DF 5: Multiferroics II (Joint Session of MA, DF, DS, KR, TT)

Time: Monday 17:00–18:45 Location: HSZ 04

DF 5.1 Mon 17:00 HSZ 04

Tuning magnetism by epitaxial strain in biferroic $Fe_{70}Pd_{30}$ films — •Sandra Weiss[1], Markus Ernst Gruner[2], Jörg Buschbeck[1,3], Ludwig Schultz[1], and Sebastian Fähler[1] — [1]IFW Dresden, Institute for Metallic Materials, P.O. Box 270116, D-01171 Dresden — [2]University of Duisburg-Essen, Theoretical Physics, Lotharstraße 1, D-47048 Duisburg — [3]ECE Department, University of California, Santa Barbara

Due to combination of ferromagnetic and ferroelastic properties magnetic shape memory alloys can be considered as multiferroics. For the magnetic shape memory alloy Fe-Pd we could demonstrate recently, that strained epitaxial film growth allows a variation of the tetragonal distortion by 27 % [J. Buschbeck et al., PRL 103, 2009, 216101]. Density functional calculations revealed a flat energy landscape along the Bain path, explaining this soft behaviour of $Fe_{70}Pd_{30}$. Here we show that tetragonal distortions up to 43 % are possible. This exceeds the Bain transformation path connecting bcc and fcc structure. $Fe_{70}Pd_{30}$ films are produced by coherent epitaxial growth on MgO substrates covered by different metallic buffer layers. By adjusting the tetragonal distortion intrinsic magnetic properties like Curie temperature, saturation magnetisation and magnetocrystalline anisotropy can be controlled. The relevance of two mechanisms for relaxation of epitaxial strain - misfit dislocations and adaptive martensite - is discussed.

DF 5.2 Mon 17:15 HSZ 04

Strain effect on the magnetic properties of $SrRuO_3$ thin films on ferroelectric PMN-PT substrates — •Andreas Herklotz, Mikko Kataja, Ludwig Schultz, and Kathrin Dörr — IFW Dresden, IMW, Helmholtzstrae 20, 01069 Dresden, Germany

We investigate a two-component multiferroic system consisting of a ferroelectric $0.72PbMg_{1/3}Nb_{2/3}O_3$-$0.28PbTiO_3$ (PMN-PT) substrate and ferromagnetic $SrRuO_3$ (SRO) thin films. The inverse piezoelectric effect of the substrate is used to reversibly vary the strain state of the epitaxial SRO films in order to clarify the strain dependence of the magnetic film properties. Buffer films of $Sr_{1-x}Ba_xTiO_3$ are introduced to vary the as-grown state of the SRO films and to cover a wider range from compressive to tensile strain.

High resolution X-ray diffraction is deployed to structurally characterize the films and to determine Poisson's ratio of SRO, which is not known so far. SQUID magnetometry reveals that the Curie temperature is increasing with tensile strain, but starts to decrease again under high strain. Angular-dependent measurements provide that the easy axis orientation shows a complex dependence on strain and temperature. SQUID measurements on conventional substrates like $SrTiO_3$ and $LaAlO_3$ and electric transport measurements complete the data.

DF 5.3 Mon 17:30 HSZ 04

Strain effect on ferroelectric switching dynamics of epitaxial $PbZr_{0.52}Ti_{0.48}O_3$ films — •Kathrin Dörr[1], Andreas Herklotz[1], Michael Biegalski[2], and Hans Christen[2] — [1]IFW Dresden, IMW, Helmholtzstr.20, Dresden — [2]CNMS, Oak Ridge National Laboratory, TN, USA

Elastic strain is known to change ferroic properties of thin films such as the remanent polarization. Less understood and little measured is the influence of the lattice strain induced by film-substrate mismatch on the switching dynamics. In this work, reversible biaxial strain has been applied to films on piezoelectric substrates for a study of their strain-dependent ferroelectric switching. $PbZr_{0.52}Ti_{0.48}O_3$ (PZT) films have been epitaxially grown by pulsed laser deposition on piezoelectric substrates of $0.72PbMg_{1/3}Nb_{2/3}O_3$-$0.28PbTiO_3$(001) (PMN-PT) buffered with a $SrRuO_3/SrTiO_3$ double layer. Four-circle x-ray diffraction has been employed to confirm the tetragonal symmetry and to measure the lattice parameters of the films. Measurements of the characteristic ferroelectric switching time at various temperatures and strains show an increase of several percent under compression, revealing a similarly strong strain sensitivity of the switching dynamics as that of the remanent polarization. We attempt to identify the strain dependence of the domain wall velocity.

DF 5.4 Mon 17:45 HSZ 04

Fabrication and multiferroic properties of $BiFeO_3/BiCrO_3$ perovskite heterostructures — •Vijayanandhini Kannan, Florian Johann, Alessio Morelli, Miryam Arredondo, Eckhard Pippel, and Ionela Vrejoiu — Max Planck Institute of Microstructure Physics, Weinberg 2, D-06120 Halle.

