

Optoelectronics

A Strategic Study of the Worldwide Semiconductor
Optoelectronic Component Industry to 2012



A Strategic Study of the Worldwide Semiconductor Optoelectronic Component Industry to 2012

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A Strategic Study of the Worldwide Semiconductor Optoelectronic Component Industry Market Prospects to 2012

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1. INTRODUCTION

1.1 OVERVIEW

This is the fourth edition of a report originated by the authors some eight years ago. It provides an overview of how the semiconductor optoelectronic component industry is changing with respect to business and technology: how big the market has become and how it continues to develop new markets through technical innovation. However, it has undergone other major changes most notably for some of the biggest players which service the needs of the world's OEMs. The latest report has more grounds for optimism even though some areas have taken longer to recover – most notably fibre optic networks – thanks to the further penetration of these components into nearly all end-user market segments.

Like the electronics industry as a whole, the optoelectronics business has much potential. It is by no means an exhausted industry making it a good prospect for the establishing new start-up companies. Each year it sees major changes in technology and the marketplace and there are many more to come. This situation is reflected in this fully revised and updated edition of the report. Once again it details the underlying drivers, technologies, usage, applications and marketing strategies that are ongoing amongst the major suppliers old and new. Today's and tomorrow's competitive market trends are overviewed according to the opinions of interviewed players and literature searches.

This new edition includes market estimates for the base year, 2007, plus the five-year forecast. However, in response to client feedback some changes have been made over the last edition. Notably, for this edition the analysis of source materials and wafers to the opto industry has not been included but will be published later as a separate report. This is a reflection of how important this part of the business has become that it deserves a separate dedicated report.

The report has been restructured for the fourth edition. As before some half dozen principal component types are covered and these have been gathered into five basic chapters. Within each of these the forecast by geographic region, by sub-type, by application is provided. In addition to description of specific industry sector characteristics, attention is given to the market leaders in each category (fuller company information is given later in the profiles chapter).

This new edition once again includes profiles of several dozen semiconductor opto component suppliers. These were chosen as being the most commercially interesting companies which will figure prominently over the forecast period. However, while some of these are the biggest earners in this sector, others are included because of their likely future impact. The list of profiled companies is meant to illustrate the nature of the opto components business which presently numbers over 600 players of various kinds as shown by the company directory in the final chapter.

The opto business is no stranger to mergers and acquisitions. The past couple of years saw further consolidation. Coincidentally with the disappearance of some older names new names have come into play. In areas such as solid-state lighting companies are very quickly ramping up their manufacturing operations and making other key investments. This is especially conspicuous in SE Asia but mainland China is no less important for the manufacture and use of opto and other components. This is forcing the major vertically-integrated companies in Japan and elsewhere to continually reappraise their strategies. All of this makes for a very interesting marketplace one which does not stand still for very long but with huge rewards for those who get their strategies right.

Finally, it should be noted that this report is mainly concerned with *semiconductor* optoelectronic components. While it includes reference to modules and displays together with some kinds of non-semiconductor optoelectronic component, e.g. sensors, this is only where relevant to the main theme. Specifically, the market analysis and forecast excludes modules (e.g. transceivers), fibre optics, connectors, displays and electro-optic components. By contrast there is some coverage of arrays and/or assemblies of devices such as focal plane array detectors and high power diode lasers.

1.2 METHODOLOGY

For the fourth edition of this report information was gathered from primary and secondary information sources.

The survey of opto semiconductor component vendors also included a limited number of end-users. These were questioned as to present and future business and technical developments within the industry. Naturally, extensive use was also made of the Internet. While all suppliers now have their own websites their information content is very mixed. This is a reflection of the concern to have the right profile but not to give away commercially sensitive information. More than ever the creation and protection of intellectual property (IP) is a major preoccupation of all participants in this industry.

Statistics quickly become dated and this is regarded as secondary data which have been used to formulate trends rather than actual forecasts which have been based entirely on primary sources.

