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External User + In-House Research - 2021

Remote Epitaxy of 3D functional semiconductors and oxides using Graphene as the Interface layer

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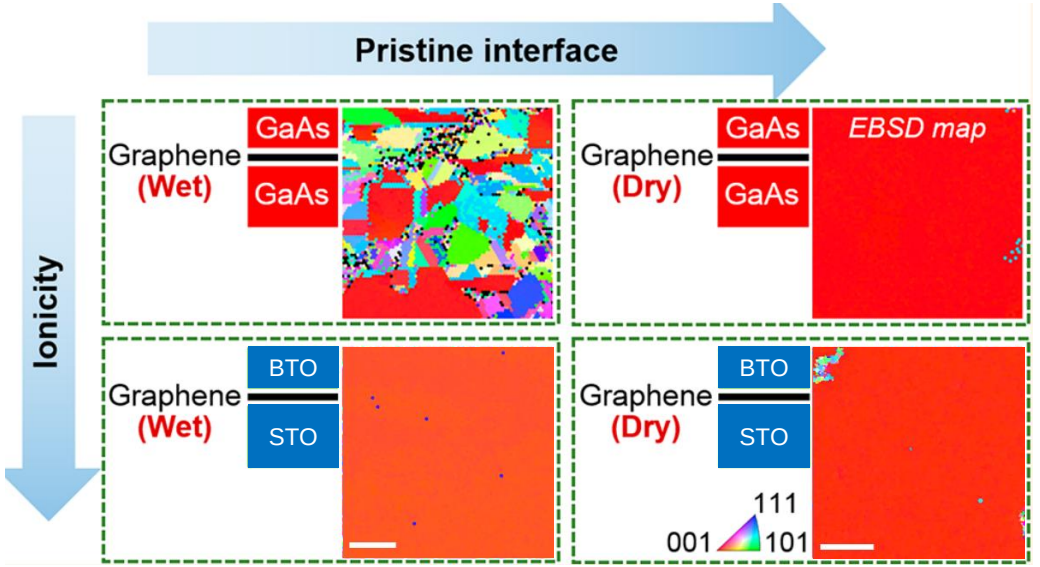
Project Summary: Remote epitaxy has drawn attention as it offers epitaxy of functional materials that can be released from the substrates with atomic precision, thus enabling production and heterointegration of flexible, transferrable, and stackable freestanding single-crystalline membranes. In this highlight, 2DCC and PARADIM team up to work with the inventor of remote epitaxy, Prof. Kim (MIT), to unveil the respective roles and impacts of the substrate material, graphene, substrate–graphene interface, and epitaxial material for electrostatic coupling of these materials, which governs cohesive ordering and can lead to single-crystal epitaxy in the overlying film. We show that simply coating a graphene layer on wafers does not guarantee successful implementation of remote epitaxy, since atomically precise control of the graphene-coated interface is required and provides key considerations for maximizing the remote electrostatic interaction between the substrate and adatoms. The general rule of thumb discovered here enables expanding 3D material libraries that can be stacked in freestanding form. This work is published in **ACS Nano 2021, 15, 6, 10587–10596**.

2DCC Role: The 2DCC provided epitaxial graphene substrates for remote epitaxy of Ge, GaAs, GaN, $BaTiO_3$.

PARADIM Role: Synthesis of $BaTiO_3$ films by remote epitaxy on substrates onto which the graphene from 2DCC had been transferred.



The method of graphene transfer (wet *vs.* dry) and the resulting interface properties can affect the electrostatic coupling between the single crystal below the graphene and its continuation above the graphene in a new growth process known as remote epitaxy. More ionic materials like $BaTiO_3$ (BTO) are more forgiving to the quality of the graphene layer than are compound semiconductors.