Bi-based multiferroic materials have attracted strong research interests due to the presence of sterochemical active $6s^2$ lone pair electrons in Bi^{3+} ions and high ordering temperatures, e.g., $BiMeO_3$ (Me = Fe, Cr, Mn, etc). In the present work, epitaxial films of $BiCrO_3$ and $BiFeO_3$ of different thickness (5 nm to 250 nm) were grown on $SrTiO_3$ (100) using pulsed laser deposition technique. Reciprocal space mapping XRD measurements showed that both $BiFeO_3$ (40 nm) and $BiCrO_3$ films (130 nm) are fully strained, having out-of-plane lattice constants of 4.075 Å, and 3.88 Å, respectively. The transmission electron microscopy (TEM) analysis of $BiCrO_3$(130nm)/$SrRuO_3$(16nm)/$SrTiO_3$ films revealed the presence of 45^o and 90^o domains along with the coexistence of three structurally different phases, (i) monoclinic (Space Group: C2/c) and (ii) orthorhombic (Space Group: Pnma) and (iii) an unknown monoclinic-like structure. $BiCrO_3$ film (160 nm) grown on $NdGaO_3$ (110) showed a coherent interface without any misfit dislocations or structural variants. A systematic approach on understanding the thickness evolution of these defects or strain induced structural variants of $BiCrO_3/SrRuO_3/SrTiO_3$ films is done. Furthermore, the fabrication and multiferroic properties of $BiCrO_3/BiFeO_3$ bilayers and multilayer heterostructures are investigated.

DF 5.5 Mon 18:00 HSZ 04

Microscopic Investigations of the Strain-Mediated Coupling in Magnetoelectric $Ni/BaTiO_3$ — •Robert Streubel[1], Denny Köhler[1], Lukas Eng[1], Rudolf Schäfer[2], Claudia Patschureck[2], Anja Wolter[2], Sebastian Gass[2], Stephan Geprägs[3], and Rudolph Gross[3] — [1]Institute of Applied Physics, Technische Universität Dresden — [2]Leibniz Institute for Solid State and Materials Research Dresden — [3]Walther-Meißner-Institute for Low Temperature Research

Coupling the (anti-)ferromagnetic and ferroelectric phases within magnetoelectrics allows affecting the magnetic properties by electric fields. Magnetoelectric heterostructures thus may be considered as prospective candidates for future nanoscale memory devices. However, since only a few single-phase room temperature magnetoelectrics exist with rather poor permeability values, simple composite materials, e.g. amorphous nickel on barium titanate ($Ni/BaTiO_3$) may be used for this purpose. While the macroscopic characterization by monitoring magnetic hysteresis and other effects has been thoroughly carried out, microscopic investigations elucidating the mechanism of ferroelectric/ferromagnetic coupling are still missing.

We report here on the nanoscale inspection of the $Ni/BaTiO_3$ system by PFM, MFM and MOKE. In addition, the saturation magnetization and magnetic anisotropy were measured by SQUID. Both stress and anisotropy within the amorphous Ni film have been modeled showing an excellent agreement with experimental results.

DF 5.6 Mon 18:15 HSZ 04

Magnetoelectric properties of core-shell $CoFe_2O_4$-$BaTiO_3$ composites — •Vladimir Shvartsman[1], Firas Alawneh[2], Morad Etier[1], Shiwam Tiwari[1], and Doru Lupascu[1] — [1]Institut für Materilawissenschaft, Universität Duisburg-Essen — [2]The Hashemite University, Zarqa, Jordan

In recent years there has been growing interest in materials exhibiting the magnetoelectric (ME) effect. A large ME coupling has been achieved in composites, where a magnetostrictive phase is mechanically coupled to a piezoelectric phase. The magnitude of the ME effect in such systems depends on the properties of the phases and the type of connectivity. In particular, in core/shell-type structures, where the magnetostrictive core is surrounded by the piezoelectric shell, a large well-defined interface area should enhance the ME coupling.

We report on results of synthesis and ME characterization of $CoFe_2O_4$ - $BaTiO_3$ composites with the core-shell structure. The ceramic samples were prepared by covering cobalt ferrite nanoparticles by a shell of $BaTiO_3$ using a sol-gel technique. Scanning probe microscopy studies confirm formation of the core-shell structure with a magnetic core and piezoelectric shell. The ME effect was measured using a modified SQUID susceptometer. Though the relatively high conductivity of the samples prevents an efficient poling of the ferroelectric component, the obtained ME coefficients are comparable to those reported for similar systems. Effects of the microstructure and ratio between piezoelectric and magnetostrictive phases on ME performance are analysed.

DF 5.7 Mon 18:30 HSZ 04

Highly ordered multiferroic nanocomposite arrays: Fabrication and Properties — •Xiaoli Lu, Yunseok Kim, Silvana Goetze, Peter Werner, Marin Alexe, and Dietrich Hesse — Max Planck Institute of Microstructure Physics, Weinberg 2, 06120 Halle, Germany

With the resurgence of interest in multiferroics, searching for materials with high coupling coefficient becomes more and more important from both fundamental and practical point of views. We report a new type of artificial nanocomposite, $BaTiO_3/CoFe_2O_4$ (BTO/CFO) heterostructured nanodot arrays. Using a stencil of ultra thin anodic aluminum oxide (AAO) membrane and pulsed laser deposition (PLD), BTO and CFO nanodots were epitaxially grown on top of each other. The size of the nanodots can be easily tuned from 60 to 400 nm. Piezoresponse force microscopy (PFM) and superconducting quantum interference device (SQUID) were used to study the nanocomposite. The local characterization of the piezoresponse and domain structure within single nanodots may shed new light on the strain-mediated magnetoelectric (ME) coupling. The epitaxial interface and reduced clamping from the substrate in this nanocomposite promise a better elastic coupling, which makes it a good prototype for nonvolatile ultrahigh-density memory unit with multi-state data storage capability.