva Optical is a medium size company in the sector. Further, there are about 50 small companies making components and subsystems. This includes subsidiaries of North America and Taiwan headquartered companies.

**Table 1.4/2: Optical Communications – Structure of the European industry, 2005**

Revenue class	Number of companies	Companies (major countries of production within Europe)	Total revenues in EUR billion
> EUR 500 Mio	< 5	Alcatel-Lucent (mainly F), Ericsson (mainly UK, I), Nokia-Siemens (mainly D)	2 ... 2.5
EUR 50 ... 500 Mio	few	Adva Optical (D); list not complete	~ 0.5
< EUR 50 Mio	~ 50		< 0.5
Total			~ 3.0

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## 1.5 Information Technology & Printing

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### Segments and major products

#### Systems

- Systems for commercial printing
- Systems for office automation and consumer electronics
  - Digital cameras and camcorders
  - Optical disk drives
  - Scanners
  - Laser and LED printers, digital copiers
  - Multi functional printers (MFPs; scan, fax, print)
  - Print on demand systems
  - Fax machines
  - Bar code readers
- Components:
  - Lasers for systems above
  - Image sensors

### European industry and world market

With a volume of EUR 50 billion the IT sector is the second largest in Photonics, worldwide. The major segment is digital cameras. These are produced in Europe only in very small quantities. Also in the segment of optical disk drives the activity in Europe is very small. In the segment of printers, digital copiers, MFPs and print-on-demand systems the European share is in the range of ~5% (estimate based on Eurostat data). In the segment of bar code readers the European share is estimated at ~15%.

In the segment of systems for the printing industry Europe holds share of about 35%. The segment is characterized by the fact that the systems are used in a production environment (printing industry), rather than an office automation and consumer environment. Products comprise printing plate and cylinder exposure systems.

**Table 1.5/1: Information Technology & Printing –  
World Market and Revenues of European Industry, 2005**  
in EUR billion

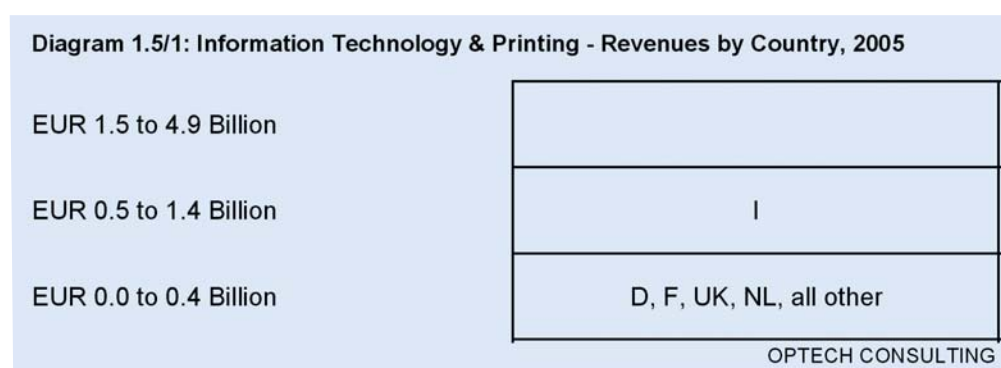
	World market	Revenues European industry	Major producing countries in Europe
Systems for printing industry	1.1	0.4	B, D, CH
Systems for office automation and consumer electronics	42.0	~ 1.5	I, NL, F, D
Components	7.2	small	
<b>Total</b>	<b>~50</b>	<b>~ 2</b>	

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Photonic components in the IT sector mainly comprise image sensors and semiconductor lasers for optical disk drives and laser printers (note that optical components such as lenses are included in the optical components & systems sector). For image sensors and semiconductor lasers the European production shares are small.

#### Production volume by country

The overall European production volume in the sector of information technology is small compared to the worldwide volume. A breakdown by country is complicated by the fact that most of the single country Eurostat data are blocked. Combining the Eurostat data with information on major manufacturers in Europe leads to the estimate shown in Diagram 1.5/1. Italy is the major producer, with products including printers, MFPs, copiers, and fax machines (Olivetti). Datalogic produces bar code readers in Italy, and is rated to be the worldwide number ten producer by a market research firm [10]. Océ of the Netherlands produces copiers, printers and print on demand systems, based on laser and LED technology, in the Netherlands and in Germany.



Eurostat data further indicates production of digital cameras in several European countries, and, to a lesser extent, production of optical disk drives. The small production volumes suggest that these are no mainstream products.

In the segment of systems for the printing industry major European producers are Barco (cylinder engraving systems for flexo printing; production in Belgium and Germany), and Heidelberg Druckmaschinen (computer to plate systems; Germany). Further activities in Europe include Datwyler (printing cylinder engraving systems; Switzerland, Germany), Stork / Schablonentechnik Kufstein (cylinder engraving systems; the Netherlands, Austria), and several companies making computer to plate systems (e.g. Basysprint of Germany and several others).

#### Characterization of European industry

Major European companies include Olivetti (office automation systems), Océ (office automation systems), Datalogic (bar code readers), Heidelberg Druckmaschinen (printing industry systems), and Barco (printing industry systems). An estimated more than 50 smaller companies produce systems for the printing industry and specialized office automation systems.

**Table 1.5/2: Information Technology & Printing – Structure of the European Industry, 2005**

Revenue class	Number of companies	Companies	Total revenues in EUR billion
> EUR 50 Mio	< 10	Olivetti (I), Océ (NL, D), Datalogic (I), Heidelberg Druckmaschinen (D), Barco (B, D)	> 1
< EUR 50 Mio	> 50		> 0.5
<b>Total</b>			<b>~ 2.0</b>

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## 1.6 Lighting

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### Segments and major products

- Lamps
  - Incandescent lamps
  - Discharge lamps
  - Also lamps for non-lighting applications are included (e.g. UV lamps for lithography, water purification, adhesive curing, etc.).
- LEDs
  - High brightness LEDs, for illumination, general lighting, signalling, etc.
  - “Low” brightness LEDs, including for illumination, signalling.
  - Also LEDs used for other applications are included (e.g. IR LEDs for remote controls, communications, etc.).

### European industry and world market

The 2005 world market for lamps accounted for a volume of EUR 13 billion, the world market for LEDs accounted for EUR 5.5 billion. The market for lamps and LEDs accounted for EUR 18.5 billion (without luminaries and electrical accessories<sup>12</sup>).

The 2005 European production of lamps is estimated at EUR 3.7 billion, the LED production accounts for EUR 0.23 billion (Eurostat). Therefore, the share in the world market is 28% in the lamp segment, and 4% in the segment of LEDs. Including related products such as ballasts and other accessories, produced by the lamp and LED manufacturers, the European production volume is estimated at EUR 6.5 billion.

These figures refer to the production volume in Europe. The total market share of European companies (including overseas production plants) is estimated at about 50% for lamps, and about 15% for LEDs. The major European lighting manufacturers, Philips and Osram, produce Lamps and LEDs to a considerable extent outside Europe. Note that, to a small extent, North America and Japan headquartered companies also produce lamps in Europe.

