Synthese
Charakterisierung
Elektrische Ermüdung
Modellierung
Bauteil

Sonderforschungsbereich 595

Elektrische Ermüdung in Funktionswerkstoffen

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Exploring the Domain Configurations and Functional Properties of Single Crystal Ferroelectric Nanoshapes

Ferroelectric materials offer great potential for influencing the future of small scale electronics: their surfaces are charged, and so interact strongly with charge-carrying metals and semiconductors - the building blocks for all electronic systems.

However, successful integration of ferroelectrics into microelectronic devices has been somewhat limited, partly because the fundamental properties associated with ferroelectrics, when in bulk form, appear to change quite dramatically and unpredictably when at the micro and nanoscale: new modes of behaviour, and different functional characteristics from those seen in bulk appear. Unfortunately, developing a full understanding of such 'size effects' has been limited by a lack of clarity and scientific consensus. The key problem is that of complexity: there are a great many ways in which the external environment, encountered at an interface, may influence ferroelectric behaviour. While this makes nanoscale ferroelectric research extremely rich, it also leads to a great deal of confusion, and thus well devised clean experiments are vital in this field.

Recently, research teams mainly in Queen's University Belfast and the University of Cambridge have attempted to gain a clear insight into the manner in which nanoscale size and changes in morphology affect ferroelectric behaviour, by mapping the properties of single crystal $BaTiO_3$ and $SrTiO_3$ nanoshapes cut from bulk using a Focused Ion Beam Microscope (FIB). Permittivity characteristics, static domain configurations and the dynamics of switching have been examined in thin film plates, nanorods and nanodots, and a summary of the findings will be presented.

In general the research has allowed the following statements to be made:

(i) in contrast to observations made on conventional thin films systems, the permittivity characteristics of thin single crystal $BaTiO_3$ with both gold and platinum electrodes behave almost exactly as seen in bulk; this immunity to reduced size is not universal, however, as the same experiments performed with $SrTiO_3$ and platinum electrodes reveal dramatic permittivity suppression consistent with dielectric 'dead-layers' at electrode-dielectric interfaces. Remarkably these observations have been successfully rationalized using atomistic simulations by Stengel, Spaldin and Vanderbilt;

(ii) the domain states present in ferroelectric nanoshapes satisfy the simultaneous desire to preserve shape on cooling through the Curie temperature, and minimize the energy associated with depolarizing fields;

(iii) switching in nanorods appears easier than in thin film plates, and the kinds of morphological pinning centres seen to be effective in ferromagnetic research (such as notches in nanowires) appear to have little impact on switching dynamics.

Der Vortrag findet um **16:15** im Gebäude der Materialwissenschaften, Lichtwiese, Petersenstr. 23, **Raum 77,** statt