Sols for Inkjet-Printing of tunable dielectric Barium-Strontium-Titanate films

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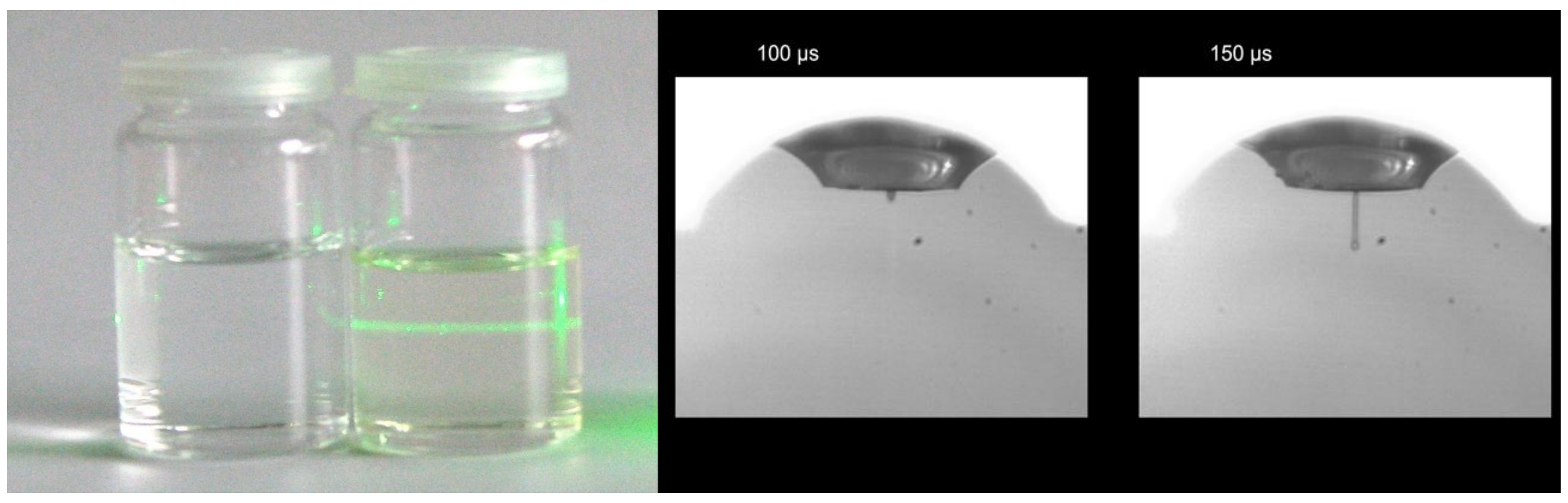
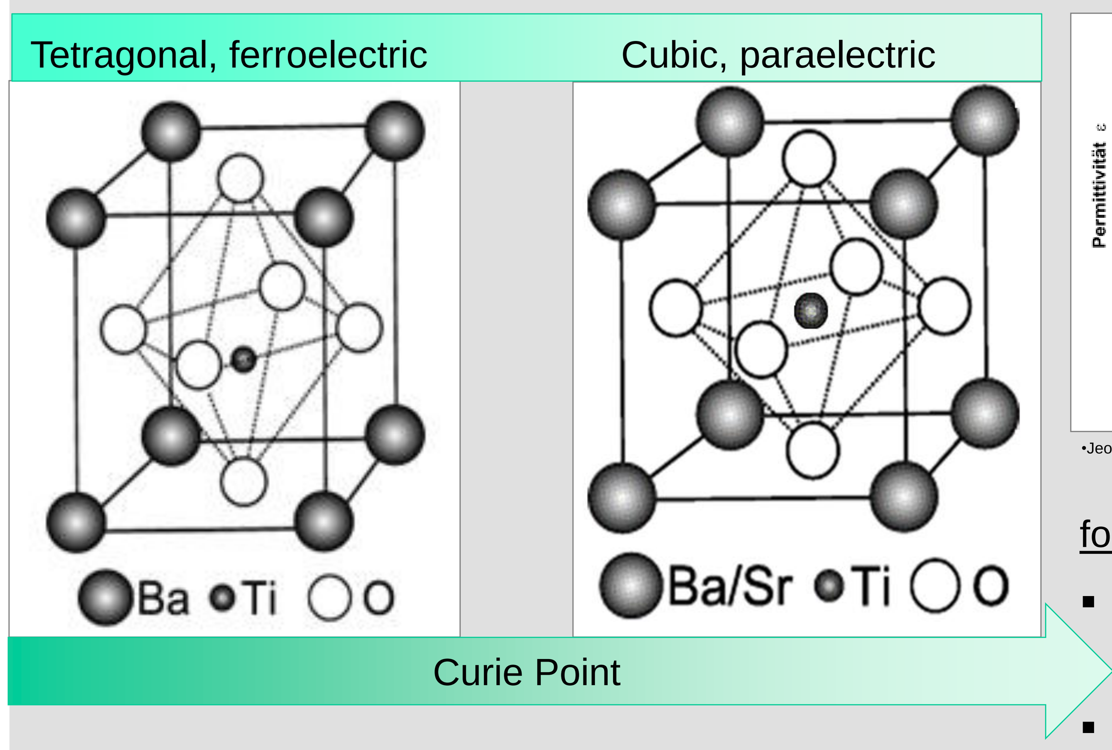
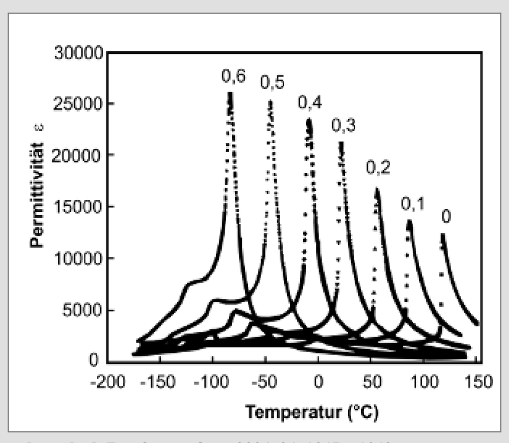