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<sup>12</sup> Luminaries and electrical accessories add an estimated EUR 32.4 billion downstream market [11].

**Table 1.6/1: Lighting – World Market and Revenues of the European Industry, 2005**  
in EUR billion

	World market*	Revenues European industry ** #
Lamps	13.0	NA
LEDs	5.5	NA
<b>Total</b>	<b>18.5</b>	<b>~ 6.5</b>

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\*) Accessories not included.

\*\*) Europe based plants only.

#) Including ballasts and accessories produced by the lamp and LED manufacturers. Not including these items, the European production accounts for a total of EUR 3.9 billion (EUR 3.7 billion for lamps, and EUR 0.23 billion for LEDs).

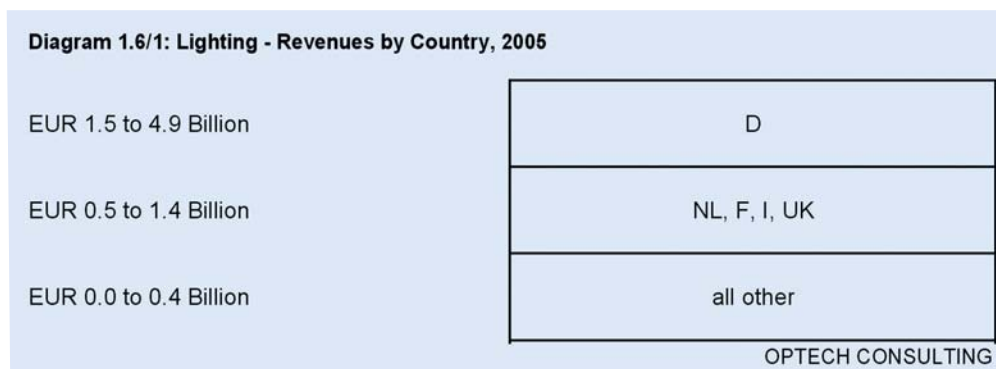
In the segment of lamps, the major competitors of the European industry are GE of the USA, NEC and Toshiba of Japan, and a large number of small producers in China. In the segment of LEDs, Osram and Philips are among the worldwide market leaders. Overall, however, Asian companies dominate the LED world market, with an estimated share of about 80%.

#### Production volume by country

The breakdown of the European production volume by country, as shown in Diagram 1.6/1, has been estimated based on the Eurostat data<sup>13</sup> and additional information from the industry (annual reports, expert interviews). Germany accounts for the largest production volume of EUR 2.3 billion. Several countries account for a production volume of > EUR 0.5 billion, including the Netherlands, Belgium, France, Italy, and the UK. Spain and Poland are also important production locations for lamps. In addition, there are production plants in Czech, Denmark, Finland, Romania, Slovakia, and Sweden.

According to Eurostat, LEDs are mainly produced in Germany and the UK. Further, Eurostat reports small production amounts, or blocked figures, for Czech, France, Denmark, Finland, the Netherlands, Spain, and Sweden. For Austria, no production is reported. In contrast, no LED chip manufacturer, producing that large amount, was identified in the UK. However, LED chips are produced in Austria by Tridonic-Atco. It appears that Eurostat is not unambiguous regarding LED chips and modules.

13 For lamps and LEDs Eurostat figures are blocked for the Netherlands, and several other countries. Some indication is available from the difference of the EU25 total vs. the reported single country contributions.



#### Characterization of European industry

The lamp production in Europe is dominated by Philips and Osram. Heraeus Noblelight of Germany produces lamps for technical applications. Also, Europe hosts lamp manufacturing plants of GE, as well as of Japan headquartered companies.

In the area of LEDs and LED lighting modules, Osram, Philips and Tridonic-Atco are major European producers. However, a substantial share of the LED production of the companies is located outside Europe. In addition, Europe hosts manufacturers focusing on the further integration of LEDs.

**Table 1.6/2: Lighting – Structure of European Industry, 2005**

Revenue class	Number of companies	Companies (major European countries of production)	Total revenues in EUR billion *
> EUR 1 billion	2	Philips (NL, B, D, Poland, other), Osram (D, Czech, Slovakia)	> 5
< EUR 1 billion	> 15	Heraeus Noblelight (D), General Electric (D), Tridonic-Atco (A), ...	~ 1
<b>Total</b>			<b>6.5</b>

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\*) revenues with lamps, LEDs, accessories; European production plants.

## 1.7 Flat Panel Displays

### Segments and major products

- Flat panel displays (FPDs)
  - TFT LCDs
  - Other LCDs
  - PDPs
  - Other FPDs
- Display materials
  - Liquid crystals
  - Display glass (for FPDs)

### European industry and world market

With the decline of the CRT Europe has lost most of its market share in the display sector. Flat panel displays (FPDs), which form by far the largest sector in Photonics, have become a mainly Asian technology. The USA has some involvement by manufacturing DLP and GLV chips for projection displays.

In Europe, only small volume production of FPDs is located. There is a small passive-matrix LCD display manufacturing activity by a Japanese-German joint venture (Optrex Europe), with manufacturing plants in Germany and Czech. Planar, a USA headquartered company, employs about 250 persons in Finland. Planar makes electroluminescent displays. Further, there are some small scale R&D driven activities, e.g. in the UK and in Germany in the area of electronic paper.

The major European activity in the flat panel display sector is the manufacturing of liquid crystals by Merck in Germany. Merck claims a 69% share in the world market for liquid crystals [12]. Also, there is a smaller activity of Schott making FPD glass in Germany. The display glass market is dominated by Corning of the USA and Asian companies. All of them have set up production plants close to the display manufacturers in Asia.

**Table 1.7/1: World Market and Revenues of European Industry, 2005**  
in EUR billion

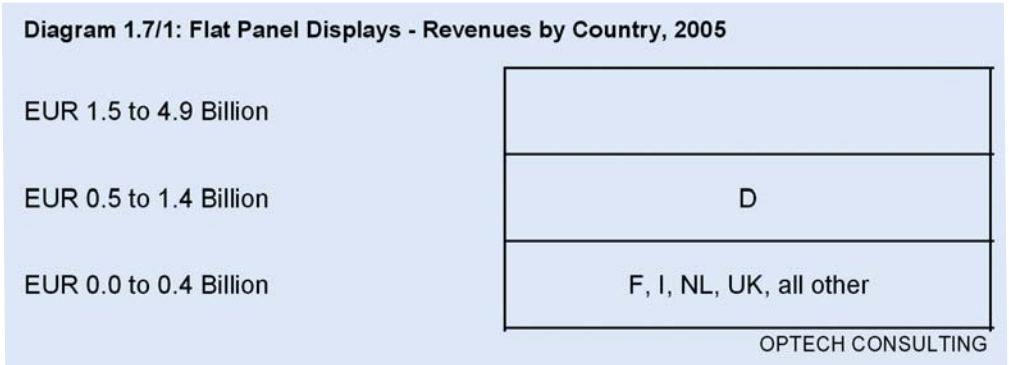
	World market	Revenues European industry	Countries
FPD	56	0.25	D, CZ, F, FIN
Materials (LC, Display Glass)	5.1	0.85	D
<b>Total</b>	<b>61.1</b>	<b>~ 1</b>	

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Philips of the Netherlands is involved financially in LG Philips LCD of Korea. Recently, LG Philips LCD has set up a back-end LCD panel assembly plant in Poland (Toshiba holds a 19.9% share). The panels assembled are for TV sets. Also TV set manufacturing plants are located in Poland (LG Electronics, Toshiba). LG Philips LCD is the first maker of large LCD panels establishing an assembly base in Europe. Sharp is now building a back-end assembly plant in Poland. IPS Alpha Technology of Japan has started TV set production in Czech in 2006, and plans a back-end LCD assembly plant in Hungary. The companies are attracted by low labour cost, low taxes and tax breaks, and access to the EU. Note that these activities did not exist in 2005, the base year of this report. Also, these are assembly activities. The technology-intensive front-end manufacturing is done in Asia.