A spreadsheet model of the market was constructed using information from primary sources and this was cross-referenced and validated using other data sources and other reports. Opinions as to the main drivers within the industry are generally consistent but this sector has been no less over confident in its market forecasts than certain others in the electronics industry: the telecom/dotcom 'bubble' in the 1990s being one example. Correspondingly, it has also made serious errors of judgements such as with the lack of prediction of the impact of high brightness short wavelength LEDs and white LEDs. Less than two decades ago these were obscure products but today they are becoming a billion dollar industry in their own right. This is the nature of the industry and it would be foolish to rule out the introduction of another disruptive technology in the forecast period.

With this in mind, historical data can provide some details of likely market and technology patterns. From these it has been possible to make some forecast of future trends within the industry. Notwithstanding the historical input, the forecasts will always be at least in some part based on subjective estimates from those questioned.

Based on the previous editions the spreadsheet model of the market was further developed and compiled to produce the cross-references matrix of market value forecasts:

- By year 2007-2012
- Across geographic regions,
- Across industrial sectors, and
- By types and sub-types of component.

1.3 GENERAL FORECAST CONSIDERATIONS

Once again, it should be noted that this report is primarily concerned with *merchant* markets and to a lesser extent *captive*. Nevertheless, many optoelectronics suppliers have a proportion of their output geared to meeting their internal needs alongside the business of selling devices onto the open market. This varies from company to company as well as regionally and by component type etc. That said very few suppliers are completely one or the other.

As the end of the first new decade of the 21st century approaches, the optoelectronics industry has returned to a period of stronger growth. Because of this it is timely to provide these forecasts and analysis. Informed comment is essential for making optimised business plans to take advantages of the opportunities and help avoid the pitfalls.

It should be noted that when compiling the figures, statistics etc., tabular information is rounded to one decimal place. Also, it will be noted that main totals may not add exactly; this is due to rounding up/down from sub-total data. For the most part all market figures are quoted in US dollar millions.

The following is a list of abbreviations which are used: -

Types of Semiconductor Optoelectronic Component

LED	Light Emitting Diode	DET	Detector
LD	Laser Diode	IMG	Image sensors
SC	Solar Cell	OTH	Other devices
OC	Optocoupler		

Application Categories

AUT	Automotive	AER	Aerospace and military
COM	Computers, data and office	TEL	Telecommunications
CON	Consumable	OTH	Categories not included
above			
IND	Industrial		

1.4 DESCRIPTION OF REPORT CONTENTS

Chapter One, this chapter, is the **Report Introduction** summarising the report methodology with consideration to the prevailing and prospective market conditions.

Chapter Two is the **Executive Summary** of the report; here are the essential findings of the market forecast figures and short descriptions of industry trends such as technological innovations impacting future progress of the industry.

Chapter Three LEDs: in this chapter the market forecast for light emitting diodes is provided. This covers the spectrum from infra-red to ultra-violet and also covers white light emitters.

Chapter Four Diode Lasers: in this chapter the market forecast for diode lasers is given. This covers three basic types, IR, red and violet as well as high power lasers.

Chapter Five covers Detectors and Image Sensors which includes discrete devices, e.g. for optical pick ups as well as CMOS and CCD arrays for cameras and other sensing applications.

Chapter Six covers Solar Cells and other components including Optocouplers.

The application data are presented for the following industrial groups, namely:

- **Automotive**
- **Computer**
- **Consumer**
- **Industrial**
- **Military & Aerospace**
- **Telecoms**
- **Others**

A full 5-year forecast and analysis is provided by application and region.

Chapter Seven provides **Company Profiles of Optoelectronic Component Manufacturers**, from the largest manufacturers to new start-ups likely to have commercial impact over the next five years. A Top Twenty ranking of these companies is also included plus summaries of merger and acquisition activities in the past year.

Chapter Eight is the **Directory of Semiconductor Optoelectronic Component Manufacturers** which includes more than 400 entries, listed in alphabetical order by company name.

Chapter Nine is a range of appendices covering secondary information including Exchange Rates, Alphabetic List of Acronyms, Glossary of Terms.