Abstract

The ceramic system $Ba_{1-x}Sr_xTiO_3$ (BST) is the most promising candidate for the realization of electronically tunable devices in electrical engineering. For these applications it is important to implement the dielectric as a structured film. To directly deposit structured ceramic films, the drop-on-demand technology using liquid precursors is a promising method. Thin ceramic films consisting of BST were fabricated using inkjet-printing of preceramic sols.

System $Ba_{1-x}Sr_xTiO_3$ (BST)

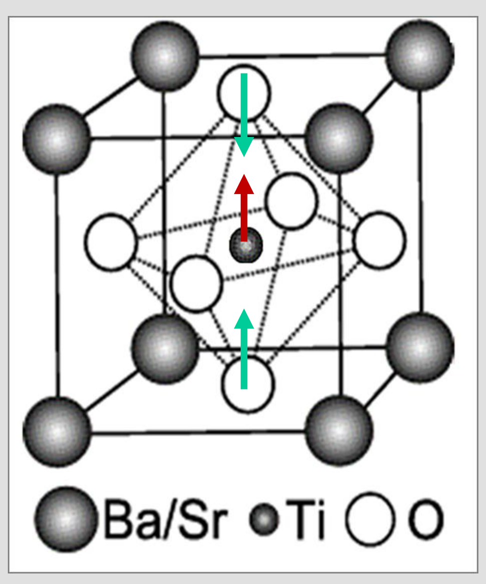


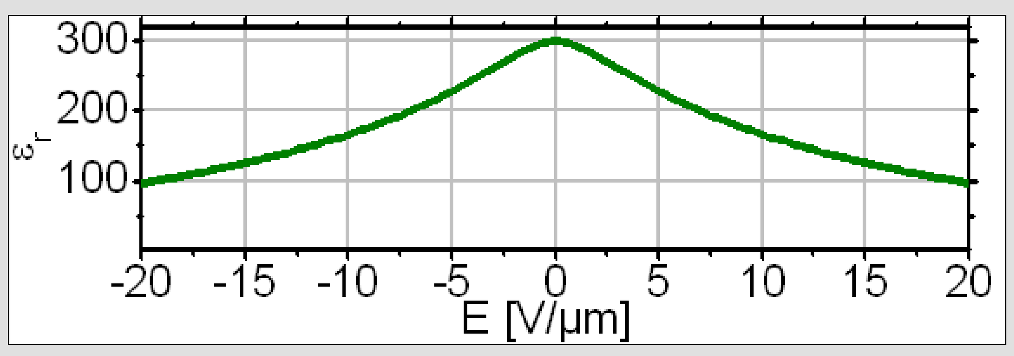


•Jeon, J., J. Eur. Ceram. Soc., 2004, 24, 1045 – 1048

for Radio frequency applications:
- Use of the paraelectric phase
- Application at Roomtemperature
  → $Ba_{0,6}Sr_{0,4}TiO_3$

$Ba_{0,6}Sr_{0,4}TiO_3$ as a tunable dielectric material





BST shows a nonlinear dependence of the permittivity on a static electrical field strength

Displacement of Ti^{4+}-ion by an external electrical field

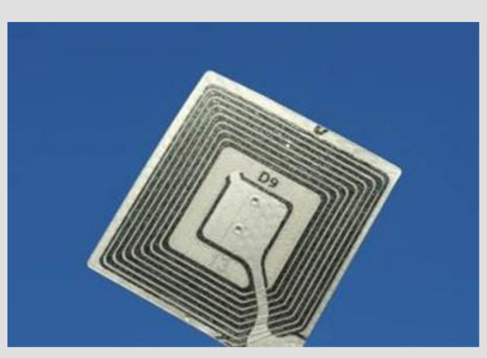
- Almost no power consumption
- Tunability continous
- Tunability speed in ns-range

Dielectric tunability

$$\tau_\varepsilon(E) = \frac{\varepsilon_r(E=0)-\varepsilon_r(E)}{\varepsilon_r(E=0)}$$

Why generating thin films by Inkjet-printing?

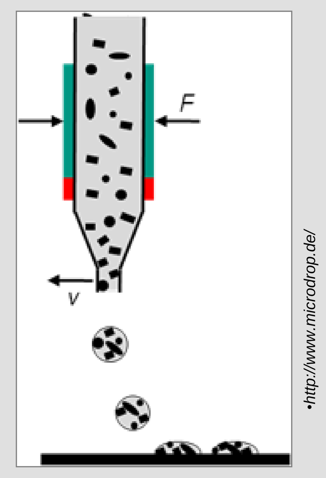
Drop on Demand
- Non-contact processing of 2D and 3D structures
- Accurate droplet generation
- Low-cost and versatile method
- Printing of different materials



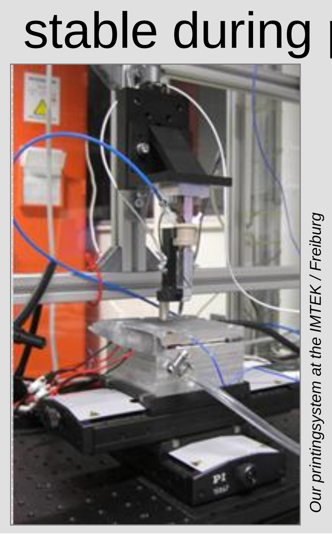
Printing System and Ink requirements

Printing system:

