

VCSEL – Vertical Cavity Surface Emitting Laser

Patent Landscape Analysis – November 2018

*3D sensing in the Apple iPhone X paves the way for new VCSEL opportunities.
How is the VCSEL-related patent landscape impacted by the rise of new applications?*



REPORT OUTLINE

- VCSELS
- Patent landscape analysis
- November 2018
- Ref.: KM18007
- PDF >160 slides
- Excel file >10,500 patents
- €6,490 for a multi-user license

REPORT'S KEY FEATURES:

- **IP trends**, including time-evolution of published patents, and countries of patent filings
- Patents' **current legal status**
- Ranking of **main patent assignees**
- **Promising applications** IP analysis: Datacom, Laser printing, Display, Laser mice, Gas sensors, Atomic clocks, Medical imaging, Automotive, Consumer, etc.
- **Key patents** and granted patents nearing expiration
- **Key players' IP position** and **relative strength** of their patent portfolios
- Key players' **IP profiles**: Ricoh, Canon, Epson, Fuji Xerox, Finisar, Broadcom, Sony, Philips, Lumentum, Osram, ams, Trilumina
- **Excel database** containing all patents analyzed in the report, including technology segmentation

RELATED REPORTS

- [iPhone X Proximity Sensor and Flood Illuminator – Patent to Product Mapping](#) (Knowmade)
- [GaAs Wafer and Epiwafer Market: RF, Photonics, LED and PV Applications](#) (Yole Développement)
- [VCSELS - Technology, Industry and Market Trends - 2018](#) (Yole Développement)
- [3D Imaging & Sensing 2018](#) (Yole Développement)
- [STMicroelectronics' Time of Flight Proximity Sensor & Flood Illuminator in the Apple iPhone X](#) (System Plus Consulting)
- [Apple iPhone X – Infrared Dot Projector](#) (System Plus Consulting)

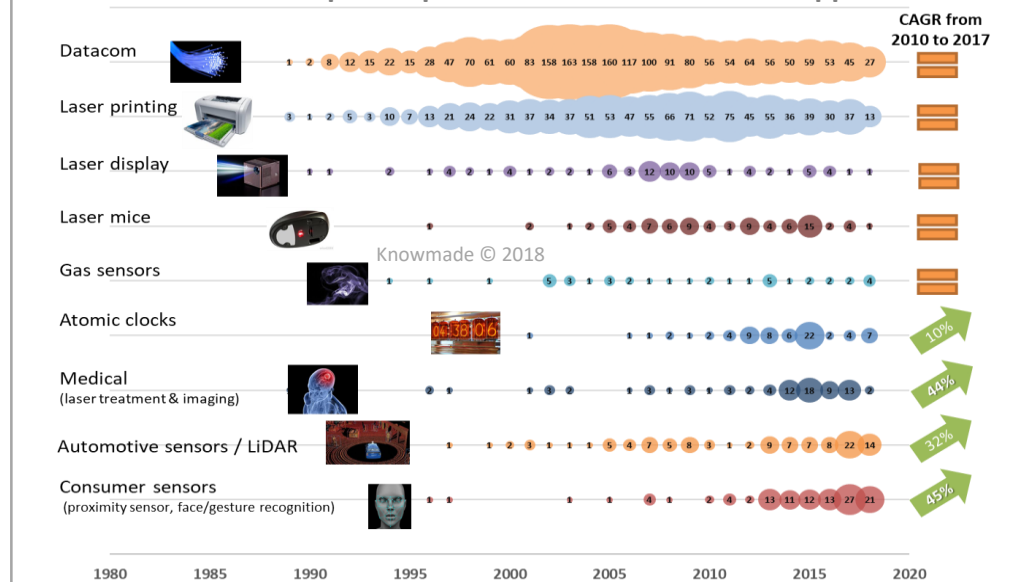
NEW APPLICATIONS DRIVE CURRENT VCSEL PATENTING ACTIVITY

The release of the Apple iPhone X in 2017 and its range of optical sensors triggered **new opportunities for VCSEL players** to address a **high-volume market**. Apple's competitors are now developing 3D sensing functions as well. However, the consumer industry is just the starting point for this new VCSEL area. Indeed, the rise of autonomous and robotic vehicles as well as medical imaging and gas sensing offer a wide range of high-volume applications that could drive the growth and development of VCSEL technology and the related market. Propelled by these new applications, the VCSEL market will enjoy a 48% Compound Annual Growth Rate (CAGR) from 2017 to 2023 and reach more than \$3.5B, according to Yole Développement.

At the beginning of this new era, **understanding the Intellectual Property (IP) position and strategy** of historical VCSEL IP players as well as identifying the **IP newcomers** and the threat they represent is crucial. In this report, Knowmade has thoroughly investigated the **patent landscape related to VCSELS, VCSEL arrays and Vertical External Cavity Surface Emitting Lasers (VECSELS)**. Our patent landscape analysis shows significant changes in the VCSEL competitive landscape.