PC monitors and TV sets are not considered to be photonic products in the present report, i.e. only the display panels are counted as the photonic product. However, specialized avionic displays have been included in the defence photonics sector (Paragraph 1.9).

Also FPD manufacturing equipment is not included in the present report. Note that European companies have a strong position in this area.



**Production volume by country**

Diagram 1.7/1 summarizes the European production volume by country (year 2005). The German production volume is mainly due to the liquid crystals manufactured by Merck.

**Characterization of European industry**

Merck accounts for revenues of ~ EUR 0.74 billion with liquid crystals (2005) [13]. All other activities are estimated to be smaller than EUR 100 million, each.

## 1.8 Solar Energy

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### Segments and major products

- Solar panels (modules)
- Solar cells

### European industry and world market

The world market for solar cells accounts for EUR 4 billion (2005), and the world market for solar panels for EUR 5 billion.

Europe holds a 28% share in the production of solar cells, and a 37% share in the production of panels. Japan holds the largest share in the supply market, due to market leader Sharp, and due to Kyocera. Other major producers are Taiwan and China.

On the demand side, Germany holds the worldwide largest share, followed by Japan. In both countries the large demand has been created by legally induced incentives.

### Production volume by country

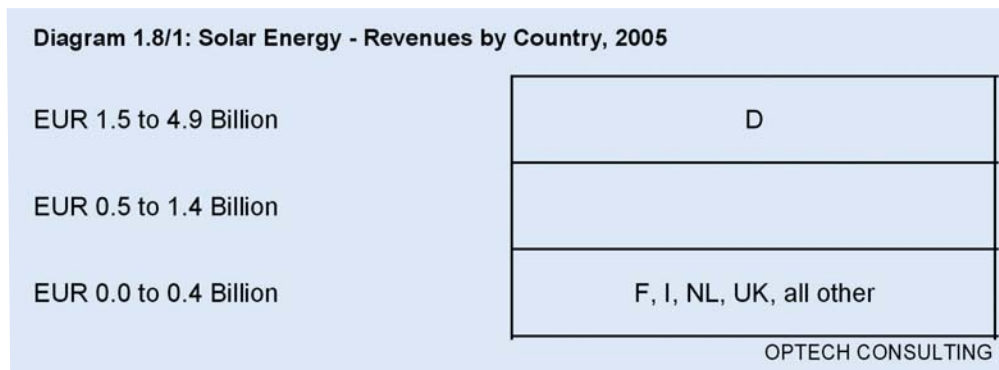
The data for the production volumes for the European countries, as summarized in Diagram 1.8/1, is mainly based on a market survey published by the Photon International magazine [14].

**Table 1.8/1: Solar Energy – World Market and Revenues of European Industry, 2005**  
in EUR billion

	World market	Revenues European industry
Solar Cells	4	1.1
Solar Panels	5	1.9
<b>Total</b>	<b>9</b>	<b>3</b>

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Within Europe, Germany dominates production volumes for solar cells and solar panels. Including both, cells and panels, Germany holds a 57% share. Other countries with a major share are Spain (13%), Portugal (7%; modules only), the UK (7%, panel assembly by Sharp of Japan), France (6%). Several further European countries host a minor activity (total: 10%).



#### Characterization of European industry

Q-Cells is the leading European manufacturer. The company makes cells only, no panels. Four other of the major European companies are headquartered in Germany: Schott Solar (cells and panels), Solarwatt (panels), Solon (panels), and SMD (now Aleo Solar; panels). Also Isophoton of Spain (cells and panels) accounts for sales above EUR 100 million. The five companies together account for a production volume of about EUR 1 billion. Further, there are about 50 companies in Europe making cells and / or panels. These companies account for a production volume of about EUR 2 billion.

**Table 1.8/2: Solar Energy – Structure of the European industry, 2005**

Revenue class	Number of companies	Companies	Total revenues in EUR billion
> EUR 100 Mio	~5	Q-Cells (D), Schott Solar (D), Isophoton (E), SMD (D), Solarwatt (D), Solon (D)	~ 1
< EUR 100 Mio	~50		~ 2
<b>Total</b>	<b>~55</b>		<b>~ 3</b>

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## 1.9 Defence Photonics

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### Segments and major products

- Systems
  - Vision and imaging systems, including periscopic sights
  - Infrared and night vision systems, hand held systems (defence, homeland security applications) and integrated systems
  - Ranging systems, laser range finders
  - Electro-optical munition guidance devices, missile guidance systems
  - Military space optronics surveillance systems
  - Avionics displays
- Components
  - Image sensors
  - Lasers

### European industry and world market

The overall revenues of the European defence photonics industry are estimated to be about EUR 5 billion, including systems and components.

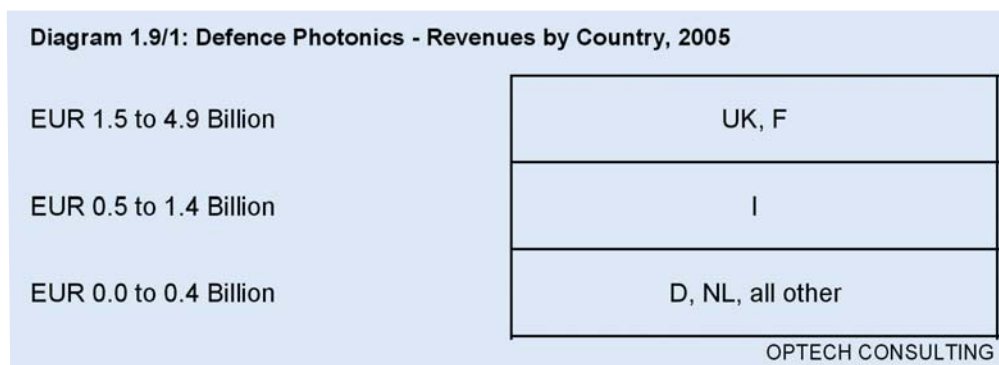
The world market is estimated at EUR 15 ... 20 billion. Production is mainly located in North America and Europe. Other countries with a substantial production volume include notably Israel, Russia, China, and Japan.

