ePIXfab

JePPIX
Platform for Photonic Integration

The Future of MPW Services

Online Panel Discussion

Multiproject wafer (MPW) services for integrated photonics started about fifteen years ago, twenty years after they had first been pioneered to great effect in the microelectronics sector. They have now become well established for a variety of PIC-platforms including silicon photonics, silicon nitride and indium phosphide. MPWs can reduce costs through sharing – fab, process and focusing on essential building blocks, and using process design kits (PDKs) to accelerate technology development through the separation of design and production. The panellist reflected on the current use of MPW services, the similarities and differences with microelectronics MPWs, and what we can learn on the route to manufacturing.

EUROPEAN CONFERENCE ON INTEGRATED OPTICS

ePIXfab and JePPIX jointly organised an online panel discussion ahead of the 2020 edition of ECIO on the topic: Will MPW services for integrated photonics grow or decline in the next 10 years? The following questions were put to the panellists:

1. Is a photonic MPW service more than just an entry-point for researchers?
2. What does it take for photonic MPW to go the same route as electronic MPW?
3. Can photonic MPW combine a low-barrier entry with a route to process differentiation?

This discussion was held ahead on 22 June, on the eve of the 2020 edition of ECIO with co-chairs Roel Baets and Kevin Williams and panellists:

Romano Hoofman (Europractice)

Mike Wale (UCL, TU/e)

Michael Hochberg (Elenion)

Francisco Rodrigues (PICadvanced)

Pieter Dumon (Luceda)

Geert Appeldoorn (SMART Photonics)

Kavitha Buddharaju (AMF)

More than an entry-point for researchers

Low barrier entry is the calling card for MPWs. According to Hoofman they will keep providing an initial route to get to a new product prototype fabricated, which is particularly important for start-ups. Appeldoorn supports MPWs for both businesses and academics, as photonics is a growing industry. The standardization that enables MPWs has a critical role. It makes it easy for users to design circuits with high-end building blocks on a par with customized development. MPWs give users a head start on their way to product development. The diversity in foundries is seen as a positive by Hoofman as the fierce competition drives down the cost and will further mature and diversify the technology offering.

Industrial product development and prototyping on MPWs is not always the obvious choice though. The fundamental advantage is that MPWs lower the cost barrier, but everything else can be a disadvantage according to Hochberg. If the most expensive cost for your business is maintaining staff, then it is often the case that dedicated mask runs can be more appropriate. And as you shift from research mode to product development you often shift from MPW to full reticule. Receiving chips instead of wafers can mean it is not possible to get wafer scale data and insights into the volume manufacturability of your design. Also, post-processing cannot be easily performed. But according to Dumon, many small applications requiring small numbers of chips will never be able to afford anything except MPW, and dedicated runs will only be accessible to larger companies and well-funded start-ups. Rodrigues highlights that MPWs are particularly useful for building block development and validation, and sees product differentiation coming at the architecture level rather than the process level for many businesses. Appeldoorn notes that a third of the MPW business is with industry customers today, and many of the supported academic designs have close industrial collaboration.

Combining platform technologies is often high on the wish lists of MPW users. Integrating electronics and photonics is a particularly popular request, but Hochberg notes that combinations of technologies are always a source of differentiation, so such technology is not shared. Dumon highlights that interposer approaches are gaining some momentum, but this becomes so application dependent that a generic multi-user approach is not viable. The PIXAPP pilot line offers opportunities for industrial R&D purposes. Hochberg adds a word of caution: the design flow to integrate multiple technologies is phallaceous: you are not doubling the difficulty but squaring it when combining multiple technologies. Nonetheless, Wale highlights that there will be a high pay off if we can introduce features that make multi-technology integration more feasible.

Going the way of microelectronics

Process design kits (PDKs) and increased design automation in photonic MPWs are making it easier for new designers to get started quickly. The learning from microelectronics has well and truly started. But the standard cell does not really exist in photonics according to Dumon, creating greater diversity in devices. Simulation models have improved strongly, but these now need to use experimentally validated data for commercial level maturity. Solid timelines will also be essential in the transition from entry point to commercial service. The fact that MPW and production processes are supported by the same PDKs will be a key enabler for a development framework that is equally mature as micro-electronics according to Wale and microelectronics continues to be a good guide on how to achieve this.

