Chip shortage could be alleviated with new production technique

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Semiconductor manufacturers may be able to produce more chips in a cheaper way thanks to a new technique developed by scientists at Nanyang Technological University (NTU), Singapore.

The technique, which creates highly uniform and scalable semiconductor wafers, could be especially useful during the ongoing chip shortage which has been squeezing manufacturers, telecommunications businesses and carmakers since the start of the Covid-19 pandemic and is expected to last for several more years.

Semiconductor chips are typically fabricated on silicon wafers and then diced into the small chips that are used in devices. However, the process is imperfect and not all chips from the same wafer work or operate as desired. These defective chips are discarded, lowering semiconductor yield while increasing production cost.

The ability to produce uniform wafers at the desired thickness is the most important factor in ensuring that every chip fabricated on the same wafer performs correctly.

Nanotransfer-based printing – a process that uses a polymer mould to print metal onto a substrate through pressure, or 'stamping' – has gained traction in recent years as a promising technology for its simplicity, relative cost-effectiveness, and high throughput.

However, the technique uses a chemical adhesive layer that causes negative effects such as surface defects and performance degradation when printed at scale, as well as being hazardous to human health. For these reasons, mass adoption of the technology and consequent chip application in devices has been limited.

But the NTU researchers have developed a chemical-free printing technique which, when combined with metal-assisted chemical etching, resulted in semiconductor wafers with nanowires (nanostructures in cylindrical form) that were highly uniform and scalable.

The semiconductor also demonstrated better performance when compared with current chips in the market, the researchers said.

The nanotransfer printing technique is accomplished by transferring gold nanostructure layers onto a silicon substrate at low temperature (160°C) to form a highly uniform wafer with nanowires that can be controlled to the desired thickness during fabrication.

The printing technique, which is chemical-free, works by triggering direct chemisorption of the thin metal films under heat – a chemical reaction that creates a strong bond between a substrate surface and the substance that is adsorbed.

This industrial compatible technique allows a wafer to be fabricated quickly and uniformly at scale (from nanometres to centimetres). At the same time, the fabricated wafer is almost defect-free, meaning that little to no chip are discarded due to poor performance.

In lab tests, the joint research team was able to achieve more than 99 per cent yield transfer of a 20-nanometre-thick gold film onto a 6 inch silicon wafer.

While this printable wafer size was limited to the laboratory setup, the team believes their technique can easily be scaled up for use on a twelve-inch wafer - the mainstream wafer size in the current production lines of semiconductor chipmakers like Samsung, Intel and GlobalFoundries.