**Table 1.9/1: World Market and Revenues of European Industry**  
in EUR billion

	World market	Revenues European industry
Systems	~15	> 4
Components (image sensors, lasers)	3 – 4	> 1 *
<b>Total</b>	<b>15 – 20</b>	<b>~ 5</b>

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\*) Partly captive revenues within system producing companies.



#### Production volume by country

The major European defence photonics producer is Thales, headquartered in France. Other major producers include Finmechanica (headquartered Italy) and Safran (France).

Following a restructuring process the location of activities does not necessarily reflect the location of headquarters. Thales has major production activities in the UK, and also Finmechanica accounts for a major UK located production volume. UK headquartered BAE Systems operates a large part of its Photonics production activities in the USA.

Overall, the UK and France are the major producers of defence photonics in Europe, with a ~ EUR 1.5 billion volume, each, followed by Italy and Germany. Smaller activities are located in further countries (e.g. the Netherlands, Sweden, Poland).

#### Characterization of European industry

France headquartered Thales is estimated to be the major producer of defence photonics in Europe, followed by Finmechanica (Italy). Thales' major production locations are in France (Thales Optronique) and in the UK (including major plants in Glasgow and Staines). Finmechanica's major production locations are Italy and the UK (including Selex Edinburgh and Selex Basildon). After takeovers both companies have major production plants in the UK.

In the UK further defence photonics activities include QIOPTIQ and BAE Systems. QIOPTIQ's products include mainly optical modules and infantry night vision sights. Also UK headquartered BAE Systems is a major producer of defence photonics systems. Their major Photonics activities are, however, located in the USA.

The French Group SAFRAN is the third largest manufacturer of defence photonics in Europe, with major plants in Poitiers and Dijon and the Swiss subsidiary Vectronix in Heerbrugg.

More than 20 further companies are estimated to account for a Europe located production volume of EUR 50 to 500 million, each.

In addition, there are many smaller companies (and smaller defence photonics activities of big companies) with revenues < EUR 50 million. These include e.g. Simrad Optronics (Norway), Thermoteknix (UK), Saab (Sweden), Sofradir (F), Technobit (E), OIP (Belgium; owned by ELBIT group of Israel), Radamec (UK), Meopta (Czech), Aimpoint (Sweden), Theon Sensors (Greece), PYSER-SGI (UK), Hall & Watts Defence Optics (UK), Davin Optronics (UK), and others.

Several of the smaller companies make night and infrared vision equipment, binoculars and telescopic sights, which can be used in the military sector, the homeland security sector, or for other applications ranging from hunting to bird watching. Binoculars and telescopic sights are included in the sector of optical components & systems (Paragraph 1. 10).

**Table 1.9/2: Structure of the European industry**

Revenue class	Number of companies	Companies (countries of production)	Total revenues in EUR billion *
> EUR 500 Mio	3	Thales (UK, F, NL) Finmechanica (I, UK), Safran (F)	~ 3
EUR 50 ... 500 Mio	5 ... 10	BAE (UK), Diehl BGT (D), QIOPTIQ (UK, D, F), Zeiss (D), EADS, Photonis (F,NL), E2V (UK)	> 1
< EUR 50 Mio	> 20		< 1
<b>Total</b>			<b>~ 5</b>

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## 1.10 Optical Components & Systems

### Segments and major products

- Optical components
  - Optical glass
  - Lenses and other optical components, with and without frame, lens assemblies
  - Camera tubes (not including solid state image sensors, see information technology sector)
- Optical systems
  - Objective lenses (not including objective lenses for wafer steppers – see production technology)
  - Classical optical systems such as e.g. telescopes, telescopic sights, binoculars, 35 mm cameras, optical equipment for film and paper print processing
  - Professional video cameras and television cameras

### European industry and world market

The revenues of European companies in the sector of optical components & systems are estimated to account for EUR 5 billion. This compares to an estimated world market of EUR 12 billion. The European share is 27% in the segment of optical components, and 58% in the segment of optical systems. While many optical components are now produced in Asia (for example the lenses for digital cameras and camera phones), Europe holds a strong position in the area of classical optical systems.

The figures on European production volumes are mainly based on Eurostat. For categories associated with optical components, the EU25 total accounts for EUR 0.6 billion. For categories associated with optical systems (including accessories), the EU25 total accounts for EUR 2.2 billion. For several categories the EU25 total is blocked in Eurostat.

**Table 1.10/1: Optical Components & Systems –  
World Market and Revenues of European Industry, 2005**  
in EUR billion

	World market	Revenues European industry
Optical Components	~ 5.5	1 ... 1.5
Optical Systems	~ 6.5	3 ... 4
<b>Total</b>	<b>~ 12</b>	<b>~ 5</b>

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Major categories, with Eurostat data on the EU25 production volume being available, include:

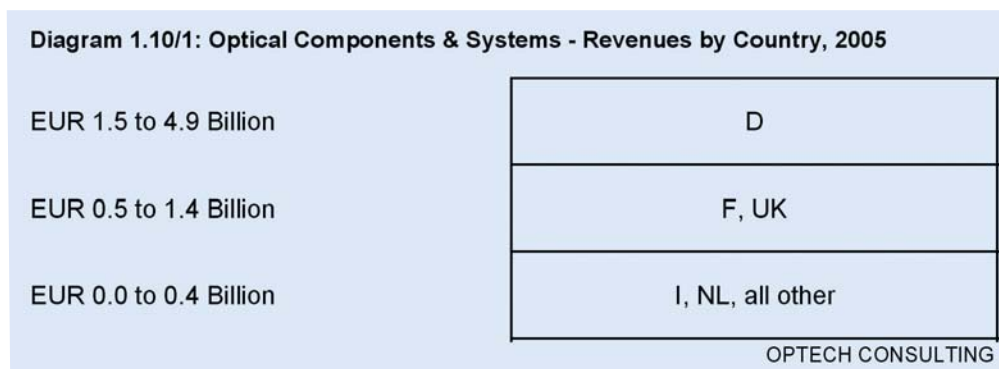
- Optical glass: EUR 207 million
- Prisms; mirrors and other optical elements; n.e.c.: EUR 313 million
- Mounted lenses; prisms; mirrors; etc; of any material; n.e.c.: EUR 238 million
- Mounted filters of any material: EUR 40 million
- Optical fibres; optical fibre bundles and cables (excluding image conductor cables; optical fibre cables made up of individually sheathed fibres)<sup>14</sup>: EUR 171 million
- Television camera tubes: EUR 133 million
- Mounted objective lenses; of any material; for cameras; projectors or photographic enlargers or reducers: EUR 80 million
- Binoculars: EUR 91 million
- Telescopic sights: EUR 221 million
- Optical devices; appliances and instruments; nes ; others: EUR 478 million
- Cinematographic cameras (excluding for film of a width < 16 mm wide or for double 8 mm film) and cinematographic projectors: EUR 113 million
- Apparatus and equipment for photographic laboratories; n.e.c.; negatoscopes: EUR 286 million
- Parts and accessories of optical appliances and instruments: EUR 449 million
- Parts and accessories for photographic cameras (excluding flashlight apparatus): EUR 113 million
- Parts and accessories for cinematographic cameras (excluding casings of textile materials designed to eliminate motor noise): EUR 66 million
- Television cameras: EUR 188 million

#### **Production volume by country**

A substantial number of figures on single country production are blocked in Eurostat. Therefore, the data available from Eurostat has been matched with information on major activities in the single countries. This leads to the breakdown of production volumes shown in Diagram 1.10/1. Germany is the leading producer, followed by France and the UK.

