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Incorporating nanomaterials into semiconductor technologies

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Semiconductor technologies are at the basis of most miniaturized systems available to us, whether in the form of microprocessors, or micro and nano -sensors, miniaturised cameras and acoustic systems, etc. Such systems are made of integrated circuits and nanoscale components built in parallel on a semiconductor substrate, following a sequence of hundreds of subtractive, thin -film based processes.
Over several decades, semiconductor technologies could afford to use only a few well -known materials, such as silicon as the semiconductor, silicon dioxide as the insulator, and generally aluminium for the wiring. In more recent times though, this very conservative industry has been forced to introduce a wide range of new materials to enable the downscaling of feature sizes as dictated by Moore's Law. Nanotechnology, and specifically nanostructured materials, have already or are being introduced in semiconductor technologies, while striving towards the ultimate miniaturisation. Nevertheless, introducing a new material is anything but a straightforward process, due to the strong constraints by chemical and particle contamination, process compatibility, thermal and mechanical stability, quality, and uniformity requirements of the processes in semiconductor manufacturing, as they dictate yield, performance and reliability of a product.
The bottom -up approach most often needed for the synthesis of nanomaterials, the intrinsically higher variability and other difficulties proper to scaling up their synthesis over large areas, as well as considerations related to the compatibility or materials and processes are only some of the bottlenecks to the incorporation of nanostructured materials in semiconductor technologies. We will review the history of successful and unsuccessful attempts to integrate 1D (nanowires) and 2D (graphene) materials as examples. We will conclude that in order for nanomaterials to be meaningfully incorporated in semiconductor technologies, their synthesis needs to be designed and informed from the start by the requirements and constraints of semiconductor manufacturing.

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