SAMPLE PAGES

- Other applications such as centre high-mounted stop lamps in vehicles continue to provide strong demand for high brightness red lamps. Amber equivalents are also in demand for indicators / trafficator lamps.
- Certain types of LED for specialist application such as aircraft lighting command steadier prices.
- New applications are continuing to open up as the benefits of solid-state lamps become better understood.

Table 3.3 Market for LEDs by Wavelength 2007-2012 (US\$ million)

	2007	2008	2009	2010	2011	2012
IR	1114					
VIS	1098					
BLUE	1333					
WHITE	1057					
Total	4602					

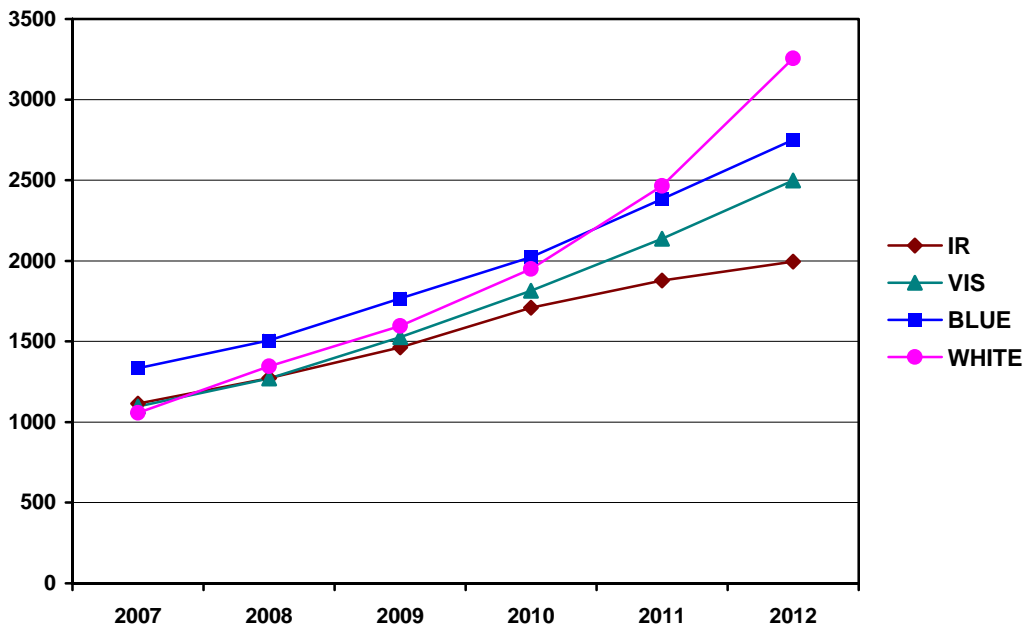


Figure 3.3 Market for LEDs by Wavelength 2007-2012 (US\$ million)

The growth of the worldwide LED market is via two basic routes:

- Expansion of existing markets including replacement of traditional light sources and displays
- Innovations in terms of new LED types or variants of existing ones creating new markets

LEDs had already been displacing existing neon and filament lamps by virtue of their uniquely attractive performance advantages. Also, the displays segment saw a tremendous upsurge in market size thanks to the advent of the blue LED completing the requirement for 3-colour full-colour displays.

- To a smaller extent LEDs have been displacing other opto component types, e.g. laser diodes in printing and short-haul telecoms. Even so LEDs will likely always find greatest application as low-cost light sources owing to limitations in their operating frequency and so on.

However, traditional lasers are not always best-suited for all applications. Generally, they are bulkier and more expensive than semiconductor lasers. Diode lasers have thus been able to take market share from traditional types. Most recently, violet laser diodes have been taking share from HeCd lasers as well as making new markets.

Key trends in the violet laser diode segment are as follows:

- The market is presently small but will grow fairly strongly. However this is mainly for instrumentation and printing equipment.
- Nichia launched a device having high enough power to be used in optical data recording and related products.
- However, existing red laser based DVD data storage is yet to reach its full commercial potential.

The January 1999 debut of commercial samples of the violet laser diode from Nichia Chemical Industries - the originator of the blue-green GaN LED - set in motion the plans for future generations of data storage products.