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<sup>14</sup> These categories do not include optical fibres and fibre cables for telecommunications (see Paragraph 1.4).



#### Characterization of European industry

The sector of optical components & systems comprises about 20 major products. The supply side is fragmented. There are estimated 10 to 20 market participants with revenues > EUR 100 million, and a large number of smaller companies.

**Table 1.10/2: Optical Components & Systems – Structure of the European industry, 2005**

Revenue class	Number of companies	Companies	Total revenues in EUR billion
> EUR 100 Mio	10 ... 20	Zeiss (D), QIOPTIQ (UK,D,F), Arri (D), ...	~2.5
< EUR 100 Mio	> 500		~2.5
<b>Total</b>			<b>~5.0</b>

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## 2. European Photonics by Country

### 2.1 Overview

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Diagram 2.1/1 shows the production volume of the European countries by Photonics sector. Germany accounts for 39% of the European production volume in Photonics. France and the UK account for 12%, each, the Netherlands for 10%, and Italy for 8%. Switzerland follows with ~4%, and Spain with ~3%. Together, these countries account for 88% of the European production volume.

**Strengths of the countries by sector are as follows:**

- **Production technology:** The Netherlands have the largest production volume due to the wafer steppers produced by ASML. Germany follows not far behind due to the laser materials processing systems and the lasers manufactured by Trumpf, RoFin Sinar, Jenoptik, and others, and the wafer stepper lenses manufactured by Zeiss. The next important producer is Switzerland, followed by Italy.
- **Measurement & automated vision:** Germany is the leading producer, with major activities in automated vision, binary sensors, spectrometers, and measurement systems for geometry and dynamics. Many other countries account for a substantial activity in measurement & automated vision, including the UK, France, Italy, Switzerland, and the Scandinavian countries.
- **Medical technology & life science:** Germany is the leading producer (microscopes, surgical microscopes, endoscopes, spectacle lenses / contact lenses). Other important producers are the UK and France (both strong in the area of spectacle lenses / contact lenses), and Switzerland (surgical microscopes).
- **In optical communications** France is the leading manufacturer, followed by Germany, the UK, and Italy.
- **In information technology** Italy is the leading producer (Olivetti). The Netherlands, Germany, and France also contribute to the – overall small – European production volume.
- **In lighting** Germany is the major producer. Other important manufacturers are France, Belgium, the UK, Italy, Spain, and Poland.
- **In the flat panel display sector** the major activity in Europe is the manufacturing of liquid crystals by Merck in Germany. All other activities are small.
- **In the solar energy sector** Germany is the leading producer. Smaller activities are hosted in Spain, Portugal, France, Italy, and several other countries.
- **In defence photonics** the UK and France are the major producers, followed by Italy and Germany.
- **In the sector of optical components & systems** Germany is the leading producer, followed by the UK and France.

Diagram 2.1/1: Production Volumes of European Countries by Photonics Sector

	Production Technology	Measurement & Automated Vision	Medical Technology & Life Science	Communications	Information Technology	Lighting	Flat Panel Displays	Solar Energy	Defence Photonics	Optical Components & Systems
EUR 1.5 to 4.9 Billion	D NL	D	D			D Σ Other		D	F UK	D
EUR 0.5 to 1.4 Billion	Σ Other	F UK Σ Other	F UK Σ Other	D F UK Σ Other	I Σ Other	F UK I NL	D	Σ Other	I Σ Other	F UK Σ Other
EUR 0.0 to 0.4 Billion	F UK I	I NL	I NL	I NL Σ Other	D F UK NL		F UK I NL Σ Other	F UK I NL	D NL	I NL

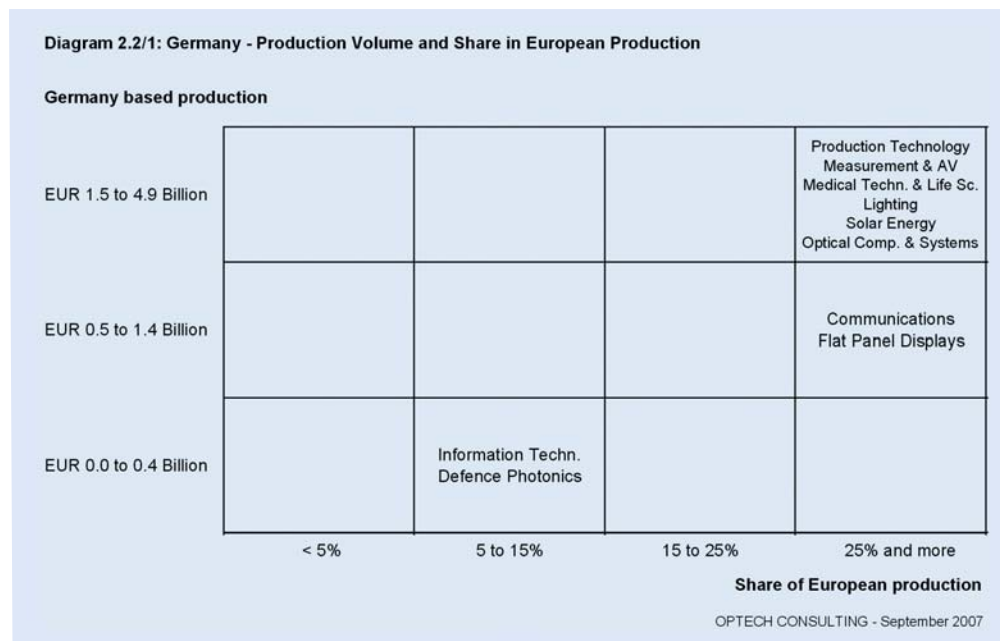
## 2.2 Germany

Germany accounts for a production volume of EUR 16.7 billion, corresponding to 39% of the European production, and to 7% of the world market<sup>15</sup>.

The German production volume in Photonics has been analyzed in detail in the report "Optische Technologien – Wirtschaftliche Bedeutung in Deutschland" [1]. Diagram 2.2/1 is based on that report.

### Major sectors of Photonics production in Germany include:

- **Production technology:** In laser materials processing the German production of lasers and laser systems accounts for EUR 1.15 billion. Major producers in Germany are e.g. Trumpf, Rofin Sinar, and Jenoptik. In lithography, Zeiss produces the objective lenses (2005: EUR 0.7 billion) for the steppers of ASML in the Netherlands.
- **Measurement & automated vision:** Germany hosts an automated vision production volume of ~ EUR 1 billion. Further, Germany hosts a binary sensor production of EUR 1.5 billion. Additional activities in Germany include spectrometers (~ 0.4 billion), and other measurement systems (EUR 0.4 billion).



