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XANES and XRD study for structure and magnetic properties in permalloy($Ni_{80}Fe_{20}$)/Ru multilayers

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The investigation of well-characterized magnetic thin films, multilayers, and nanostructures is an active field of research. Layered structures consisting of ferromagnetic and non-ferromagnetic metals are of technical as well as of fundamental interest. Such systems are an area of intense research today partly due to the application potentials of magnetic properties such as the GMR. This phenomenon is closely related to the coupling, known as the Ruderman-Kittel-Kasyua-Yosida (RKKY) interaction, which is accompanied by an oscillatory magnetic moment in the nonmagnetic spacer layer.

The late 4*d* transition metals are "almost" ferromagnetic in a sense that calculations of very thin films of Ru, Rh, and Pd often predict stable ferromagnetic moments. In outr preliminary XMCD experiment, an enhanced orbital magnetic moment of Fe in the permalloy(Py) films is observed. It is an unusual phenomenon because the orbital moment of 3d transition metal is usually quenched due to the crystal field. In this study, we attempt to characterize the crystalline and electronic structure of the thin Ru and Py layers. Because the diffraction peaks of Ru and Py in the plane-normal XRD were obscured by the strong Laue function of Pt(111) buffer layer. Further tilt hk-circle scans were added to illustrate the crystallographic orientation. The epitaxial orientation of the Py/Ru/Py trilayer and Pt buffer layers was determined as Py(111)|Ru(0001)|Py|Pt(111),Py[1-10]||Ru[11-20]|Py|Pt[1-10],andPy[11-2]|Ru[1-100]||Pt[11-2].

Figure 1 is a typical result of in-plane XRD and an azimuthal six-fold symmetry was also observed in the hk-circle scan which indicates a good epitaxial growth was obtained.

It is believed that the magnetic properties would be changed due to a variation of inter-atomic distances and crystal symmetry. It is also known that the spin and orbital moment at surface are often enhanced compared to the bulk values due to the symmetry breaking and *d* band narrowing. A strain of expanded in-plane Ru(11-20) was obtained as 1.18% for 7Å, 0.96% for 9 Å and 0.5% for 25 Å Ru layers. But no obvious pseudomorphic HCP structure or large strain of Py layers were observed which might be excluded from the formation of enhanced orbital moment of Fe.

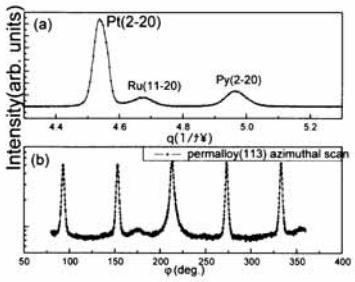

Figure 1 (a) Typical in-plane XRD of Py/Ru/Py trilayer.
(b) An azimuthal scan of Py(113)

Electron hybridization at interface can give rise to charge transfer across interface, resulting in a change of the density of states near the Fermi level. Thus the electronic structure of Ru might play an important role. Unfortunately, there is a little difficulty due to the unexpected incident photon energy change comes from mechanical screw backlash to measure the XANES of Ru thin layers this time.

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X-ray absorption spectroscopy studies of phase transitions of the nanocrystalline zirconia under high-pressures

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In this work, nanocrystalline zirconia (around 29 to 68 nanometers) was been measured by *in-situ* XAFS and X-ray diffraction under high-pressure which was performed in the BL12B2 beamline during Nov. 1 to Nov. 5, 2003. In addition, XANES and EXAFS studies have been especially useful in providing electronic properties and structural information about the nanocrystalline materials. The data of EXAFS allows determination of local structural parameters.

Solid solutions of zirconia (ZrO_2) are still an interesting subject which combines high-temperature stability and high strength problems involving the first-principle computational materials and high-pressure physics. Until today it is still controversial on the subjects of driving forces and structure phase transformations induced by the high pressure. Previous first-principle calculation predicted that the high-pressure transition point is between 3 and 6 GPa where the monoclinic phase transforms to orthorhombic phase. In our studies, XRD analysis shows that the phase transformation begins earlier from 2.7 GPa and extended to 6.8 GPa, but XANES analysis shows that the *d* density of states was separated into three district components as the uploading process, which implies that the change of the local structure was more complicated than the theoretical prediction. The EXAFS data analysis shown that the bond-lengths of cation-oxygen (Zr-O) shell increased with the uploading process, which might be due to the repulsive Zr-O interaction or the geometrical distortion of the oxygen sublattice.

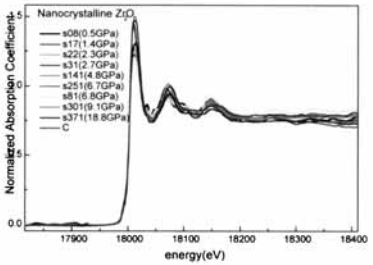

Figure 1 The Zr K-edge XAFS spectra in nanocrystal zirconia at different pressure.

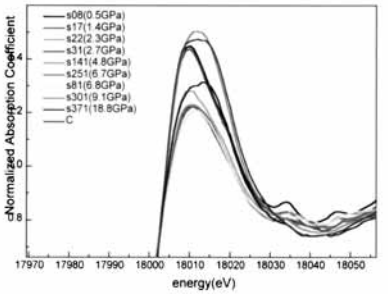

Figure 2 The XANES v.s. Pressure in nanocrystal zirconia.