At the end of 2004 the first digital VCRs based on violet lasers were appearing in Japan. The year had also seen the commercial debut of high-end archival systems from US companies based on VLDs. These are high-capacity back up systems but their cost was high meaning that their general market appeal will be fairly limited. The market is presently dominated by the PS3 which plays movies as well as games followed by BRD players and BRD recorders.

Other factors likely to influence the progress towards full-scale market uptake of this promising new range of products included resolution of the industry standard. This was settled favour of the Sony-backed Blu-Ray when the Toshiba-backed HDTV format ceased.

4.3 MARKETS BY APPLICATION

The market is broken down according to each generic application sector type in the following series of tables. As shown in Table 4.21, the telecoms sector market value is estimated to be US\$740 million with a forecast CAGR of 12% over the next five years it will have increased to be worth over US\$1.2 billion by 2012.

Table 4.21 Laser Diodes Telecom Market by Region 2007-2012 (US\$ million)

	2007	2008	2009	2010	2011	2012
N America	156					
Japan	191					
Europe	125					
Asia Pacific	185					
RoW	83					
Total	740					

As shown in Table 4.22 the computer sector market value is estimated to be US\$908 million with a forecast CAGR of 22% over the next five years it will have increased to be worth US\$2.5 billion by 2012.

Table 4.22 Laser Diodes Computer Market by Region 2007-2012 (US\$ million)

	2007	2008	2009	2010	2011	2012
N America	253					
Japan	240					
Europe	109					
Asia Pacific	263					
RoW	44					
Total	908					

7.5 AVAGO TECHNOLOGIES

Palo-Alto, CA, USA-based Avago Technologies was formed in late 2005 when Agilent Technologies Inc (which was itself spun out of Hewlett Packard in 1999) was acquired by KKR and Silver Lake Partners for \$2.7 billion, and the name was changed to Avago. For the year-ending October 2007 Avago reported net revenue of \$1.5bn, essentially flat on the prior year. GAAP net loss for FY 2007 was \$(159m), whilst R&D expenditure for FY 2007 was \$205m.

- Avago in July 2007 completed its acquisition of Infineon Technologies AG's Polymer Optical Fiber (POF) business unit based in Regensburg, Germany. Infineon's POF business is the leader in the fast growing market for automotive multimedia 'infotainment' networks and transceivers for safety systems. This business unit also provides transmitters and receivers for industrial drive controls and home broadband services. All research and development, marketing, and manufacturing employees of Infineon's POF group became Avago employees and continue to be located in the present Regensburg facility.

The company claims to be the leader worldwide in:-

- Red and amber LEDs for electronic signs and signals
- Optical encoders used in inkjet, laser and photo printers
- Photo-IC optocouplers for plasma TVs
- Optical mouse sensors
- Infrared transceivers for notebooks and PDAs
- Additionally, Avago is the world's only high-volume manufacturer of microwave FBAR (film bulk acoustic resonator) filters

Facilities

The Company has silicon and III-V manufacturing in the USA and Singapore, with assembly and test in Malaysia and Singapore. Contract manufacturers are used throughout Asia for Packaging and Test. Avago also has facilities in Germany regarding to its newly-acquired POF business from Infineon.

- Avago utilizes a proprietary automated test system for LEDs.

Avago has industry leading research and development capabilities in several III-V technologies, including VCSELs, FP lasers, DFB laser and uncooled EML lasers.

Products

Avago manufactures products for industrial and automotive, wired infrastructure, wireless communications, and computer peripheral applications. Avago has a wide range of optoelectronic products including LEDs, LED displays, light bars, optical navigation sensors, optical receivers, optical transceivers, optical transmitters, and optocouplers.

The company was the first to offer LED displays. It is also a leader in VCSELs (although primarily for captive use), and a leading supplier of analog interface components for communications, industrial and consumer applications, as well as offering the industry's broadest portfolio of IrDA transceivers, interface ICs and discrete emitters and detectors.