<sup>15</sup> In the report "Optische Technologien – Wirtschaftliche Bedeutung in Deutschland" [1] the German production volume is estimated at EUR 16.3 billion, and the world market at EUR 211 billion. The differences are mainly due to the defence sector, which is not included in the report on Germany.

- Medical technology & life science: Germany produces endoscope systems (EUR 0.57 billion), as well as microscopes and surgical microscopes (EUR 0.9 billion). Further products include spectacle lenses and contact lenses (EUR 0.68 billion), medical lasers & systems (especially for ophthalmology), diagnostic systems for ophthalmology, and medical imaging systems.
- Optical communications: Siemens (now Nokia Siemens) is the major producer of optical networking systems in Germany. The next important manufacturer is Adva Optical. Alcatel-Lucent also produces and has R&D activities in Germany. There are about 15 smaller companies making components and modules.
- Information technology: Activities mainly comprise systems for the printing industry (Heidelberger Druckmaschinen and other companies), and LED printers (Océ).
- Lighting: Osram is the major producer of lamps, and also produces LEDs in Germany. Also Philips operates a major lamp production plant in Germany. Heraeus Noblelight produces lamps for technical use.
- Solar energy: The German production volume accounts for EUR 1.7 billion, of which EUR 0.95 billion are due to solar panels, and EUR 0.75 billion due to solar cells. Major producers include Q-Cells, Schott Solar, SMD, Solarwatt, and Solon, and many smaller companies. Wacker makes solar grade silicon.
- Defence photonics: Zeiss and Diehl BGT are major producers in Germany. There are several manufacturers of infrared and night vision equipment.
- Optical components & systems: Schott produces optical glass. Optical components are produced by system companies like Zeiss, but also by specialized companies such as Linos (now part of QIOPTIQ) and Sill Optics. There are several manufacturers of binoculars and telescopic sights. Arri produces equipment for the movie industry.

## 2.3 France

France accounts for a production volume in Photonics of EUR 5.4 billion, which corresponds to 12% of the European production volume and about 2.5% of the world market.

### Major sectors of activity in France are:

- Defence photonics: France headquartered Thales is the major producer of defence photonics in Europe. Its production plants are mainly located in France and the UK, with smaller activities in other countries. Also Safran is an important producer in this sector in France. Total revenues of France located production plants are estimated in the range of EUR 1.5 billion.
- Optical communications: France headquartered Alcatel-Lucent is the worldwide market leader for optical networking systems, with estimated 2005 revenues in this sector of ~EUR 1.5 billion<sup>16</sup>. Production locations include France, the USA, and other countries.
- Measurement & automated vision: Products comprise spectrometers (produced e.g. by Japan headquartered Horiba Yobin Yvon, and by Sopra), measurement systems for semiconductors (Sopra), binary sensors (Automelec), automated vision systems (about 25 companies were identified in France), and other optical measurement systems.

**Diagram 2.3/1: France - Production Volume and Share in European Production**

#### France based production

EUR 1.5 to 4.9 Billion				Defence Photonics
EUR 0.5 to 1.4 Billion		Measurement & AV Med. Techn. & Life Sc. Lighting Optical Comp. & Systems		Communications
EUR 0.0 to 0.4 Billion	Production Techn. Flat Panel Displays	Information Techn. Solar Energy		
	< 5%	5 to 15%	15 to 25%	25% and more

**Share of European production**

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<sup>16</sup> Estimate by RHK [9].

- Medical technology & life science: Based on Eurostat data the production volume for spectacle lenses / contact lenses in France is estimated at about EUR 0.5 billion. Eurostat also indicates a production volume of EUR 0.04 billion for ophthalmic instruments. Essilor, with total revenues of ~EUR 2.5 billion [15], is the world market leader in the segment of spectacle lenses & contact lenses. Production plants are located in different countries, worldwide.
- Lighting: A production volume of about EUR 0.6 billion is estimated based on Eurostat data.
- Optical components & systems: Based on Eurostat data a production volume of EUR ~0.5 billion has been estimated for France. Products include television camera tubes, television cameras, optical components (mounted lenses), and objective lenses.
- Solar energy: The production volume of solar cells and solar modules in France is estimated at EUR 0.18 billion [14].
- Information technology: Eurostat shows production of printers (EUR 130 million; type of printers not specified). Figures on photocopiers are blocked in Eurostat.
- Production technology: Production volume is comparably small. Laser machines are produced e.g. by. Technifor and Lectra Systemes, and 10 to 20 small companies.
- Flat panel displays: A low volume LCD activity is operated by Thales Avionics LCD SA near Grenoble, which may be included in the defence photonics sector.

AFOP, the French Trade Association for Optics and Photonics, has estimated the French Photonics cluster [16], and concludes that there are approximately 1'000 companies in France active in the Photonics related sector with nearly 35'000 employees, and a total turnover of about EUR 10 billion.

The latter figure differs from the EUR 5.4 billion estimate of the present report.

The difference may be attributed to the following issues<sup>17</sup>:

- The present report counts production volumes of France located facilities only, while AFOP includes the total turnover of France headquartered companies (e.g. production volumes of Essilor or Thales in production facilities in other European and non-European countries).
- The present report does not include revenues of Photonics products imported to France. For the employment in France, the EUR 5.4 billion revenues lead to an estimate of about 30,000 persons employed. This figure, calculated using a set of sector typical per-employee revenues, is close to the AFOP estimate of 35'000 employees.

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<sup>17</sup> One of the authors of the AFOP data was asked to comment, but did not respond.

## 2.4 United Kingdom

The UK accounts for a production volume in Photonics of EUR 5.2 billion, which corresponds to 12% of the European volume, and 2.3% of the world market. The production volume comprises substantial contributions from six out of the ten sectors of Photonics, and smaller contributions from other four sectors (Diagram 2.4/1). UK subsidiaries of companies headquartered in other European countries contribute substantially to the volume, e.g. in the sectors of defence photonics and optical communications.

### Major sectors of Photonics production in the UK are:

- Defence photonics: Revenues of the industry in the UK are estimated at ~ EUR 1.5 billion. Thales is the biggest defence photonics producer in the UK, followed by Finmechanica (Selex), QIOPTIQ, and BAE Systems. Note that BAE Systems mainly produces its photonics systems in the USA. Also QINETIQ, a major UK defence technology producer, has some involvement in Photonics (R&D, e.g. on thermal imaging, remote sensing, displays). Also two free space optical communication systems companies are based in the UK (note that free space optical communication is a small market).
- Medical technology & life science: Revenues of the industry in the UK are estimated at nearly EUR 1 billion. The largest part of the production volume is due to spectacle lenses / contact lenses (Eurostat: EUR 0.62 billion). Further products include ophthalmic instruments (Eurostat: EUR 0.06 billion) and medical lasers.

