2D-material based devices in the logic scaling roadmap | imec

Alternatively, imec explores direct growth of 2D materials at reduced temperatures, which may enable good quality layers only when deposited at smaller, selected areas.

A 300mm integration platform for 2D-based planar pFETs

So far, most integration efforts have been made on n-type devices. At IEDM 2023, imec in collaboration with Intel were the first to demonstrate 300mm integrated planar **WSe_2 pFET transistors**, using a similar process flow as for MoS_2 nFETs [14]. The teams also provided a clear analysis of the impact of grain size on the performance and reliability of the device.

A path to increased reliability and reduced variability

In previous years, imec and Vienna University of Technology (Prof. Tibor Grasser's group) made progress in **quantifying the reliability and variability** of 2D-material based devices. They studied the impact of, for example, 2D layer thickness, crystal grain size and orientation, and 2D growth template on the performance of 300mm integrated MX_2 planar devices. They were also able to identify the **root cause** of the reliability and variability issues and are now working towards solutions. [15]

Addressing the remaining challenges: a collaborative effort

While big leaps forward have been made by various research groups worldwide, some breakthroughs are still needed to bridge the gap towards high-volume manufacturing at advanced nodes. Imec identifies **fab-**

compatible source/drain contact formation, controllable **doping** and the enablement of **CMOS** with MX_2 devices (i.e., integrating p and n type FETs together) as the most **critical obstacles** going forward. Solving these issues requires a **collaborative effort**, involving industry leaders, university groups and research institutions, as well as tool developers.

With these issues solved, the future looks bright for 2D materials. Not only do they promise to **advance the logic scaling roadmap from A7 on**, but their characteristics also allow to **expand the application domain** far beyond logic. Benefiting from their extremely low off-state current, they show potential for **embedded DRAM** applications – possibly from the A7 node onwards. In addition, the transport properties of 'surface-like' 2D materials are very easy to perturbate, and this makes them ideally suited for **probabilistic computing** or even **machine learning** applications.

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Want to know more?

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