Realizing Record Electro-Optic Response at Cryogenic Temperatures

V. Gopalan, V.A. Stoica, L.-Q. Chen (all Penn State), and D.G. Schlom (Cornell)

The search for thin-film electro-optic materials that can retain superior performance at cryogenic temperatures has become critical for quantum computing. Barium titanate ($BaTiO_3$) thin films show large linear electro-optic coefficients in the tetragonal phase at room temperature, but less so in the rhombohedral phase at low temperatures. Manipulating such phase transformations and retaining superior electro-optic properties down to liquid helium temperature is of immense technological interest.

Utilizing the thermodynamic theory of optical properties, **users of PARADIM theorized that a large low-temperature electro-optic response** should occur in the metastable monoclinic phase of $BaTiO_3$. At the Platform, a **strain-tuned $BaTiO_3$ thin film was made by a new method developed by PARADIM**'s In-House team. The user then measured the linear electro-optic coefficient to be 2516 pm/V at 5 K, which is an order of magnitude above the best prior reported performance. In contrast to conventional $BaTiO_3$ films, where the electro-optic coefficient degrades on cooling, the electro-optic coefficient increases by 100× during cooling of the appropriately strained $BaTiO_3$ film. Further, at the lowest temperature, significant higher order electro-optic responses also emerge. These results represent a new framework for designing materials with property enhancements by stabilizing highly tunable metastable phases with strain.

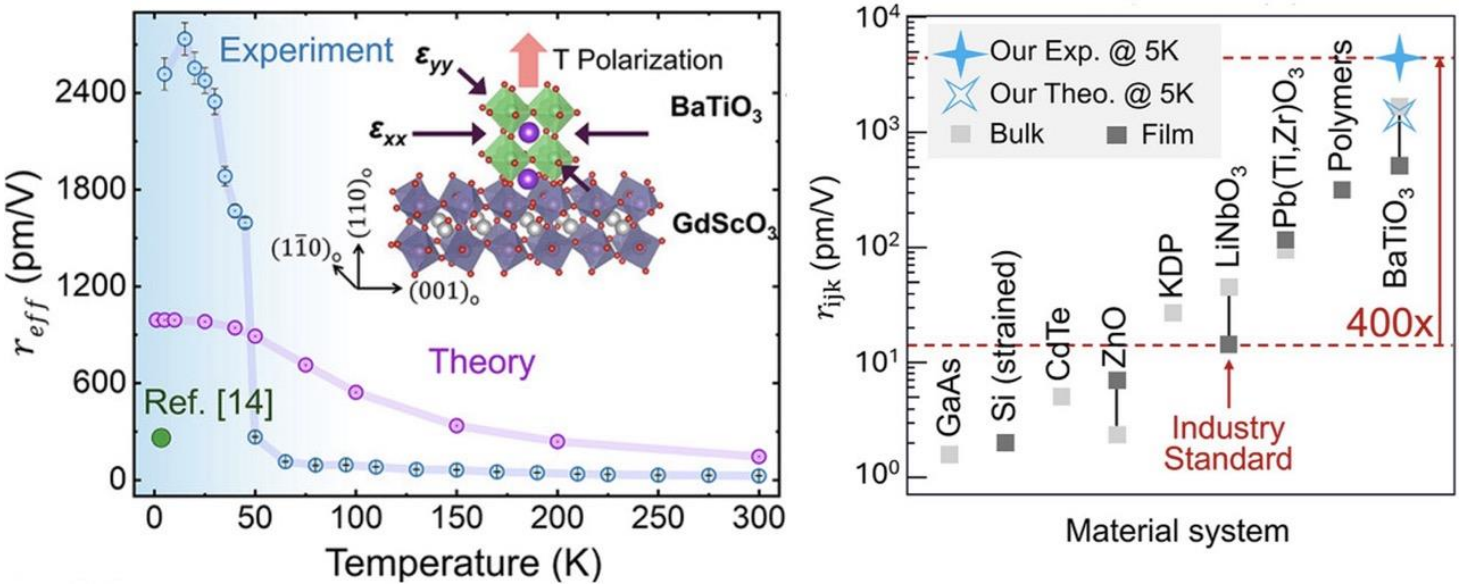

Figure. (Left) Comparison between experiment (blue) and phase-field simulation (purple) of the effective electro-optic coefficient of a $BaTiO_3$ film strained to an underlying $GdScO_3$ substrate (–1% biaxial compressive strain) vs. temperature. The best prior cryogenic coefficient reported is also shown (green). **(Right)** Comparison between the maximum electro-optic response obtained in this work and several other benchmark materials.

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