**Diagram 2.4/1: UK - Production Volume and Share in European Production**

#### UK based production

EUR 1.5 Billion and above				Defence Photonics
EUR 0.5 to 1.4 Billion		Measurement & AV Med. Techn. & Life Sc. Lighting	Communications Optical Comp. & Systems	
EUR 0.0 to 0.4 Billion	Production Techn. Information Techn. Flat Panel Displays	Solar Energy		
	< 5%	5 to 14%	15% to 24%	25% and more

**Share of European production**

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- Optical components & systems: Based on Eurostat data revenues of the industry in the UK are estimated at ~ EUR 0.75 billion. Products comprise optical glass, optical and optoelectronic components (lenses, mirrors, filters, fibre-based components, camera tubes, etc.), and optical and optoelectronic systems (objective lenses, binoculars and telescopic sights, television cameras) and accessories. Also lasers (other than lasers for materials processing and medical therapy) are counted in the category of optical components & systems. Note that there are also companies making optics polishing equipment (not included in the present report).
- Measurement & automated vision: Revenues are estimated at ~ EUR 0.5 billion. The UK produces spectrometers (Eurostat: EUR 220 million), and spectrometer based analytical systems. Further, automated vision systems are produced in the UK, including for the security sector.
- Lighting: The total production volume is estimated at ~ EUR 0.5 billion, including accessories. Eurostat indicates a production volume of EUR 166 million for lamps, but the data for several lamp categories is blocked for confidentiality. For LEDs, Eurostat reports a production volume of EUR 80 million for the UK. As no major LED chip manufacturer was identified in the UK it is assumed that the figure refers to LED modules.
- Optical communications: Revenues are estimated at ~ EUR 0.5 billion. E.g. Ericsson produces optical networking systems in the UK (after takeover of Marconi in 2005). Bookham is active in the optical networking components segment. Small firms, typically spinouts from institutes and major technology firms, produce components and modules.
- Solar energy: Sharp of Japan integrates solar panels in Wrexham, UK. In 2005, production volume was ~ EUR 200 million.
- Production technology: The production volume for the sector is estimated at ~ EUR 150 million. Lasers and / or laser machines for materials processing are produced by GSI Group, Group 600 / ElectroX, Exitech (Oerlikon Group), SPI Lasers, Powerlase, and several smaller manufacturers.
- Flat panel displays: Production activities, e.g. in the area of electronic paper, have a small volume.
- Information technology (IT): After Xerox has sourced out photocopier manufacturing, production of Photonics related IT in the UK is small. There are small bar code system manufacturing firms. Photonic related IT activities - which are not added to the figures in this report – include storage system test equipment (Xyratex is a worldwide market leader), and CD/DVD production equipment (major producers are located in the UK).
- Also related to Photonics, but outside the scope of this report, there are several major companies producing equipment for manufacturing of semiconductor lasers.

## 2.5 Italy

The Italian production volume in Photonics accounts for EUR 3.6 billion, which corresponds to 8% of the European production volume, and 1.5% of the world market.

### Major sectors of Photonics production in Italy are:

- Information technology (IT): With estimated revenues of EUR 0.7 billion Italy is the leading IT Photonics producer in Europe. Olivetti (100% Telecom Italia) produces laser printers, multifunctional printers (MFPs), digital copiers, and fax machines. Data-logic produces bar code scanners. The company, with revenues of about EUR 250 million, is estimated by market researchers to be the tenth largest company in the automatic data capture business, worldwide [10].
- Defence photonics: Finmechanica produces photonics based defence components and systems in Florence (Galileo Avionica) and near Rome (Selex Sistemi Integrati).
- Lighting: An Italian production volume of ~ EUR 0.5 billion for lamps (incl. accessories) has been estimated based on Eurostat data. Eurostat does not indicate any LED production.
- Medical technology & life science: The production volume is estimated at EUR 300 ... 400 million. According to Eurostat the production volume of spectacle lenses / contact lenses accounts for EUR 150 million, and the production of ophthalmic instruments for EUR 70 million. El.En. produces medical laser systems and markets them worldwide through its consociates.

**Diagram 2.5/1: Italy - Production Volume and Share in European Production**

#### Italy based production

Production Volume (EUR Billion)	< 5%	5 to 15%	15 to 25%	25% and more
EUR 1.5 to 4.9 Billion				
EUR 0.5 to 1.4 Billion		Lighting	Defence Photonics	Information Techn.
EUR 0.0 to 0.4 Billion	Production Techn. Medical Techn. & Life Sc. Flat Panel Displays Solar Energy	Measurement & AV Communications Optical Comp. & Systems		

**Share of European production**

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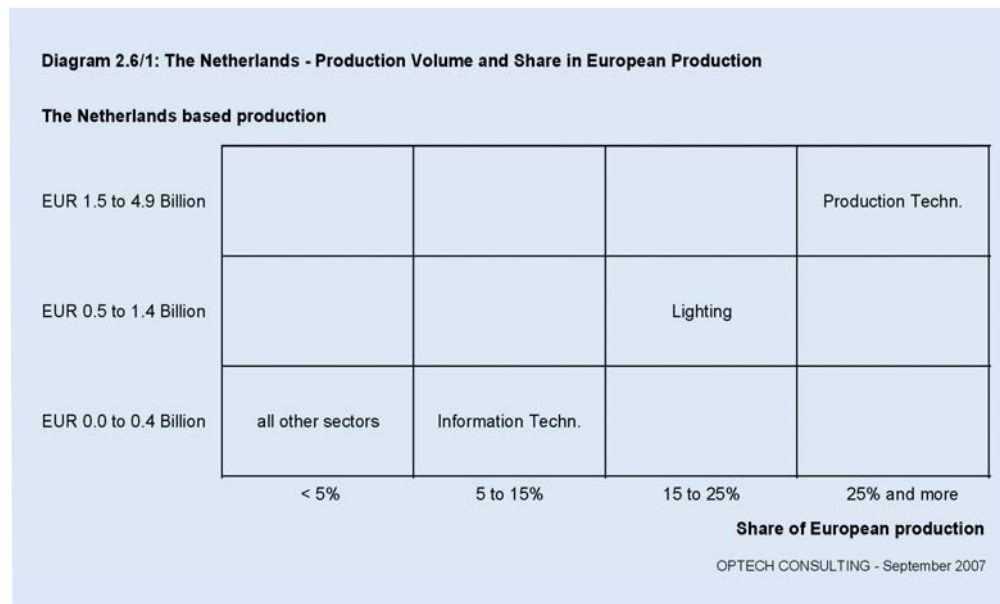
- Measurement & automated vision: The Italian production volume is estimated at EUR 300 ... 400 million, including systems for automated vision, and other optical measurement systems for industrial use. Further, Eurostat indicates a small production volume of spectrometers.
- Optical components & systems: Italy produces optical components, fibre-based components, and classical optical systems (including equipment for processing of films, equipment for cinemas, and television cameras).
- Production technology: Laser machines and lasers are produced by Prima Industrie, Data-logic / Laservall, El.En., and about 30 smaller companies. The total production volume is estimated at EUR 200 ... 250 million.
- Optical communications: Ericsson, due to the takeover of Marconi in 2005, produces optical networking systems in Italy.
- In the solar energy sector Italy accounts for a production volume of EUR 100 million [14].