Avago is the technology leader in high speed, low voltage and high integration optocouplers, and offers the widest range of packages and worldwide safety approvals. Key products include multi-channel and bi-directional digital optocouplers, intelligent power module gate driver interface devices, 3.3 V and 5 V digital optocouplers, 100 Kbaud to 50 MBaud digital logic gate optocouplers, 100 MBd magnetic isolators, gate drive and current sense optocouplers, solid state relays (MOSFET), phototransistors and analog and high-performance hermetic optocouplers.

- Avago Technologies in March 2008 announced that its ambient light photo sensor with logarithmic current output was selected as one of EN-Genius Network's 2007 Product of the Year Award winners.

Examples of recent products include: -

- Avago announced a new miniature autofocus LED for use in ultra-slim digital still camera and cell phone designs. With a footprint that can fit on the head of a pencil eraser, Avago claims the ASMT-FJ30 orange flash LED is the thinnest autofocus LED in the industry and can play a key role in helping digital still camera and camera phone designers to further reduce the overall thickness of those applications. It is suitable for use as an auxiliary autofocus flash in camera applications that require long distance illumination and a narrow radiation pattern.
- With 2.5A maximum peak output current, Avago's ACPL-K312 gate drive optocoupler successfully addresses low power consumption requirements and provides high noise immunity. Fast IGBT switching improves efficiency and makes the new gate drive optocoupler ideal for IGBT/MOSFET gate drives, AC/brushless DC motor drives, industrial inverters and switching power supplies. The ACPL-K312 offers low power consumption with a low I_{cc} of 3.0 mA and high CMR of 15 KV/ μ s@ $V_{cm} = 1.5kV$. Low I_{cc} also allows for a boot-strapping topology on high-side drive which eliminates the need for an auxiliary power supply and provides smaller storage capacitance. The ACPL-K312 is housed in a stretched SO-8 package and provides 8 mm creepage and 8 mm clearance which reduces up to 40% of board design space versus standard 300 mil DIP packages.
- In February 2008 the company announced the addition of four new colors to its series of super half-watt power PLCC-4 surface-mount LEDs for automotive and electronic sign applications, thereby offering a full range of colors for 0.5W PLCC-4 LEDs.
- Avago announced a new ambient light sensor, the APDS-9007, with a precise, logarithmic output response over a wide range of lighting conditions. With logarithmic output, the new sensor is designed to cover a wide range of brightness (3 lux to 70 K lux). This makes ambient light sensing suitable for mobile and other applications, such as outdoor lighting and solar panels, which may be operated under direct sunlight. Designed to closely follow the human-eye spectral response curve, Avago's APDS-9007 ambient-light photo sensor produces reliable sensor reading under diverse lighting conditions. The APDS-9007 is also designed to significantly reduce power consumption and save battery life in portable and mobile devices by enabling the auto adjustment of the LCD backlight intensity and keypad lighting.
- Avago's series of Extra Bright II oval Red, Green and Blue LEDs are suitable for the electronic signs and signals (ESS) market. The Company's series of 4 and 5 mm oval through-hole LED lamps have been specifically designed for use in full color ESS applications such as passenger signs, variable message signs, scoreboards and channel lighting. The HLMP-Lx63 (4 mm) and HLMP-Hx63 (5 mm) series of LEDs provide an oval shaped radiation pattern, a wide viewing angle and high illumination intensity to make display characters viewable from any angle in bright sunlight. Moreover, these LED lamps have a very smooth, matched radiation pattern to ensure consistent color mixing in full color applications. Each lamp is made with advanced optical grade epoxy to offer superior high temperature and high moisture resistance in outdoor ESS applications.
- Avago has a new line of RoHS-compliant infrared discrete emitters which are specifically designed for a wide range of industrial and consumer applications, such as home appliances, notebook, gaming devices, parking meters and smoke detectors. The ASDL-4360/4560/4561 are high-performance 850-885 nm emitters in a surface mount package. The ASDL-4860 is a high power 850 nm IR emitter in a top emitting surface mount, ultra low profile package. It is packed with high performance features ranging from brightness, speed and excellent heat dissipation with its capability to drive at 500mA. Additionally, Avago has added the ASDL-4263/4264, which are 940 nm emitters in through-hole package.
- Avago in summer 2007 announced a new line of high brightness red, amber, and orange AlInGaP PLCC-4 SMT LEDs for use in interior and exterior automotive and electronic signs and signals applications. These top-mounted lensed LEDs provide high reliability, a narrow 50° viewing angle and a matched radiation pattern. The HSMx-A46x series of Power PLCC-4 SMT LEDs are single-chip packages that have been developed to tolerate the harsh conditions found in automotive, and indoor and

