



	Experiment title: Valence electronic and magnetic structure of magnetoresistive $\text{Co}_2\text{Cr}_{1-x}\text{Fe}_x\text{Al}$ Heusler alloys	Experiment number: HE-1539
Beamline: ID08	Date of experiment: from: 03 September 2003 to: 09 September 2003	Date of report: 25/02/04
Shifts: 18	Local contact(s): Dr. Nicholas BROOKES	<i>Received at ESRF:</i>

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Report:

Introduction

Materials displaying large changes in resistivity in response to an applied magnetic field are currently at the focus of a large scientific interest due to their potential for applications in magnetic field sensors and spintronics devices [1]. Although ferromagnetic manganites show colossal magnetoresistance effects around their Curie temperature the features important for spintronics applications, such as low field and nearly temperature independent magnetoresistance, are only found at low temperatures. Recently Felser et al. [2] guided by characteristic features in the electronic structure of manganites prepared the half metallic Heusler compound $\text{Co}_2\text{Cr}_{0.6}\text{Fe}_{0.4}\text{Al}$ and found a surprisingly large magnetoresistance of 24% in a relatively low magnetic field of up to 0.1T at room temperature.

Although of tremendous applied interest the microscopic origin of the large magnetoresistance in these materials is poorly understood. The sample preparation guidelines used by Felser et al. were based on selecting halfmetallic Co_2CrAl parent compounds and positioning a van Hove singularity near the Fermi level by doping with Fe. Both electronic features were predicted by first-principles calculations [2] but so far have not been identified spectroscopically. As a first step in this direction we used circular dichroism in $2p$ resonant photoemission spectroscopy [3] to study element specifically the spin dependent valence electronic structure of $\text{Co}_2\text{Cr}_{1-x}\text{Fe}_x\text{Al}$ for two doping levels $x=0.4$ and $x=1.0$.

Experiment

The experiments were performed at the beamline ID8 using the spin-polarized photoelectron spectroscopy setup. Valence band spectra of Heusler compounds with different Fe concentrations were measured at photon energies corresponding to the L_3 resonances of Fe and Co. The angle of incidence was set to 30° with respect to the sample surface and the photoelectron analyzer was positioned at normal emission. Sample preparation was done by scraping the sample-surface with a boron nitride head under UHV conditions (2×10^{-10} mbar). We monitored the oxygen and carbon $1s$ photoemission signals to check the surface cleanliness. The total energy resolution of the incident x-rays and the electron spectrometer was 400meV.

Results

$\text{Co}_2\text{Cr}_{1-x}\text{Fe}_x\text{Al}$ samples display soft magnetic behavior with a remanent magnetization of only 10% of the saturation magnetization [2] and a micron sized domain structure [4]. Resonant $2p3d3d$ photoemission with circularly polarized x-rays measures the local $3d$ spin polarization independent of the orientation of the magnetic moment [3]. In the resonant excitation process the circular x-ray polarization orients the core hole

orbital moment along the x-ray helicity direction. Spin orbit coupling is then responsible for aligning the spin along the orbital moment. The $2p3d3d$ resonant photoemission process transfers this spin polarization to the emitted electrons. It has been observed that especially the high binding energy part of the spectrum is atomic-like and characteristic of the final state $3d$ multiplet configurations. However, near the Fermi-level deviations from a nearly atomic-like multiplet have been observed [3].

Fig.1 shows typical resonant photoemission spectra of $\text{Co}_2\text{Cr}_{1-x}\text{Fe}_x\text{Al}$ Heusler alloys for $x = 0.4$ (red lines and symbols) and $x = 1.0$ (black lines and symbols) recorded at the Fe (left) and Co (right) L_3 resonances. The dominant feature of the unpolarized spectra (top panels of Fig. 1) is the well known two-hole final-state satellite [5]. The different intensities for the two spectra taken at the Fe resonance simply reflect the different Fe content of the samples. The peak shift observed in the Co spectra is due to a slight deviation of the photon energy for the two spectra. The observed asymmetry at the Co resonance (lower right panel) does not depend on the Fe doping and qualitatively resembles that of Ni metal [6]. Interestingly, significant changes of the spin-polarization especially near the Fermi-level are observed at the Fe resonance (lower left panel) when varying the Fe doping. This is a clear indication that the spin-polarized density of states changes with Fe doping especially near the Fermi level. A quantitative description of the spectra is underway that should clarify whether the observed effects are caused by the predicted valence electronic features of $\text{Co}_2\text{Cr}_{0.6}\text{Fe}_{0.4}\text{Al}$ Heusler compounds [2].

