Highlights

RESEARCH AREA 2 - **Functional and Complex Materials for Innovative Electronics and Sensing** - 2022

"A Two-Dimensional Superconducting Electron Gas in Freestanding $LaAlO_3/SrTiO_3$ Micromembranes "

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Freestanding oxide membranes constitute an intriguing material platform for new functionalities and allow integration of oxide electronics with technologically important platforms such as silicon. Sambri et al. recently reported a method to fabricate freestanding $LaAlO_3/SrTiO_3$ (LAO/STO) membranes by spalling of strained heterostructures. Here, we first develop a scheme for the high-yield fabrication of membrane devices on silicon. Second, we show that the membranes exhibit metallic conductivity and a superconducting phase below ~200 mK. Using anisotropic magnetotransport we extract the superconducting phase coherence length $\xi \approx 36-80$ nm and establish an upper bound on the thickness of the superconducting electron gas $d \approx 17-33$ nm, thus confirming its two-dimensional character. Finally, we show that the critical current can be modulated using a silicon-based backgate. The ability to form superconducting nanostructures of LAO/STO membranes, with electronic properties similar to those of the bulk counterpart, opens opportunities for integrating oxide nanoelectronics with silicon-based architectures.

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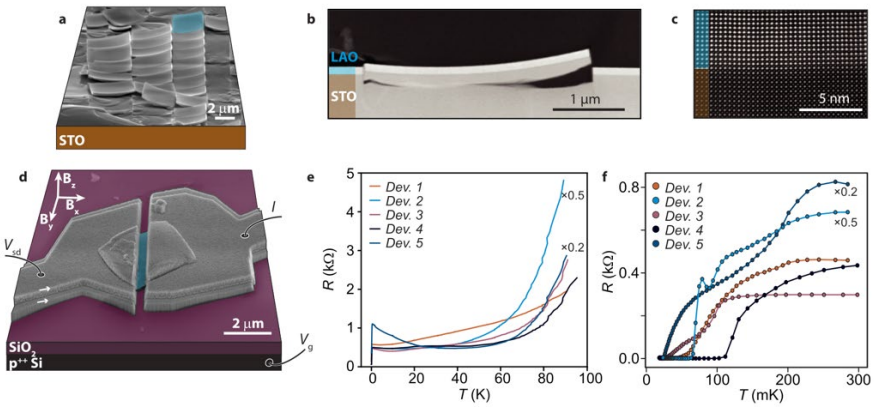

Fig 1: (a) Tilt-view scanning electron microscope (SEM) image of the as-grown LAO/STO micromembranes. (b) Low-magnification scanning transmission electron microscope (TEM) image of a cross section of the growth substrate. The LAO layer (blue) appears with a lighter contrast in comparison the STO (brown). A partially released LAO/STO micromembrane is apparent with curving due to a LAO/STO lattice mismatch. (c) High-resolution image of the epitaxial LAO/STO interface. (d) Artificially colored SEM of a finished LAO/STO membrane device fabricated on a p++ Si/SiO2 substrate. The degenerately doped substrate acts as a backgate electrode in the measurements. (e) Two-terminal resistance vs temperature for five devices showing metallic behavior. (f) Low-temperature regime of (e) showing superconducting transitions. In (e) and (f), the resistance of the cryostat filters and the membrane/metal interface have been subtracted (see text) and results for Dev. 2 and 5 have been scaled by factors of 0.5 and 0.2, respectively, for clarity.