outdoor sign applications to produce higher light output compared to PLCC-2 SMT LEDs. The HSMx-A46x series of LEDs are ideal for use in instrument panel backlighting, dome lighting, turn signals and CHMSL in automobiles, as well as interior/exterior variable message signs. The HSMx-A46x series of LEDs can also be used for push button and signal lighting in industrial applications.

- 1-Watt warm white LEDs were added to the family of Moonstone™ power LEDs. Available in one of the industry's thinnest packages, Avago's ASMT-MY00 LED provide designers of solid-state lighting applications with a competitively robust and reliable package that provides high brightness illumination and easy installation. The ASMT-MY00 is ideal for use in applications that require ultra-high-brightness LEDs, such as decorative lights, garden lights, task and reading lights, architectural, accent and marker lights.
- In March 2007 Avago announced the completion of full Telcordia GR-468-CORE qualification of its next-generation 850 nm VCSEL (in full production). Products including 10 Gb/s Ethernet and 8 Gb/s Fiber Channel transceivers and 6.25 Gb/s Parallel Optics transmitters based on Avago's next-generation VCSELs are scheduled for commercial release later in 2007.
- The company's series of high-brightness warm white through-hole (TH) LEDs in a 5 mm round package are suitable for use in a wide range of solid-state lighting and illumination applications. Available in a several packaging options, Avago's HLMP-CYxx TH LEDs target designers of retail and commercial display lighting, as well as street and portable lighting applications. The HLMP-CYxx series of 1-3/4 high intensity white LED lamps, which are based on InGaN material technology, are untinted and non-diffused, and incorporate precise optics which produce well-defined spatial radiation patterns at specific viewing angles (available in 15-, 23-, 30- and 50-degrees).
- Avago announced an addition to its intelligent gate drive optocoupler product family with the ACPL-332J and -331J series of high-speed IGBT optocouplers which are easy-to-implement in industrial inverter and power management applications, such as isolated IGBT/power MOSFET gate drives, AC and brushless DC motor drives, industrial inverters and uninterruptible power supplies. Avago's highly integrated ACPL-332J and -331J intelligent gate drivers improve precision and efficiency of motor inverters by featuring Active Miller Clamp, integrated Vce desaturation detection, under voltage lockout protection, built-in IGBT shut down, and isolated open collector fault feedback. Active Miller clamping eliminates the need for a negative gate drive, saving negative power supply and PCB space. Additionally, Avago's new gate drive optocouplers enjoy an industry-best CMR which ensures reliable operation under noisy environments.

Alliances

In 2005, the company sold its stake in joint venture company, LumiLeds Lighting to its partner, Philips. Since then, Philips has acquired the remaining outstanding shares in Lumileds; in 2006 it became a wholly-owned subsidiary of Philips.

Other alliances include:

- The Company is a member of IrDA (Infrared Data Association), which promotes interoperable, low cost infrared data interconnection standards.
- Avago (as Agilent) was a founding member of the Optical Internetworking Forum (OIF), an open forum focussed on accelerating the deployment of optical internetworks.

8 COMPANY DIRECTORY

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WS: <http://www.yokogawa.com/opt/top/opt-toppage-en.htm>
Measurement, control and IT company, has a large photonic components factory built to meet demand for 10- and 40-Gb/s components. Yokogawa signed a deal to supply high-speed III-V components to Fujitsu. It first revealed plans to build the \$230m fab in June 2005, along with brief details of a very fast optical packet switch that it had developed for 40-Gb/s optical networks.

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