piezoelectric Drop-on-Demand (DoD) system
Microdrop - Autodrop Professional

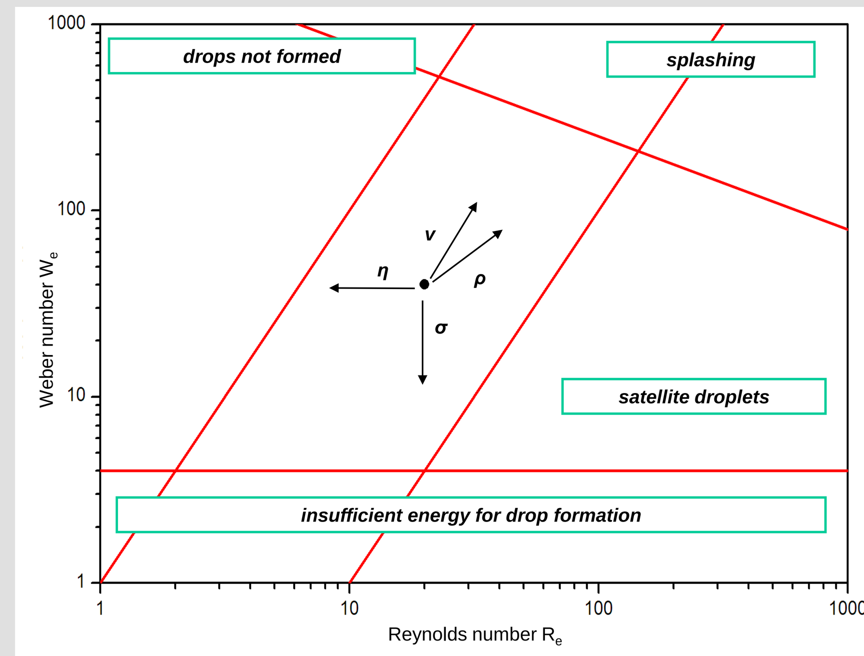


Ink requirements
- constraints for surface tension and viscosity
- typical values:
  - σ = 10 – 100 mN/m
  - η = 5 – 50 mPas
- stable during printing