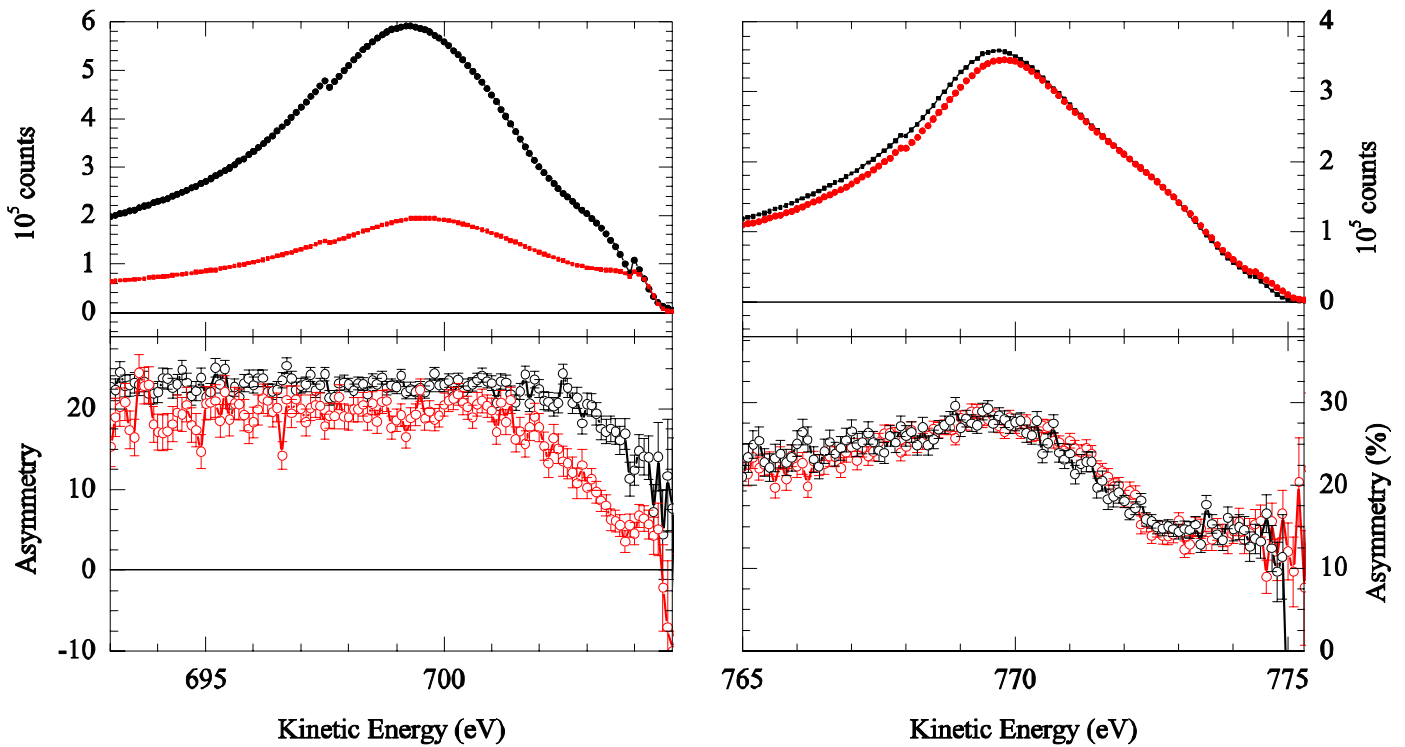


Fig. 1 $2p3d3d$ resonant photoemission spectra obtained for excitation with circularly polarized x-rays taken at the Fe (left) and Co (right) L_3 resonances. Shown are (top panels) the unpolarized resonant photoemission spectra and (bottom panels) the asymmetry of the measured spin polarization for two Heusler compounds, $\text{Co}_2\text{Cr}_{1-x}\text{Fe}_x\text{Al}$, with $x=0.40$ (red) and 1.0 (black). The kinks observed in the unpolarized spectra are artefacts produced by the hemispherical energy analyzer lens settings. These features are absent in the spin-resolved spectra.

references

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