## 2.6 The Netherlands

The Netherlands account for a production volume in Photonics of about EUR 4.4 billion, which corresponds to 10% of the European production volume and 2% of the world market. Note that more than half of the production volume is due to ASML, and a large part of the remaining volume is due to Philips.

### Major sectors of activity in the Netherlands are:

- Production technology: In the lithography segment, ASML accounts for revenues of about EUR 2.5 billion (2005) [5]. The production volume in the laser materials processing segment is small.
- Lighting: Philips produces lamps in the Netherlands (as well as in several other European countries).
- Information technology (IT): Océ produces digital photocopiers and printers based on LED and laser technology.
- Medical technology & life science: The production volume is estimated at about EUR 0.2 billion, including spectacle lenses / contact lenses, and ophthalmic equipment.
- Optical components & systems: Products include optical glass, optical components (prisms, mirrors, etc.), television camera tubes, and television cameras.



- Measurement & automated vision: Eurostat indicates that important segments such as spectrometers are not represented in the Netherlands. The industry structure of the country suggests that there is manufacturing of automated vision systems, and of optical measurement systems for industrial production.
- Defence photonics: Thales has a smaller production activity in the Netherlands.
- Solar energy: The production volume of solar cells and modules is small [14].

## 2.7 Other European countries

The “other countries” include Europe except the five major Photonics producers (Germany, France, UK, Italy, the Netherlands). Together the other countries account for a production volume of EUR 8.1 billion, corresponding to 19% of the European production volume in Photonics.

This includes:

- Switzerland with an estimated EUR 1.5 ... 2 billion. Major product segments comprise production technology (laser materials processing systems and/or lasers are produced by Bystronic, Trumpf, Lasag), measurement & automated vision, defence photonics (Vectronix of Safran group), medical technology & life science (Leica Microsystems producing surgical microscopes), and optical components & systems (e.g. Fisba Optik).
- Spain with an estimated ~ EUR 1.5 billion. Major sectors of production include lighting and solar energy.
- Belgium: Production areas include lighting (lamp production by Philips), measurement & automated vision, and production technology (laser materials processing systems).
- Poland: Production activities include lighting (lamp production by Philips), defence photonics, and smaller scale activities in other sectors.

**Diagram 2.7/1: Other European Countries - Production Volume and Share in European Production**

**Production based in other European countries**

Production Volume (EUR Billion)	Share of European production			
	< 5%	5 to 9%	10 to 24%	25% and more
EUR 1.5 to 4.9 Billion				Lighting
EUR 0.5 to 1.4 Billion			Production Technology Measurement & AV Medical Techn. & Life Sc. Defence Photonics Optical Comp. & Systems	Information Techn. Solar Energy
EUR 0.0 to 0.4 Billion			Communications Flat Panel Displays	

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Note that in Poland, as well as in neighbouring countries, assembly plants are being set up for consumer electronics, and also for office automation products. The back-end assembly of LCD panels might be included in the present report (in contrast to other assembly activities such as TV set assembly). In 2005, the base year of this report, LCD panel assembly in Poland had not started yet.

Many other countries host Photonics production activities: Sweden (defence photonics, production technology, measurement & automated vision, optical networking), Finland (laser materials processing systems, automated vision systems), Denmark (optical measurement systems), Austria (lighting, optical components & systems), Portugal (solar energy, medical technology & life science), Bulgaria (optical components), Slovenia (laser systems), Lithuania (laser systems), etc. The list is far from being complete. For the countries mentioned above activities are not confined to the examples given, and there are smaller scale activities in most other European countries.

# Appendix: Methodology, Definitions

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The present report provides information on the European Photonics industry:

- Revenues by product segment
- Breakdown by major producing countries
- Structure of the European industry, size of companies
- Number of persons employed

The products included in this report are shown in Table 1 (see summary of the report). Note that there are further Photonics related products, which are not included in this report (see box below).

The present report was evaluated as follows. Based on the report on Germany [1], and on an analysis of other sources of information (see below), a draft report was completed. Excerpts of the draft report were sent to experts for review and their information and suggestions were added.

Primarily, the data on European industry revenues was assessed. The number of persons employed was calculated by using information on average revenues per employee, differentiated by Photonics sector and country.

## **Products not included in the present report**

Mobile phones with camera. Note that image sensors, camera optics, and displays are included as components.

PC monitors. The display panels are included as components.

TV sets. The display panels are included.

Optical fibres and fibre cables for communication purposes. The production figures are given in paragraph 1.5, but not added to the total of the optical communications sector.

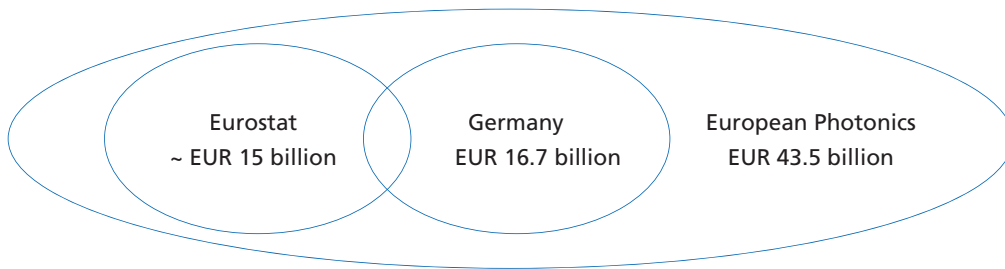
Semiconductor materials.

Manufacturing equipment (e.g. for optical components, materials, etc.).

The characterization of the structure of the European industry required the evaluation of production volumes for companies by product sector, and for single countries. It is important to note that these figures are estimates, combining published information on revenues and the number of employees with additional information regarding products and production plants. That type of quantitative breakdown is not generally published, and stock market regulations may request companies not to comment.

**Sources of information for the present report comprise:**

- The report on the German Photonics industry [1]. The report also provides comprehensive information on the world market. All data on world markets shown in the present report has been taken from the report on Germany. The report further provides the information on production volumes in Germany (except for the defence photonics sector, which was not part of the analysis on Germany). Germany accounts for 39% of the European Photonics industry.
- Eurostat production data [17]. Eurostat covers about 35% of the European Photonics industry, which partly overlaps with the 39% for Germany (see schematic below).
- Annual reports of major European manufacturers and other published company information.
- Information published by market research firms.



**The following definitions are used throughout the report:**

- World market: sales volume per year in the respective sector or segment. The world market refers to Photonics products, and does not include accessories, parts and service. Also, it does not include retail sales cost. Markets for major products along the “food chain” are added up (e.g. lasers and laser systems).
- Revenues of the European industry: revenues of production plants in Europe. The revenues include accessories, parts and service. Revenues along the “food chain” are only added up in open markets, not for captive component integration within a company.

While the parts and service issue tends to overestimate the European share in the world, the integration issue tends to underestimate it. The order of magnitude of both effects is less than 10% for Photonics as a whole, and both effects tend to compensate each other.

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