3D Sensing/Imaging – The Next Killer Application for VCSEL? Yes If …

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Abstract

VCSELs are not new but have recently come back on the front of the scene with the release of the 2017 Iphone X, that use such device for 3D sensing/imaging features. Less than one year after the release of Apple's flagship, its competitors have followed the same trend, and VCSEL has become a hot topic in the smartphone industry.

The authors have thoroughly analyzed the VCSEL industry landscape, including VCSEL technological status and its strengths and weaknesses for 3D sensing/imaging applications.

INTRODUCTION

Data communications (datacoms) was the first industrial application to start integrating Vertical Cavity Surface Emitting Lasers (VCSELs). Their sweet spot has been in short-distance data communication due to their low power consumption and competitive price compared to Edge Emitting Lasers (EELs). Driven by the development of datacenters, the VCSEL market and production boomed in the 2000s with the internet's popularity, and then grew steadily. Some new applications for VCSEL emerged, like laser printers and optical mice, but weren't strong growth drivers.

Only in 2014, almost 20 years since the first use of the technology in datacom, VCSELs started to make their way into high volume consumer smartphones. But this coupling with sensors for proximity sensing and autofocus functions was only the beginning of the VCSEL success story.

In 2017 Apple released the iPhone X, with a 3D sensing function based on this technology. The iPhone X integrates three different VCSEL dies for the proximity sensor and the Face ID module, and made the VCSEL market explode in 2017, propelling overall revenue to ~$330M.

AFTER 20 YEARS, THE VCSEL BUSINESS HAS FOUND ITS KILLER APPLICATION – AND IS LIKELY TO EXPLODE

Good iPhone X sales have triggered the interest of other smartphone brands in this breakthrough 3D sensing function. Less than one year after the release of Apple's flagship, its competitors have followed the same trend and started to integrate 3D sensing technologies. Xiaomi and Oppo were the quickest on the draw, with the Xiaomi Mi8 and the Oppo Find X models presented in the second quarter of 2018. Vivo and Huawei followed rapidly, still in 2018. Only question remain toward Samsung and its next Galaxy S10 which may favored fingerprint under display rather than 3D face recognition.

In this context, the explosion of VCSEL demand initiated in 2017 will persist for the next five years, potentially multiplying the business opportunity more than tenfold; from $330M in 2017 to $3.5B in 2023 (Fig. 1). During that time, the technology might also find some new growth drivers into some other high volume applications such as automotive Light Detection and Ranging (LiDAR) or gas sensors [1].

This trend will likely cause rapid evolution in the VCSEL industry in coming years in the form of investment, new entrants and mergers and acquisitions (M&A).

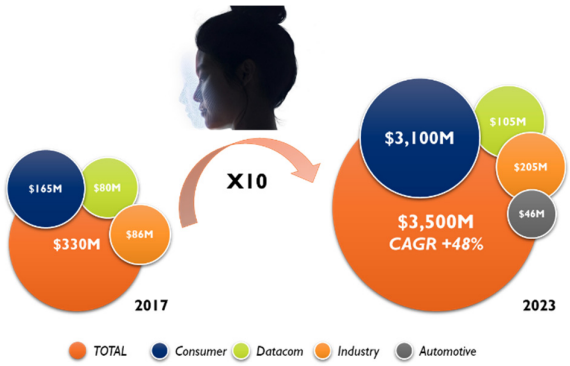

Fig. 1 VCSEL market forecast by segment.

NOT ALL VCSELS ARE CREATED EQUAL! APPLICATIONS DRIVE DEVICE SPECIFICATIONS

The variety of applications using VCSELs involves a variety of specifications at the device level, mostly in size, output power and number of laser cavities. As a result, the surface of a VCSEL chip or array can range from less than 0.1mm² for datacom and proximity sensing applications to more than 70mm² for LiDAR application (Fig. 2). As the VCSEL surface increases with the needed output power, so do the number of cavities and the complexity of the manufacturing process, mostly in 'front-end' chip fabrication.

The current shift from the datacom industrial era to the 3D sensing/imaging consumer era is likely to have a strong impact on manufacturing expertise related to

VCSELs. Typically, whereas datacom uses 3” or 4” diameter wafer manufacturing processes, consumer applications requires 6” wafer processing to hit their cost targets and also larger VCSEL arrays. This evolution has a direct impact on manufacturing yield, which is still low today for 6” processes. This is mostly related to epiwafer manufacturing, for which the epitaxy uniformity is still a major challenge, compared to 3” or 4” wafer epitaxy. Typically, a difference of 1% in the layer thickness will result in a wavelength deviation of 10nm. And knowing that epitaxy yield will drive overall VCSEL manufacturing yield, it is now at the heart of VCSEL industry investments in key equipment for MOCVD and metrology.

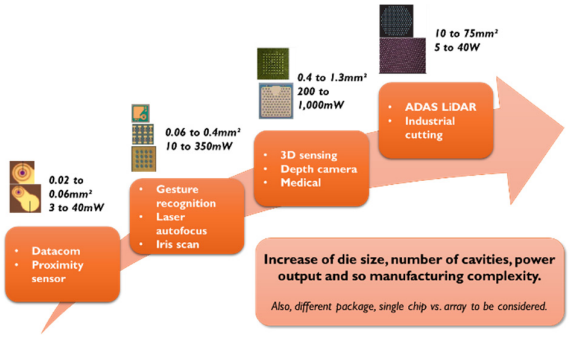

Fig. 2 VCSEL specification vs application requirements.

A NEW WAVE OF INVESTMENT AND M&A HAS STARTED

VCSEL market volume is expected to grow from 652M units in 2017 to more than 3.3B units in 2023 at a 31% compound annual growth rate for this period ($CAGR_{2017-2023}$). This booming trend is likely to trigger interest in VCSEL technology at many industry levels (Fig. 3), including OEMs, integrators, device manufacturers, epi houses, foundries, equipment and material suppliers. To be able to follow this booming demand, more than 100 MOCVD reactors will be needed, which is likely to please companies that supply this equipment, such as Aixtron, Veeco and Taiyo Nippon Sanso.

We expects therefore strong investment and proliferation in the VCSEL industry with the entry of several new players, mostly from the LED industry, whose technology is similar. Since 2016, we have already seen some M&A, like ams’ acquisition of Princeton Optronics and Osram’s deal for Vixar and investment in manufacturing expansion or supply chain reinforcement, like Apple investing $390M in Finisar. We expects the bulk of these investments to occur in the coming years.

And once VCSEL hype reaches its peak, we also expects a necessary consolidation phase with more M&A occurring at all level of the supply chain and to support different strategies:

- Vertical integration - from system to module and/or from module to component
- Application diversification - from datacom to sensing
- Business diversification - from LED or EEL devices to VCSELs

Fig. 3 VCSEL players’ ecosystem.

CONCLUSIONS

3D sensing/imaging is definitely the next killer application for VCSEL. But the technology still need some development at the device, module and system level to fulfill requirements of smartphone OEMs and make 3D sensing/imaging explode for such applications. Once the technology will be qualified for smartphones, allowing for further cost reductions, new relay of growths might emerge such as LiDAR or 3D printing.

REFERENCES

[1] P. Mukish, P. Boulay, “VCSEL Market, Technology and Industry” Yole Développement, May 2018.