Highlights

ACTIVITY B Superconducting and correlated low dimensional materials and devices for quantum electronics and spintronicst - 2020

Self-Formed, Conducting $LaAlO_3/SrTiO_3$ Micro-Membranes

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The discovery of 2D conductivity at the $LaAlO_3/SrTiO_3$ interface has been linking, for over a decade, two of the major current research fields in materials science: correlated transition-metal-oxide systems and low- dimensional systems. Notably, despite the 2D nature of the interfacial electron gas, the samples are 3D objects with thickness in the mm range. This prevented researchers so far from adopting strategies that are only viable for fully 2D materials, or from effectively exploiting degrees of freedom related to strain, strain gradient and curvature. Here a method based on pure strain engineering for obtaining freestanding $LaAlO_3/SrTiO_3$ membranes with micrometer lateral dimensions is demonstrated. Detailed transmission electron microscopy investigations show that the membranes are fully epitaxial and that their curvature results in a huge strain gradient, each layer showing a mixed compressive/tensile strain state. Electronic devices are fabricated by realizing ad hoc circuits for individual micro-membranes transferred on silicon chips. The samples exhibit metallic conductivity and electrostatic field effect like 2D-electron systems in bulk heterostructures. The results open a new path for adding oxide functionalities into semiconductor electronics, potentially allowing for ultra-low voltage gating of a superconducting transistors, micromechanical control of the 2D electron gas mediated by ferroelectricity and flexoelectricity, and on-chip straintronics.

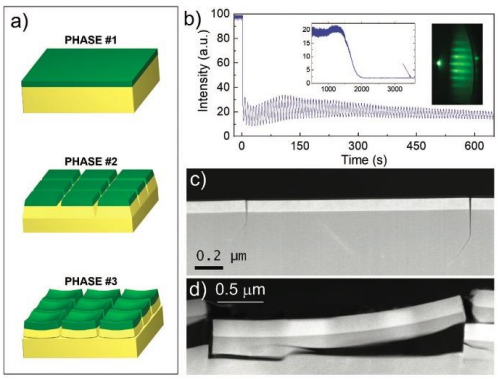

Fig 1: a) Sketch depicting the three different stages for LAO/STO membrane formation, b) Evolution of RHEED (0,0) spot intensity for a 180 nm sample and final pattern, c) and d) Low-resolution cross section SEM image of phase #2 and #3, respectively.

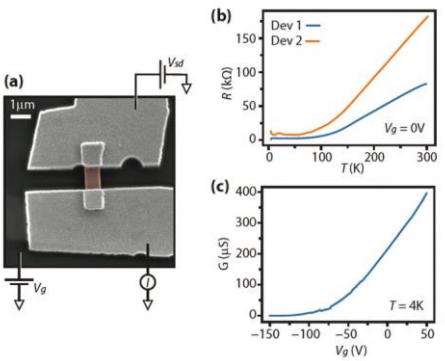

Fig. 2: a) False color SEM micrograph of a typical µHS device after transfer to a Si/SiO_2 substrate and contacted in a two-terminal configuration; b) Resistance as a function of temperature for two typical devices showing metallic behavior; c) The gate dependence of the conductance of Device 1 at 4 K.