VCSEL-related patent activity began in the late 1980s amongst US and European datacom players like Motorola, Finisar, Broadcom and NEC. Since 2010, **decreasing IP activity related to datacom and laser printing has been balanced by the emergence of new applications like LiDAR and 3D sensing**. New applications like facial and gesture recognition, LiDAR and gas sensors and their promising market value have pushed **many newcomers** to enter the VCSEL-related IP landscape, including Apple, Heptagon/ams, Stanley Electric and LG Innotek. 3D sensing and LiDAR currently appear as the most attractive applications for main VCSEL IP players like Ricoh, Finisar, Sony, Osram and Lumentum. This change in IP strategy heralds future shifts in the VCSEL-related market. Today, the IP landscape related to VCSELS for 3D sensing is young and unsettled. A race has just started between the strong historical VCSEL IP players coming from datacom or laser printing and the newcomers/specialized players like Philips and Trilumina that need to strengthen their IP position. Thus, VCSEL IP players are entering a phase where M&A, litigation or IP acquisitions will be key.

Time evolution of patent publications for main VCSEL applications


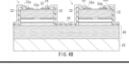


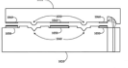




Scope of the patent landscape

REPORT SCOPE

In this report, Knowmade has selected and thoroughly investigated the **>4,200 inventions** related to **VCSEL manufacturing and applications** that have been **published worldwide**. These patents were filed by more than **900 different patent applicants**.

This report also provides a deep analysis of patents related to **promising technologies** and **main players' IP portfolios**.

Example	Selected patents			Example
	VCSEL devices and systems	VCSEL applications	Excluded	
Patents related to VCSEL or VECSEL manufacturing and process	X			 DE202018001341 VCSEL with improved optical and electrical limiting APPLE
Patents related to VCSEL or VECSEL array	X			 US7957447 Vcsl array device and method for manufacturing the vcsl array device FUJII XEROX
Patents claiming systems and devices that specifically use VCSEL (Lidar, Printing, etc.)		X		 KR0117861 Optical source and detector using vertical cavity surface emitting laser diode SAMSUNG ELECTRONICS
Patents describing VCSEL, VECSEL or VCSEL array as the preferred solution to perform an operation		X		 EP3301477 System for determining a distance to an object XENOMATIX
Patents describing a systems and devices that can use either edge emitting laser or VCSEL			X	 US9830937 Horizontal cavity surface emitting laser assembly features for heat assisted magnetic recording SEAGATE TECHNOLOGY
Patents related to edge emitting laser (EEL) or any other infrared emitting device			X	 US20170365982 Edge-emitting semiconductor laser and method for operating a semiconductor laser OSRAM
Patent related or describing a surface emitting laser with a horizontal cavity			X	 EP3297105 Driver circuit for a laser diode STMICROELECTRONICS

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REPORT'S MAIN ASSETS

- Identifying the newcomers and evaluating their portfolios' strengths and weaknesses

In this report, Knowmade discusses the **more than 50 newcomers** that have entered the **VCSEL IP landscape** in the last seven years. **Most relevant newcomer IP profiles** are analyzed within, based on their market position, portfolio size, and IP activity growth.

- Understanding the key players' patented technologies and current IP strategies

More than **900 patent applicants** are involved in the **VCSEL IP patent landscape**. This report reveals the **IP position of key players** through a detailed analysis of their patent portfolios. We also provide an understanding of these players' **patented technologies**, their **IP strategy**, and their **capability to limit other firms' patenting activity and freedom-to-operate**. Moreover, we discuss the **relative strength of the top patent owners** as derived from their patent portfolios size, prior-art contribution, geographic coverage, and IP blocking potential, highlighting their most **valuable patents**.

- Analyzing IP players' position on promising applications and their main inventions

This report provides an understanding of **IP players' positions on promising applications**. **Main IP players and key patents** are presented for each segment, along with an **understanding of the current technical challenges addressed in the patents**.

