Layered Ferroics as Superior Microwave Dielectrics

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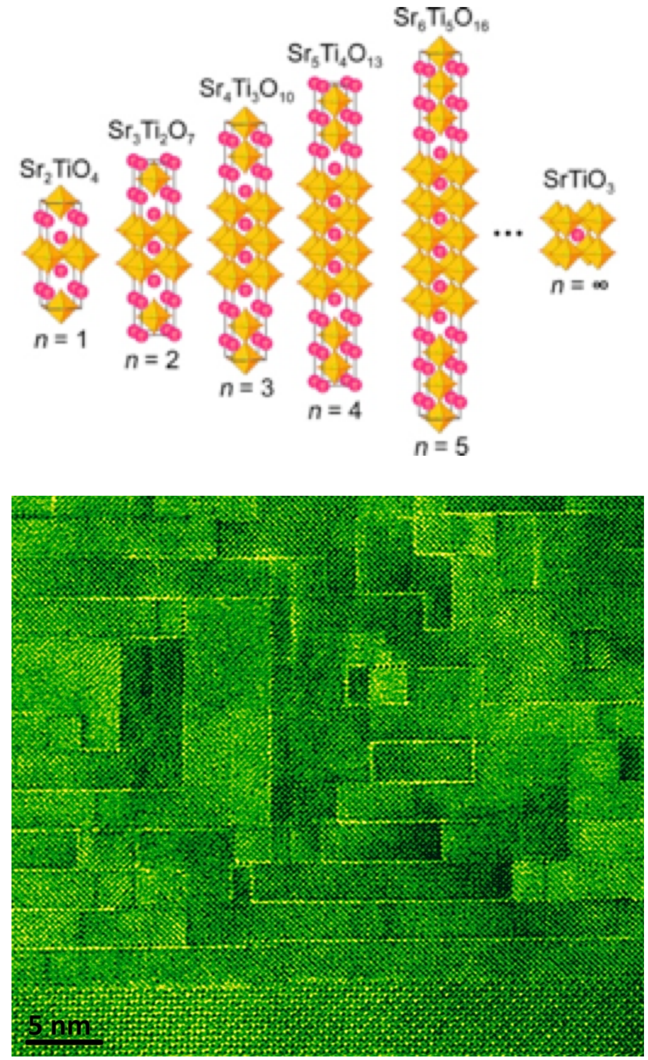
Penn State MRSEC IRG1-TEAM (Strain-enabled multiferroics), in close collaboration with Cornell MRSEC, U Maryland, NIST and others, has designed and demonstrated the world's best tunable microwave dielectric to date operating with the highest reported Figure of Merit up to 125GHz. This could result in a new generation of superior electronically tunable microwave filters, antennas, and phase shifters for improved wireless communications using Cellphones and other devices. The team predicted an unusual polar state in $Sr_{n+1}Ti_nO_{3n+1}$ Ruddlesden-Popper (RP) phases (inset) under tensile biaxial strain, where beyond a critical layer thickness $n>n_c$, an in-plane polarization sets in within the perovskite layers. This indicates the importance of the dimensionality "n" in turning on and off the ferroelectric properties. Moreover, these layered structures are believed to accommodate nonstoichiometry through the formation of additional rock-salt layers (SrO), thus significantly decreasing dielectric losses. The lead author, Lee (advisor Schlom) was supported by Penn State MRSEC and received his PhD from Penn State in 2012. Haislmaier, Vlahos, and Gopalan performed nonlinear optical characterization of these materials. The work is published in the journal *Nature* (doi: 10.1038/nature12582, published october 16, 2013).



Schematic and cross-sectional transmission electron micrograph of $Sr_{n+1}Ti_nO_{3n+1}$ thin films grown by molecular beam epitaxy. The "bricks" are RP phases and the "mortar" are additional SrO layers that are believed to accommodate non-stoichiometry and lead to lower dielectric losses.