Field-effect Transistors Get a Boost from Ferroelectric Films

Scientific Achievement

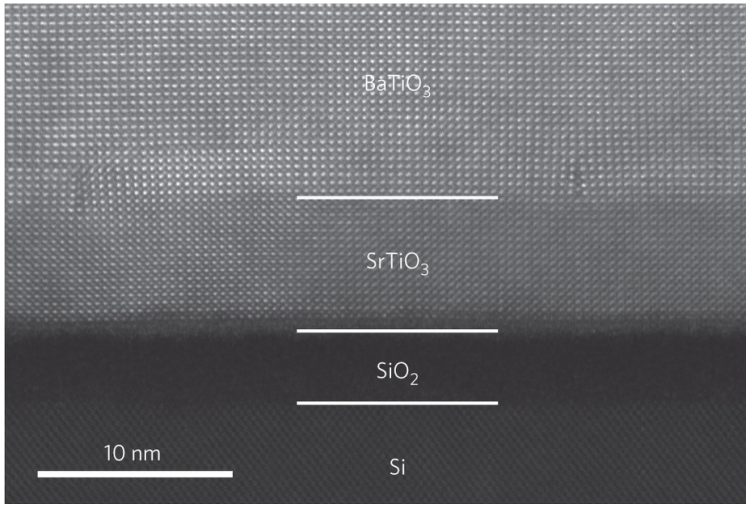
Developed a complex metal oxide film using ferroelectric materials that allow for switching of polarization without the use of a conducting bottom electrode

Significance and Impact

These films could allow for smaller microelectronic devices that reduce voltage required to switch electronic signals and maximize output without excess heat

Research Details

- Performed x-ray diffraction to characterize tetragonality, or "out-of-squareness," of the crystal structure within the film; crystal units found to have correct electrical polarization to make good transistors
- Used piezoresponse force microscopy to determine that ferroelectric switching films could be produced at 8 to 40 nanometers thick, though a thickness of just 10 nanometers proved best to ensure polarity was evenly distributed across the film



These ferroelectric films are grown on a base of silicon. Alignment of the crystal structures, seen here in a transmission electron microscope (TEM) image, is crucial to the efficient transfer of electricity. The researchers grew a barium-titanate film on a silicon base using molecular beam epitaxy. The crystalline structures of barium-titanate and silicon don't precisely line up, so it's a bit like trying to get tennis balls to fit into an egg carton. They're too large for the depressions, so a buffer layer has to be added to ensure that good registry will be made between the two substances. In this case, strontium-titanate was used because its crystal unit size is between that of silicon and barium-titanate, which allows for a gradual re-alignment of the crystal structure in the film.

C Dubourdieu, J Bruley, TM Arruda, A Posadas, J Jordan-Sweet, MM Frank, E Cartier, DJ Frank, SV Kalinin, AA Demkov, V Narayanan, *Nature Nanotechnology* **8,** 748-754 (2013)

Work was performed at Brookhaven National Laboratory, Oak Ridge National Laboratory, University of Texas at Austin, and IBM

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