Fully transparent transistors fabricated at Back-End-of-Line conditions

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Transparent oxide thin film transistors (TFTs) are an important ingredient of transparent electronics. Their fabrication at the back-end-of-line (BEOL) opens the door to novel strategies to more closely integrate logic with memory for data-intensive computing architectures that overcome the scaling challenges of today's integrated circuits.

Here, PARADIM users first apply a variant of molecular-beam epitaxy (MBE) called suboxide MBE (S-MBE) to grow epitaxial indium oxide (In_2O_3) at BEOL temperatures with unmatched crystal quality. They then use these high-quality indium oxide films as the channel layer in TFTs and demonstrate **the highest performance fully transparent oxide TFTs ever reported**. The key behind these results is the ability of S-MBE to navigate kinetic pathways. Providing a pre-oxidized molecular beam of In_2O by S-MBE—instead of a beam of indium atoms as would be used in conventional MBE—bypasses the rate limiting step to the formation of In_2O_3 allowing it to be fabricated at low temperature with unprecedented structural and electronic perfection.

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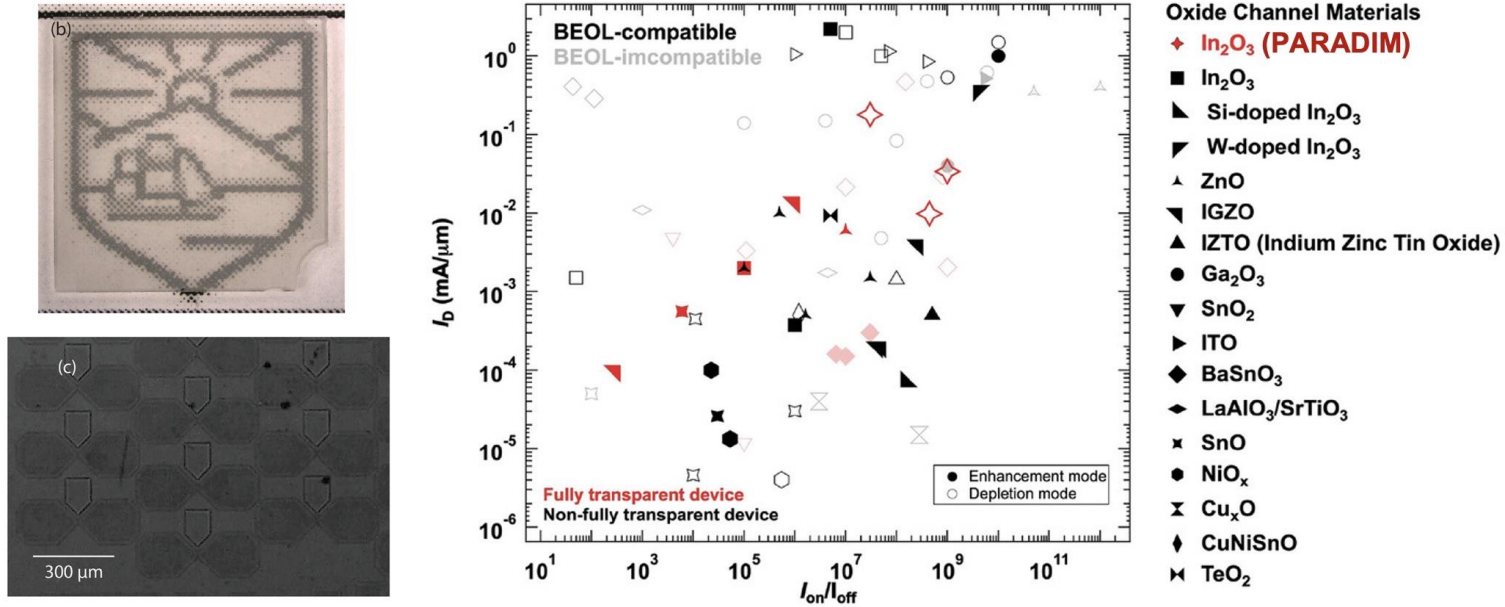

Figure: (**Left, top**) Brightfield micrograph of an epitaxial In_2O_3 10mm × 10mm sample grown by S-MBE with a transistor structure demonstrating the full transparency of the devices. (**Left, bottom**) Darkfield micrograph of the same sample at a higher magnification where the outline of the transistor structures can be seen. (**Right**) Comparison of the saturation drain current I_D and the currents on/off ratio (I_{on}/I_{off}) achieved for the devices shown in this work (red crosses) together with the best values from the literature. Devices fabricated at BEOL-incompatible temperatures are shaded. Fully-transparent devices are marked in red. Not fully transparent devices usually rely on a non-transparent contact. Solid symbols denote devices operated in enhancement mode, while devices operated in depletion mode are marked with open symbols.