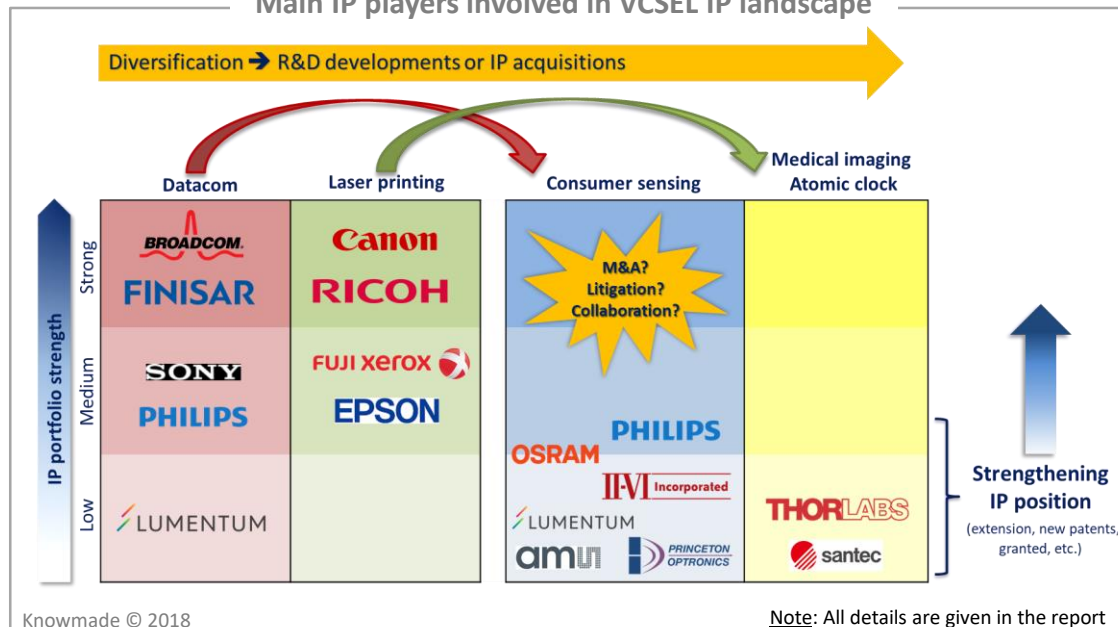
- Identifying and understanding key patents related to VCSEL manufacturing

This report provides a detailed **analysis of key patents** rated as **seminal, blocking and/or promising** related to **VCSEL manufacturing**. Furthermore, patents related to **yield improvement** and **eye safety** have also been identified and analyzed in order to understand the actual solutions to answer these technical challenges.

USEFUL PATENT DATABASE

This report also includes an **Excel database** with the **>10,500 patents and patent applications** analyzed in this study. This useful patent database allows for **multi-criteria searches** and includes patent publication numbers, hyperlinks to the original documents, priority date, title, abstract, patent assignees, and **technological and application segments**.

Main IP players involved in VCSEL IP landscape



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Note: All details are given in the report

COMPANIES MENTIONED IN THIS REPORT (NON-EXHAUSTIVE LIST)

RICOH, FINISAR, SEIKO EPSON, BROADCOM, CANON, FUJI XEROX, HONEYWELL, PHILIPS, SAMSUNG, AGILENT TECHNOLOGIES, OSRAM, HEWLETT PACKARD, FURUKAWA ELECTRIC, MOTOROLA, UNIVERSITY OF CALIFORNIA, SONY, NEC, KODAK, AT&T, PAKON, OPTICAL COMMUNICATION PRODUCTS, IBM, CREO MANUFACTURING AMERICA, FAR EAST DEVELOPMENT, FPC, LASER PACIFIC MEDIA, NPEC, QUALEX, CIELO COMMUNICATIONS, MITEL SEMICONDUCTOR, SUMITOMO ELECTRIC, XEROX, NOKIA, PANASONIC, THORLABS, OCLARO, AGERE SYSTEMS, TOSHIBA, LUMENTUM OPERATIONS, GENERAL ELECTRIC, ROHM, ARASOR, INTEL, INFINEON TECHNOLOGIES, NOVALUX, MELLANOX TECHNOLOGIES, MURATA MANUFACTURING, ADAPTIVE OPTICS, APPLE, TRANSAMERICA, PRAEVIUM RESEARCH, VERTILAS, SIEMENS, MITSUBISHI, KYOTO UNIVERSITY, HITACHI, II VI LASER ENTERPRISE, AVANEX, BOSCH, NIPPON TELEGRAPH AND TELEPHONE, FUJITSU, and more.

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ABOUT KNOWMADE

Specialized in the analysis of patents and scientific information, **Knowmade** provides technology intelligence and IP strategy consulting services. The company supports the business development of R&D organizations, industrial companies, and investors by offering them a deep understanding of their IP environment and technology trends.

Knowmade operates in the following industrial sectors: compound semiconductors, power electronics, RF & microwave technologies, LED/OLED lighting & display, photonics, memory, MEMS & sensors, manufacturing & advanced packaging, battery & energy management, biotechnology, pharmaceuticals, medical devices, medical imaging, and agri-food & environment.

Knowmade's experts provide prior art search, patent landscape analysis, scientific literature analysis, patent valuation, IP due diligence, and freedom-to-operate analysis. The company also delivers litigation/licensing support, technology scouting, and IP/technology observation. **Knowmade's** analysts combine their technical and patent expertise with powerful analytics tools and proprietary methodologies, delivering invaluable patent analyses and scientific reviews.

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VCSEL – Vertical Cavity Surface Emitting Laser

Patent Landscape Analysis – November 2018

Ref.: KM18007

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Signature:

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IBAN: : FR76 1460 7003 6360 6214 5695 139

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