Foundry-based Optical Components Changing the World

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Abstract:

The evolving fabless, foundry-based model to manufacture optical devices for the growing 3D sensing and optical communication applications is changing our daily lives. A world of facial recognition, autonomous vehicles, and terabit data communication is hungry for more capacity and lower cost solutions. Much progress has been made over the past 5 years in the manufacturing capability, cost reduction, and worldwide deployment of III-V foundries of optical devices. The fabless model has been widely adopted by established companies, as well as, startups. What does a state-of-the-art III-V foundry look like today and where is it headed? What the Silicon industry has done for decades, the III-V optical component manufactures have just begun to explore. How will optical component suppliers differentiate from one another and compete with module integrators and end users, who themselves can establish their own fabless component supplies? The future is bright for optical component suppliers, but the path to success requires thinking strategically. In light of recent US Government initiative, CHIPS for America Act, the geopolitical impact will be significant. The result of recent supply shortages and political uncertainties in Asia, has prompted the US to set a goal to bring back semiconductor fabrication onto the mainland. This effects mainly the Silicon industry, but certainly has ramifications to the compound semiconductor supply of optical and RF chipsets needed for national security of internet communication and defense applications. The bottom-line is that foundry produced optical components are changing the world – how we communicate, purchase our groceries, secure our homes, watch our entertainment, and how we attend our classes and beyond.

WHAT WOULD WE DO IF THE INTERNET WAS FREE?

In a recent analysis done by Reviews.org they found the following about internet costs.

"We compared prices across 22 different internet providers and found the average internet plan costs around $61 per month. If that seems high, it's not just you. That average cost is up from $57 a month in December 2020."[1]

To most middle-class households this cost is relatively cheap, but add on the cost for cellphone coverage, streaming services of entertainment/sports/music/news, cellphone cost, equipment rental, and the total household cost can be well over $500/mos. This results in a total spend of $6,000US per year per household. Many lower income families cannot afford this expense, leading to an education divide in the US.

Let's take a look at how the cost of data communication has declined. In 1996, the first year that VCSELs were used to introduce the one gigabit Ethernet transceiver, the cost of the module was $500. In today's dollars that translates to $888 in 2022 after inflation and the cost of living is added. In contrast, the $500/gigabit of optical connectivity costs $1/gigabit today. A 100 gigabit Ethernet module for the data center costs less than $100 in 2022.

Foundry-based VCSEL, vertical cavity surface emitting laser, production has dropped the cost of each chip by an order of magnitude compared to low-volume in-house production. Each in-house fab facility has the burden of the entire cost of owner on the products that it produces. In a foundry model, the cost of ownership is shared among all the users and any unused capacity by one customer is easily taken up by another customers. This has enabled startup optical companies to compete with well-established optical corporations. The later driving larger optical

suppliers to accelerate growth through acquisition to improve capacity utilization. If all optical and RF manufacturing moves to the fabless model, there will be a time when the internet might be free. Maybe paid for by part of the tax that each household pays or paid for by all the ads and services in the Metaverse.

WHAT HAS $1 VCSELS ENABLED IN THE WORLD?

In the past 5 years, the onset of foundry-based VCSELs has enabled a new industry and application in 3D sensing (3DS). First introduced as facial identification to unlock your cellphone back in 2017. To enable this application, upwards of 1,000 six-inch (150mm) wafers need to be processed per week. This seems trivial for Silicon foundries, but it was unheard of in the optical component industry. Back then the state of the art was four-inch GaAs and three-inch InP wafers processed at 10s of wafers per week. To be fair, there was no optical application that required 1,000s of six-inch wafers per week. Optical communication in the data center is still 1/1000th the volume required for consumer electronics. The 3DS application has not stopped at facial recognition. It has expanded to the growing autonomous vehicle LIDAR application, home security, commerce security (think no credit card or phone, just your face for payment), and eventually to the Metaverse.

We will soon live, work, play in a completely mixed reality (MR) that combines virtual and augmented reality together while working from home or out about in the city.

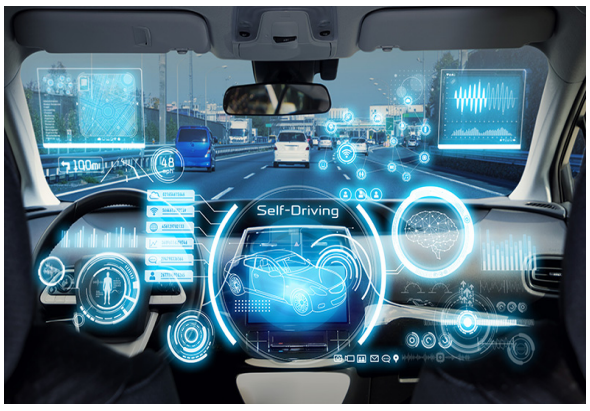

Figure 1 Future 3DS applications in self-driving cars with mixed reality heads-up display. [2] Viavi Solutions

In the Metaverse, companies will compete for your attention and dollars by providing virtual or real-world ads from clothes, food, entertainment, to political support and non-profit causes. In order to gain more participation in the Metaverse, large companies will eventually provide free 3DS glasses, internet, and other incentives for you to join their Metaverse. It's the same model as the electric toothbrush, which costs less than $10US upfront, but replacement toothbrush parts cost $30US for a pack of 2. The Metaverse will enable virtual or mixed reality work and play lowering the carbon output that use to come from commuting to work or having to build large office buildings to house workers. There will still be leisure travel and sports events for those who want to be physically present, but others, who traditionally could not afford to fly or attend a major sporting event, will be able to be virtually present in the future.

CONCLUSIONS

The increasing capability of III-V foundries to manufacture optical components has resulted in tremendous volume increases enabling new optical applications. Datacom optical solutions use 10's of wafers per week while consumer electronics solutions (e.g. Facial recognition, 3D sensing) uses 1000's of 6" (150mm) wafers per week. The increased foundry capacity, combined with higher yields, have driven costs of optical components lower, enabling new applications (e.g. Mixed reality, Metaverse, AI) that will change the world. The cost for 1 Gigabit of optical data center communication is less than $1, prompting the question, what will the world do when the internet is free and universal? The future of work, travel, entertainment, will all be affected by the increased availability of high-volume, low-cost, optical solutions.

REFERENCES

[1] www.investopia.com

[2] https://www.viavisolutions.com/en-us/osp/solutions

ACRONYMS

VCSEL: Vertical Cavity Surface Emitting Laser