



## **Electroceramics XIII**

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<sup>2</sup>W. Eerenstein, F.D. Morrison, J. Dho, M.G. Blamire, J.F. Scott & N.D. Mathur, *Science*, **307** (5713), 1203a, 2005.

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| O.65 | <b>From quantum paraelectric to antiferromagnetic: The phase diagram of almost multiferroic <math>\text{Sr}_{1-x}\text{Eu}_x\text{TiO}_3</math></b><br><u>Annette Bussmann-Holder</u><br>Solid State Research, Max-Planck-Institute, Stuttgart, Germany |
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$\text{SrTiO}_3$  (STO) is a quantum paraelectric with extrapolated ferroelectric transition temperature of  $T_C=37\text{K}$ . At  $T_S=105\text{K}$  STO undergoes an antiferroelectric phase transition from cubic to tetragonal.  $\text{EuTiO}_3$  (ETO) behaves rather analogous to STO at low temperatures where also quantum paraelectricity exists. In addition, ETO becomes antiferromagnetic at  $T_N=5.5\text{K}$ . Since both compounds have the same lattice constants and the ionic radii of Sr and Eu are comparable, it is challenging to investigate mixed crystals of the end members for possible multiferroic properties.

We have concentrated on the structural instability at  $T_S$  which we have recently shown to exist also in ETO. This increases nonlinearly with increasing x in  $\text{Sr}_{1-x}\text{Eu}_x\text{TiO}_3$  to  $T_S=280\text{K}$  for x=1. Simultaneously the dynamics change from displacive to order / disorder. However, the structural instability follows for all x mean-field behavior whereas the soft optic mode reveals a boundary between the distinct dynamics of the pure compounds.

The theoretical analysis is complemented by EPR, specific heat, resistivity and mSR measurements.

Possible applications of the layered mixed crystals are addressed where multiferroic properties are suggested to be realized.

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| O.66 | <b>Evolution of inhomogeneities in alkoxide-carboxylate precursor sols and amorphous xero-gel films of barium titanate and lead zirconate titanate</b><br><u>Tomasz M. Stawski</u> , Sjoerd A. Veldhuis, Hessel L. Castricum and Johan E. ten Elshof<br>MESA+ Institute for Nanotechnology, University of Twente, Enschede, Netherlands |
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Lead zirconate titanate and barium titanate are important ceramic materials used in contemporary electronic devices. A substantial effort has been made to develop sol-gel methods and appropriate precursors enabling synthesis of sub-200 nm films. In order to understand the differences in crystallization behavior between both materials, a better understanding of microstructure evolution in sols and drying thin films is desired.

We investigated the alkoxide-carboxylate routes for both materials. In the case of amorphous  $\text{BaTiO}_3$  gels, the system developed into separate  $\text{TiO}_x$  and Ba-rich phases, as proven by small angle X-ray scattering (SAXS), and EELS mapping in TEM. Depending on the hydrolysis conditions we observed phase-separated domain sizes of 2 to 30 nm. We also performed time-resolved SAXS to study gelation and drying of thin films.

$\text{Pb}(\text{Zr,Ti})\text{O}_3$  sols evolved in a different manner. It was observed that Pb and Ti components remained homogeneously mixed on the nano-scale, whereas Zr clustered into cylindrical stacks of zirconia tetramers.

Crystalline nano-clusters of zirconia were found embedded in an amorphous matrix containing Pb and Ti in as-dried films, as shown by TEM/EELS. Formation of these crystalline species was suppressed by extensive hydrolysis of sols. In this case the presence of an excess of water was a factor that homogenized the system.