Licensable intellectual properties (IP blocks) and a stream of new building blocks will be required to accelerate design and product innovation. Some designers look for portability across foundries but maintaining IP blocks has a cost. According to Hochberg, fabless IP tends to a winner takes all eco-system due to the economies of scale. IP portability is not done in the analog electronics world and photonics is arguably an extreme case of analog. Increased amounts of off the shelf design IP will however be needed according to Dumon. Electronics uses MPWs for different reasons to photonics according to Buddharaju. The CMOS world has prohibitive mask costs and large wafer volumes are needed, but neither is necessarily the case for photonics. Also, the CMOS front end of line is fairly decoupled from packaging and assembly, which is certainly not the case in photonics, where precision assembly methods are required. Finally,

the photonic integration supply chains are not yet aligned.
Yield learning is where the microelectronics industry excels, and this is achieved through volume processing and statistical process control. While MPW customers can benefit from systematic improvements in the building blocks, the yield learning for their own specific design is more challenging. Hochberg notes that user feedback from MPWs will not be enough for yield learning because they are building something relatively complex at the cutting edge and if something goes sideways in the process, the ability to give feedback to the fab is close to zero. Full wafer processes would be needed for this level of feedback. Wale notes that we need to be controlling the right things so the feedback loop from the users to the fab will be essential. The most important thing is that the fab needs to have really comprehensive test coverage. Best- and worst-case numbers: every specification needs a trace and test margin and the foundry has to deliver what it specifies. Production lots will become closer to the MPW offer by constantly updating MPW functionality, benefiting from production yield learning. MPW is a means to sharpen our game and improve the standard processes according to Appeldoorn. While there is a need for production and MPW to diverge, Buddaharaju emphasises that it is best to keep them as close to each other as possible.

Low-barrier entry or process differentiation?

The baseline process is needed to keep the lights on according to Hochberg and the MPW should be close to the baseline process. But no one makes money running MPWs. Most fabs do this to the generate customers who then go on to fill the fab. Economies of scale encourage consolidation around one platform but there is a customer need and a viable model for specialty processes according to Buddharaju. The motivates limiting the number of processes to ensure high enough volume per process.

> ***"A commercial-grade MPW is one of the hallmarks of a truly stable foundry process"***
>
> ***- Hochberg***

Diversification of processes for speciality applications will be possible as the market develops. The success of CMOS did not kill off BiCMOS or III-V HEMTS in electronics, instead these became premium technologies. Process customization can build on the MPW technology as long as there is a path to scale later on. This is a step in the product development process as it is in microelectronics. O-band platforms would be a particularly welcome development according to Rodrigues. There is a rich history of fabs with baseline process which can implement specific changes at a volume. This is always a trade-off between technology risk and economic upside, and the fab will need to make money out of the process, so pricing and exclusivity are all discussed.
In a world where the industry is expanding exponentially, the number of niches also expands at an exponential pace. Business developers are constantly approached with bright ideas, so it's essential to start with a business case discussion. It's always a question of how much change is needed, how much risk you want to take, how much you pay and how many wafers you need according to Hochberg. Differentiation is provided at a premium and is the fundamental dynamic of creating new processes.
Modularity may offer a third way between standardised process and customised process, offering differentiation on the customer side. Here we learn again from microelectronics. CMOS has a checklist of hundreds of customer-selectable qualified processes in the PDK. Some processes have a bunch of different modules which have an impact of cost and the electronics MPW will be a subset of the options which are mostly compatible

and can be stripped out to reduce cost. We will see new platforms based on existing platforms with special building blocks, but MPW will still provide an initial route to get to a new product.

Outlook

Integrated photonics is ramping up. The number of design starts is probably exponential with all the new players. Silicon photonics is at the verge of mass disruption according to Buddharaju, predicting a scale somewhere between CMOS and MEMS in ten years' time. But why are the large foundries paying attention now? Many big silicon foundries see integrated photonics as strategic. A lot of people see an end to the ability to push data through copy at reasonable power and more and more links will go optical. The diversity in designs and applications at the MPW phase indicates impact far beyond communications and into sensors. More MPW players will be offering services according to panellists and frequent MPW runs will be the sign of a healthy industry. Hundreds of thousands of production wafers are predicted, and while only a negligible proportion will be MPW, you certainly want MPWs to be available for the next wave of innovation.

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