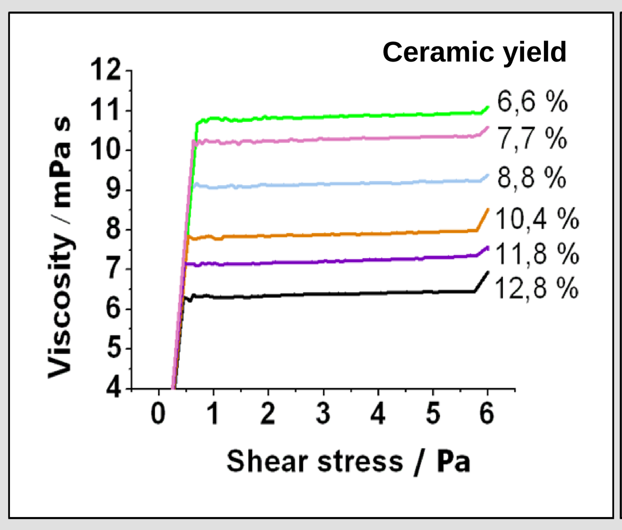


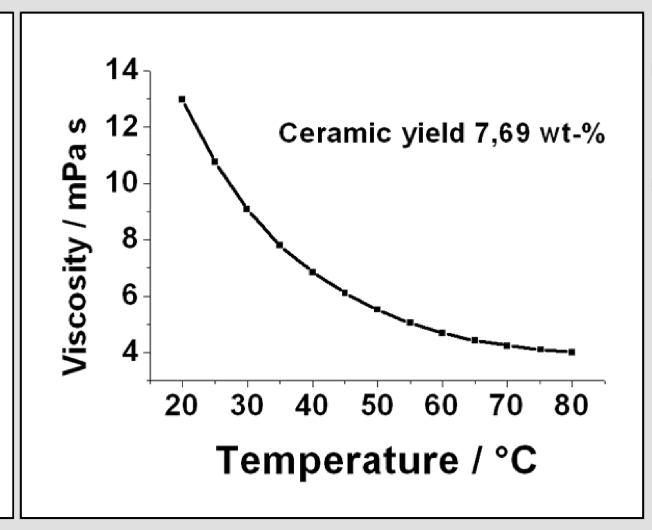
$$W_e = \frac{v^2 \rho a}{\gamma}$$

$$R_e = \frac{v \rho a}{\eta}$$



after Derby, J. Eur. Ceram. Soc. 2011, doi: 10.1016/j.jeurceramsoc.2011.01.016





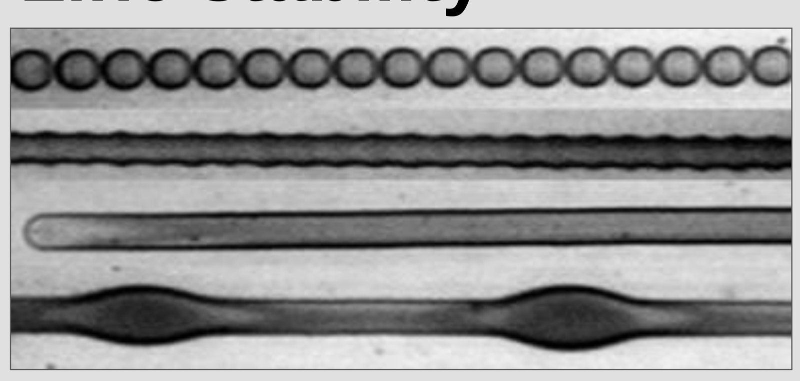
- Surface tension: 31,74 mN/m at RT
- Z = 4,26 (= Oh^{-1}) (Optimum 1 < Z< 10)

d = nozzlediameter
ρ = density
σ = surface tension

Decrease of viscositiy by
- Increase of the ceramic yield
- Increase of the temperature

$$\frac{\sqrt{W_e}}{R_e} = Oh = Z^{-1} = \frac{\sqrt{\rho \sigma d}}{\eta}$$

Line stability



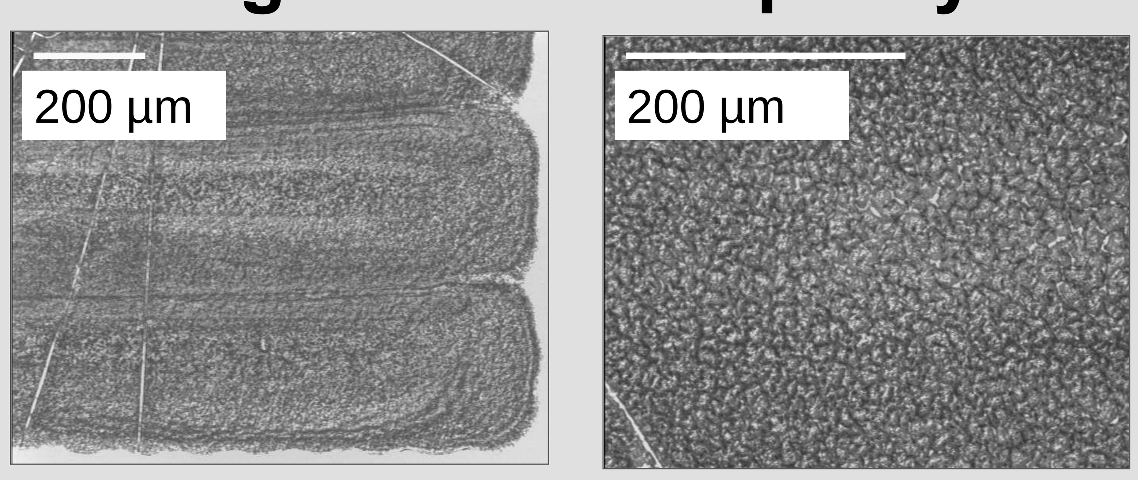
$x > x_{max}$

x = Dotspacing

$x < x_{min}$

requirements
- continuous line
- stable liquid bead

Homogeneous film quality due to…



- ... minimization of printing frequency
- ... adequate speed of substrate
- … an optimum of dotspacing

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