Spin-Resolved Photoemission in Layered Magnetic Systems

F. Matthes, L.-N. Tong, A. Rijevski, M. Müller, C.M. Schneider

Inst. f. Festkörperforschung IFF-6, Forschungszentrum Jülich, Jülich, Germany

Layered magnetic systems continue to be of major interest for both technological applications and basic research. On the one hand, they constitute the essential building blocks for novel devices in magnetic data storage and spintronics. On the other hand, they allow one to study the fundamental aspects of magnetism in new magnetic materials and in reduced dimensions. Presently, two issues are of particular interest. First, the interplay of ferromagnetism and electronic structure in complex compounds, such as binary or ternary alloys, half-metals, or magnetic semiconductors. The investigations strive at an understanding of the various exchange-interaction mechanisms, determining the magnetic order in such compounds. Second, the magnetic behavior at surfaces and interfaces, which is closely related to the question of electronic interface states and their influence on the electron spin polarization at the interface.

Spin-resolved photoelectron spectroscopy is a versatile tool to address the aspects mentioned above. Since the photoelectrons from ferromagnets are spin-polarized, an *explicit* spin analysis via a spin-polarization detector yields directly a detailed information about the spin character of the electronic states participating in the photoemission process [1]. A complementary experimental technique is magnetic dichroism in the photoelectron distribution (MDAD), which exploits the interference between spin-orbit and exchange coupling during a spin-dependent photoexcitation event, thereby providing an *intrinsic* spin detection mechanism [2]. Our studies addressed two different thin film systems. The binary alloy Ni_xPd_{1-x} is a model case for a ferromagnetic compound with two isoelectronic constituents of different spin-orbit coupling strength. The system Fe/MgO is not only a model system for a ferromagnet/insulator, but has recently become of interest in context with spin-polarized tunneling processes [3].

The fcc Ni_xPd_{1-x} films were grown on $Cu_3Au(001)$ and exhibit characteristic variations in the photoemission spectra with the alloy composition, which can be traced back to the corresponding changes in the electronic structure. In order to support the interpretation of the experimental data, bulk band structure calculations were carried out within the Munich SPR-KKR package. Although gross spectral features can be explained by an increase of spin-orbit coupling with increasing Pd-content, an overall agreement with the theoretical predictions is difficult to achieve. This may be due to electronic correlations, which are known to dominate the valence band photoemission from pure Ni. In the MgO/Fe(001) system, we started out with a 16ML Fe film grown on GaAs(001), which yielded spin-resolved photoemissin spectra in good accordance with bulk band structure calculations. Upon coverage with 1-2 ML MgO, we observe an overall persistance of the spin-polarization in the Fe-related states, although initial state bands of different symmetry are affected differently. This is probably related to a slight oxygen deficiency in the MgO layer, which prevents the formation of FeO at the MgO/Fe interface.

References:

[1] W. Schattke and M. Van Hove, *Solid-State Photoemission and Related Methods* (Wiley-VCH, Berlin, 2003).

[2] W. Kuch and C.M. Schneider, Rep. Prog. Phys., **64** (2001) 205.

[3] S. Yuasa, T.Nagahama, A. Fukushima, Y. Suzuki, and K. Ando, Nature Materials, **3** (2004) 868; S.S.P. Parkin, C. Kaiser, A. Panchula, P.M. Rice, B. Hughes, M. Samant, and S.-H. Yang, Nature Materials, **3** (2004) 862.