Properties of $Ba_{0.6}Sr_{0.4}TiO_3$ based Coplanar and MIM Varactors

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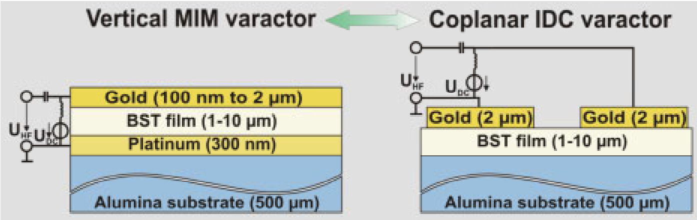
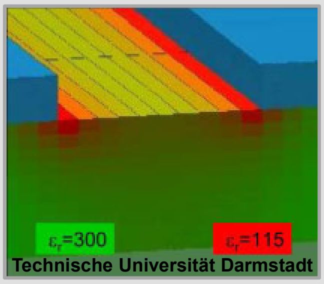
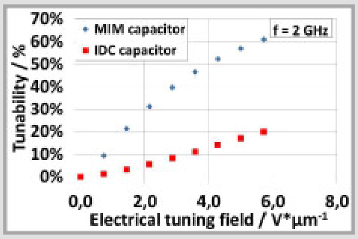


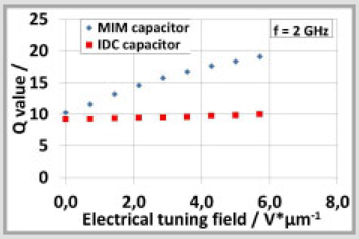
Abstract

The ceramic solid solution $Ba_{1-x}Sr_xTiO_3$ (BST) is one of the most promising tunable dielectrics for the implementation of thick film based varactors. Electrically tunable varactors are in great demand for radio frequency (RF) applications, such as phase shifters or matching networks. Metal insulator metal (MIM) capacitors provide some advantages over coplanar interdigital capacitors (IDC), due to a homogeneous tuning field.

Properties of MIM and IDC varactors



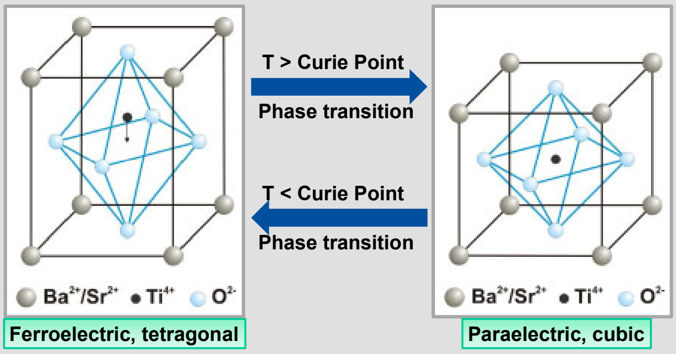


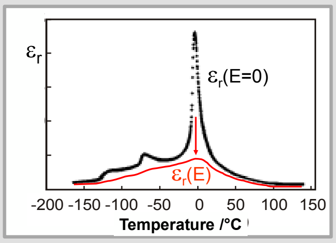


- IDCs: Inhomogeneously tuned
- MIMs: Homogeneously tuned
- MIMs: Higher tunability
- MIMs: Increasing Q value with increasing tuning field

→ **MIMs superior to IDCs**

Barium strontium titanate ($Ba_{1-x}Sr_xTiO_3$)

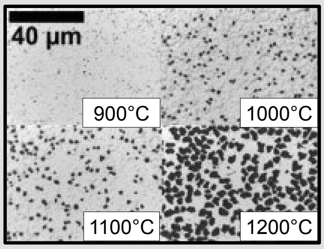


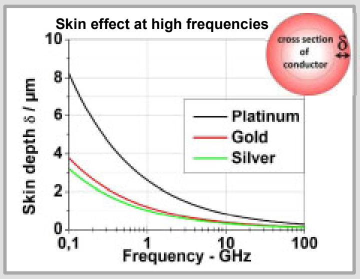


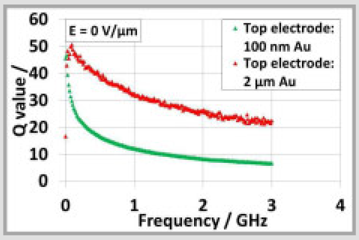
$Ba_{0,6}Sr_{0,4}TiO_3$:

- paraelectric at room temperature
- tradeoff between tunability and low dielectric losses

Influence of electrodes on loss factor (tanδ)







- Degradation of platinum bottom electrode during sintering
- Gold or silver electrodes favorable
- Q value strongly influenced by thickness of the electrodes

→ **Thicker electrodes**
→ **Take care on thermal budget!**

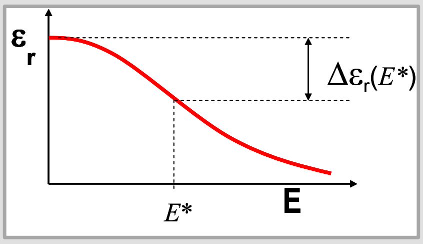
$Ba_{0,6}Sr_{0,4}TiO_3$ as tunable dielectric

Tunability

$$\tau(E) = \frac{\Delta\varepsilon_r(E)}{\varepsilon_r(E=0)}$$

Quality value

$$Q = \frac{1}{tan\delta}$$



tan δ: Loss factor
ε_r: Permittivity
E: Tuning field

- nonlinear dependency of permittivity
- almost no power consumption
- fast response time (ns)

Conclusion

- MIM varactors superior to coplanar IDC varactors due to homogeneous tuning field
- Strong impact of electrodes on dielectric properties (loss factor tanδ) of $Ba_{0,6}Sr_{0,4}TiO_3$ MIM varactors
- Galvanic reinforcement of the bottom electrode necessary for further increase of Q value
- Reduction of the sintering temperature below 1000°C necessary for the use of gold or silver bottom electrodes

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