9.7 Interview with the CTO

Hichem M'Saad
Chief Technology Officer

Hichem M'Saad, Management Board member and Chief Technology Officer, discusses some of the technology inflections that will drive significant opportunities for ASM, such as the transition to gate-all-around, metal ALD, and selective ALD. He also shares his view on ASM's strength in innovation, the expansions in Korea and Arizona, as well as an update on the silicon carbide Epi business.

Can you update us on the outlook for opportunities in gate-all-around?

The move to gate-all-around (GAA) transistors will drive significantly more opportunities for ASM, in ALD and Si Epi. In ALD, the number of both work function layers as well as ALD dielectric dipole layers is increasing, driven by the need for devices with multiple gate operating voltages for optimizing power and performance. We also see an increase in the number of ALD patterning films, as a corresponding new ALD patterning layer comes with each new dipole layer.

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The move to GAA is also significant for Epi, as the GAA structure is actually made by the Epi superlattice. This transition offers ASM the opportunity to gain market share. Also, you see innovation in how you can make contact to the source and drain epi films: using epi silicon to lower the resistance. This translates to several opportunities for Epi in GAA.

Apart from the new GAA transistor architecture, what are other drivers of the growth we expect for the ALD market, including opportunities in memory applications?

In logic/foundry, there are two factors. In metals, it's the industry's adoption of ALD molybdenum to replace CVD tungsten and PVD copper interconnects. The move away from PVD copper is driven by the fact that with the via becoming smaller and smaller, its resistance becomes high, due to the high resistivity of the liner. If you can move to ALD molybdenum, which does not need a liner, you can significantly reduce the via resistance.

Also, ALD molybdenum is being considered in the back-side power-distribution network. In general, one can say that ALD molybdenum simplifies the process flow and lowers resistance. This change from CVD tungsten and PVD copper to ALD molybdenum is therefore clearly significant for the industry.

The second factor is the adoption of selective ALD in the GAA device. It is used in BEOL (back-end-of-line) mainly, to improve device performance and reliability, as well as simplify the process flow. For example, the adoption of metal-on-dielectric selective ALD in BEOL,

which enables a process where the metal liner is only deposited on the sidewall of the via and not on the bottom, leading to a lower via resistance. There has been talk about selective ALD for many years, and now it is happening, which is exciting.

Furthermore, in memory, in 3D-NAND, as structures are becoming taller and taller, new ALD processes for gap-fill and stair-case fill are driving further growth. In DRAM, increased adoption of high-end logic in peripheral and logic control chips used in high-bandwidth memory, drives growth in ALD high-k and ALD work function layers.

ASM is committed to maintaining single-wafer ALD market share of at least 55% during the next five years. How does ASM stay ahead of the competition?

The key is to keep innovating. For example, we started the ALD molybdenum innovation, and we have the first wins for that application. Innovation must continue, and it starts with developing new precursors, films, and plasma sources for applications like gap-fill and dielectric liners. We have added to our plasma-enhanced ALD (PEALD) capability, so-called inductively coupled plasma ALD that provides a higher radical density, enabling highly conformal deposition, even on complex structures.

'The key to staying ahead is to keep innovating.'

Another area of innovation is selective ALD processing. For this, we needed to develop a new platform that would allow us to integrate different processing steps, like cleaning and surface treatments, together with ALD. All these different processes need different reactors, all attached to one platform, so we added more reactor ports to our platform.

The combination of precursor and reactor innovation and more platform ports has led to our expanded XP8 platform, all aimed at keeping our market share above 55%.

A fundamental part of our innovation is patent filing, and we continue to have the strongest ALD patent portfolio. In addition, in the 2023 listing of global top-20 semiconductor companies by overall patent strength, ASM ranked third, only behind two leading semiconductor device companies.

Next to ALD, Si Epi is a strategic growth driver for ASM. What are the key opportunities?

We see silicon Epi as a growing market, both in logic/foundry and also in DRAM. DRAM has now started using Epi SiGe in the peripheral transistor channel, and more applications like storage node contacts and source/drain contacts may follow to enable continued scaling and performance enhancements. For logic/foundry, we foresee increasing intensity for Epi applications. Epi defines the transistor channel, which now has multiple layers in GAA devices, and the source/drain epi layers are also becoming more complicated.

In addition to the continued growth of leading-edge Epi driven by GAA and high-performance DRAM, we also see growing use of Epi in the market of wafer, power devices, and non-leading-edge foundry. In short, we see significant opportunities in the Epi market.

Can you update us on the status of the integration of LPE, and did the SiC Epi business growth in 2023 meet your expectations?

The growth in our SiC Epi business really exceeded our expectations. The technology offered by LPE is the right technology for the SiC power-device market. Feedback from our customers shows our reactor technology is best in class, with the lowest in-film defectivity. This drives lower leakage performance, as well as the lowest surface defectivity, resulting from the absence of film particles breaking off from the reactor walls.

The business integration is going well. Manufacturing capacity has increased in both Italy and Singapore, allowing us to meet demand. We have increased our engineering resources for SiC, invested in our process-development cleanroom in Catania, as well as investing in new metrology equipment. We have developed our new PE2O8 tool, a cluster two-reactor 200mm system for increased productivity, and have started shipments to customers.

ASM has R&D and development facilities all over the world. What is the rationale for the planned expansion of R&D infrastructure in Korea and Arizona? And how do you keep track of all these spread-out activities?

The expansion makes sense as it's taking place at the locations where we are expanding our ALD product and application portfolio for the growing ALD market. As ALD is the new CVD, its growth is continuing, and we are just taking the necessary steps in line with what we have been communicating.

In addition, having different R&D sites reflects our fundamental belief that our people are really what counts. Having the right people for the technology is the most important part of innovation and product development. To this end, we have strong development teams around the world. This aligns with the vision of our company's founder, Arthur del Prado, who believed in having top-quality teams in their specific technology field.

You shared at Investor Day that ASM's furnace installed base has grown since 2019. What has driven this growth?

Developing new furnace products, the 200mm A400 DUO and the 300mm SONORA, that are very reliable and innovative in both process technology and productivity, has spurred this installed base growth. We have been experts in furnace technology for many years, and have continued to improve the products and processes to succeed in the market.

Looking back on 2023, what are the highlights that stand out for you?

There are quite a few things I'm proud of. For example, with our core Epi technology we showed that we've achieved superior technology that can measure actual wafer temperature and control it to a precise level. This makes me proud of our team's innovation mindset.

'Having the right people is really the most important part of innovation and product development.'

I would also like to highlight our entry into the mainstream metal deposition market with our metal ALD technology, and the rapid market-share growth in SiC epitaxy. This reflects the soundness of the LPE acquisition, and ASM's ability as a complete organization, including supply chain and manufacturing, to react to this rapid growth.

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Hichem M'Saad
Member of the Management Board and Chief Technology Officer