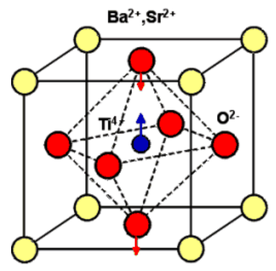
Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft

Institut für Materialforschung III / Abteilung Keramik

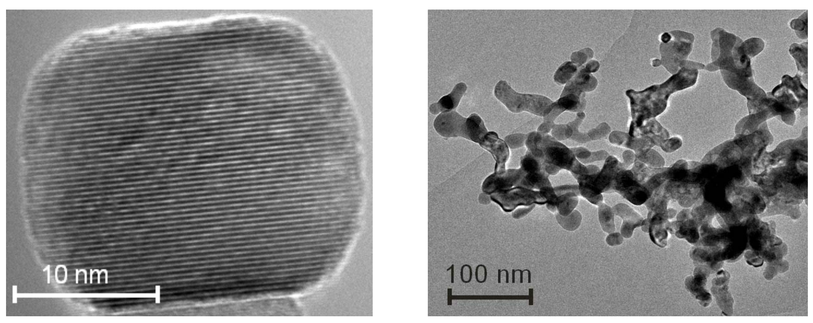
Doped $Ba_{0.6}Sr_{0.4}TiO_3$ Thick Films for Tunable Microwave Applications

Motivation

The relative permittivity ε_r of ferroelectrics like $Ba_{0.6}Sr_{0.4}TiO_3$ (BST) depends on an externally applied electric field. Based on BST thick films passively tunable microwave components like varactors or tunable lines can be realized, which show very low tuning current consumption.



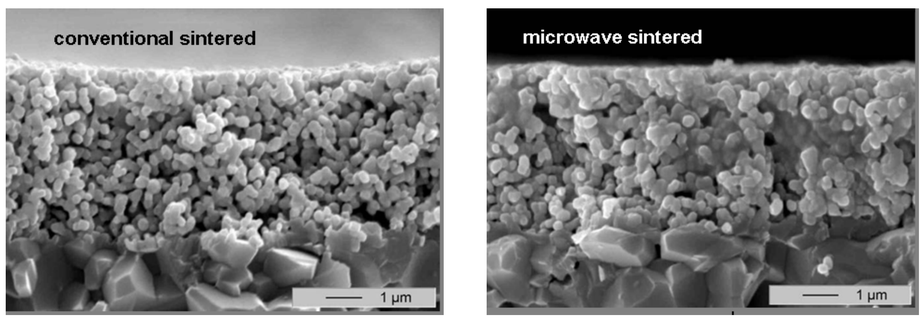
Powder Synthesis



TEM images of BST grains
Primary particle size: 30 - 50 nm
Specific surface area: approx. 20 m^2/g

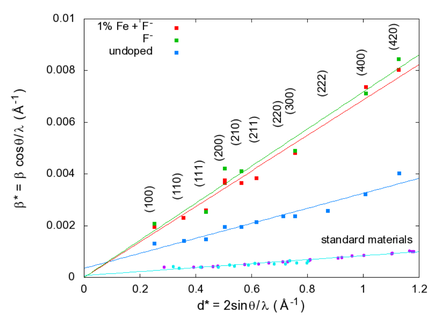
The metal organic precursors are synthesized through a modified sol-gel process, in which the doping elements such as Fe, F can be easily added. The doped BST powders are obtained after spray-drying of the sols and subsequent calcination of the precursors.

Screen-printing & Sintering

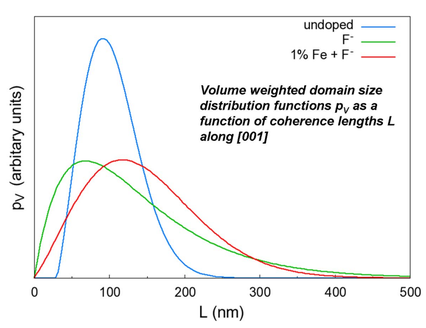


The ceramic BST powders were screen-printed onto polycrystalline Al_2O_3 substrates.
The screen-printed thick films can either be sintered conventionally or by microwave sintering.

Synchrotron Powder X-ray Diffraction



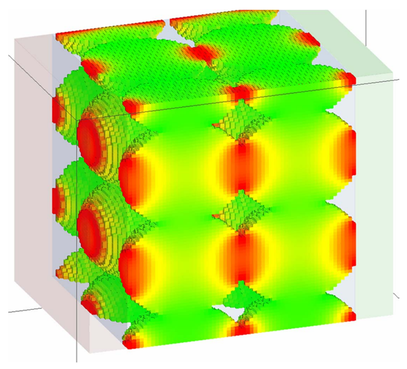
Williamson-Hall plot

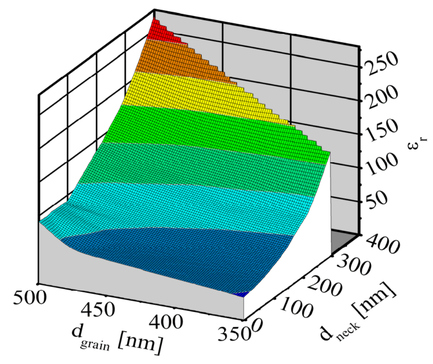


„Double-Voigt“ method

The microstructures of undoped and doped BST powders and thick films were investigated at the ANKA PDIFF beam line.

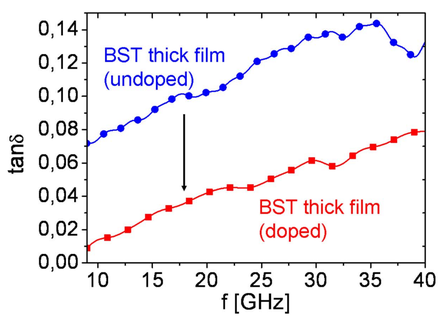
Electromagnetic Simulation



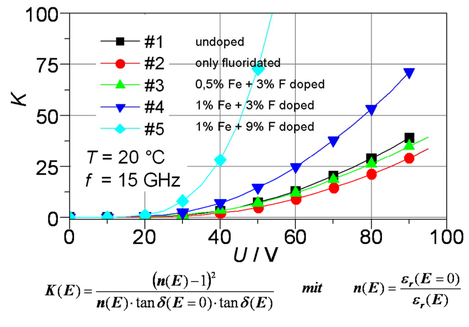


A nonlinear 3D Finite-Difference-Time-Domain electromagnetic solver is applied to simulate the influence of the microstructure on the dielectric properties.

Dielectric Properties



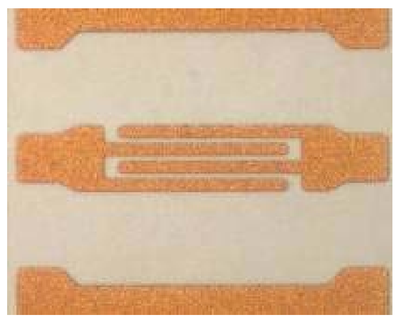
Dielectric loss depending on frequency



K factor depending on tuning voltage

Co-doping with Fe and F leads to a significant reduction of dielectric loss (tan δ) at RF and room temperature. Consequently the commutation quality factor K increases.

Applications



- Tunable filters
- Tunable impedance matching networks
- Tunable antennas
- RF-ID Systems

The BST thick films with improved quality have a high potential for application in tunable microwave components. The material can be optimized to meet the electrical and technological requirements.

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