Controlling the dielectric response of $SrTiO_3$

Melentev A.V.[1*]
[1] Moscow Institute of Physics and Technology, Dolgoprudny, Russia
*email: aleksandr.melentyev@phystech.edu

Abstract

Strontium titanate ($SrTiO_3$, STO) is a quantum paraelectric used in novel energy storage, memory and microwave optical devices for its high permittivity and low losses in a broad frequency range from radio to sub-terahertz [1,2]. Real permittivity of pure crystalline SrTiO3 reaches values as high as 24000, and more than 99% of it is contributed by the TO1 phonon soft mode (SM) associated with a potential ferroelectric phase transition [3]. However, in other forms of STO such as thin films or ceramics dielectric response can differ significantly. Sufficiently strained thin films can become ferroelectric. Polycrystalline samples exhibit SM hardening, resulting in a decreased maximal permittivity in a broader temperature range. In order to tailor the dielectric properties of STO to a specific application, we need to understand microscopic mechanisms governing the SM behavior. We will discuss how chemical doping, oxygen vacancies and mechanical strains influence the soft mode dynamics and the crystal structure of STO crystals [4] and thin films [5].

The study was supported by the Ministry of Science and Higher Education of the Russian Federation grant No. 075-15-2024-632.

Bibliography

[1] A. K. Tagantsev et al., Ferroelectric materials for microwave tunable applications, J Electroceram 11, 5 (2003).
[2] A. Tumarkin et al., $SrTiO_3$ Thin Films on Dielectric Substrates for Microwave Applications, Coatings 14, 3 (2023).
[3] J. Petzelt, D. Nužnyj, Soft Polar Phonon Mode in $SrTiO_3$ Single Crystals, Ceramics and Thin Films, in: A. Tkach and P. Vilarinho (Eds.), Strontium Titanate: Synthesis, Properties and Uses, Nova Science Publishers, New York, 2019, pp 1-39.
[4] Talanov M.V. et al., Transition metal-doped SrTiO3: when does a tiny chemical impact have such a great structural response?, J. Materr. Chem. C, 12, 22 (2024)
[5] Zhukova E.S. et al., Terahertz ferroelectric soft mode in weakly doped SrTiO3: M thin films (M=Mn, Ni, Fe, Co), J. Alloys. Comnd. 976, 173255 (2024)