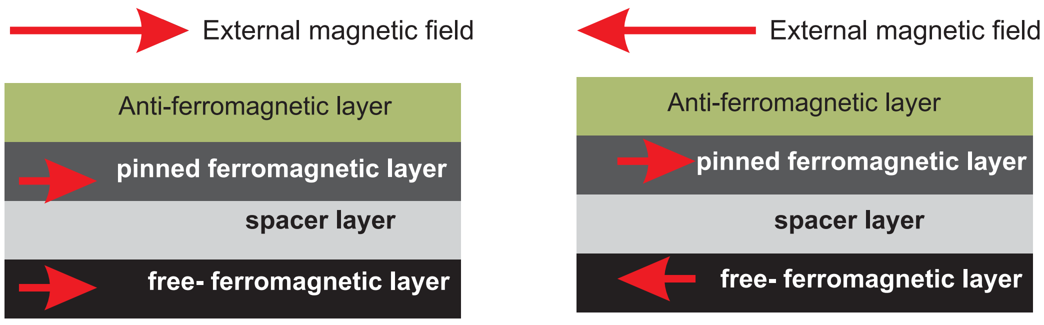
Characterizing Oxide Barrier Layers in Ta-Co-Cu-Co-O-Co-NiMn Spin Valves

M.Kinyanjui[1], A.Chuvilin[1], U.Kaiser[1], A.Gupta[1,2], S.Mohanan[2], U. Herr[2]

[1]Materialwissenschaftliche Elektronenmikroskopie, University of Ulm, Albert-Einstein Allee 11, D- 89081 Ulm, Germany
[2]Institute für Mikro- und Nanomaterialien University of Ulm, Albert-Einstein Allee 47, D-89081 Ulm, Germany

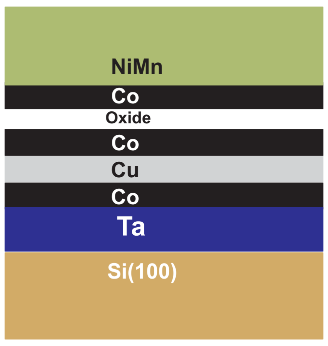
Spin Valves



Parallel alignment low resistance — Anti parallel alignment high resistance (GMR)

Spin valves are used as magnetic sensors, read heads for hard disks or as spin valve transistors.
Spin valves consists of several magnetic layers separated by a non magnetic layer, one of the layers is pinned by an anti-ferromagnetic layer while the other is free to change its magnetization with respect to an external magnetic field. The resistance of the multilayer known as magnetoresistance depends on the relative orientation of the magnetization in the layers (figure (1a,b).[1,2]

Motivation



The spin valve structure in this study consists of **Ta-Co** (Ferromagnetic)**-Cu** (spacer layer)**-Co-Oxide-Co-NiMn** (Antiferromagnetic layer) multilayer system.

- Annealed at 350°C for 10 min. to induce the NiMn phase transformation from the non-magnetic. disordered Face Centred cubic to anti-ferromagnetic FaceCentred Tetragonal phase.
- Annealing treatment is accompanied by thermal degradation of the layers through interdiffusion and alloying at the interfaces.
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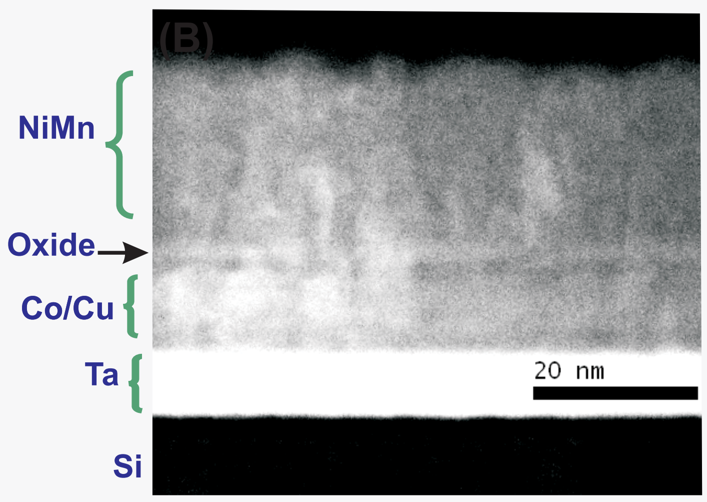
- Oxide barrier layers were incorporated into a Ta-Co-Cu-Co-Oxide-Co-NiMn layer system as an attempt to prevent degradation of the magnetic properties through interdiffusion. [3].

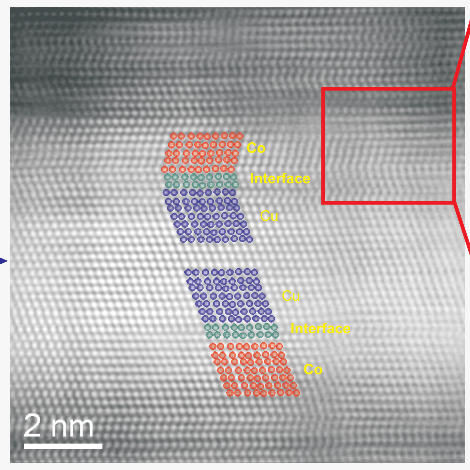
Experimental

Ta-Co-Cu-Co-Oxide-NiMn layyers were deposited on a Si(100) substrate by DC Magnetron Sputtering. The oxide layer was formed by exposing Co layer to pure O_2 with O_2 flow rate of 5 sccm at 10^{-2} mbar. Magnetic properties were measured using Vibratiing sample magnetometer (Lake Shore 735 VSM). TEM samples were prepared using the cross sectional technique. Energy Filtered TEM (STEM) and Scanning TEM(STEM) and High Angle Annular Dark Field (HAADF) investigations were carried out were carried on a Titan 80-300.microscope.

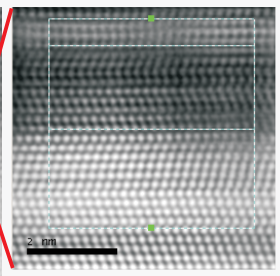
Oxide Layer structure- STEM HAADF results



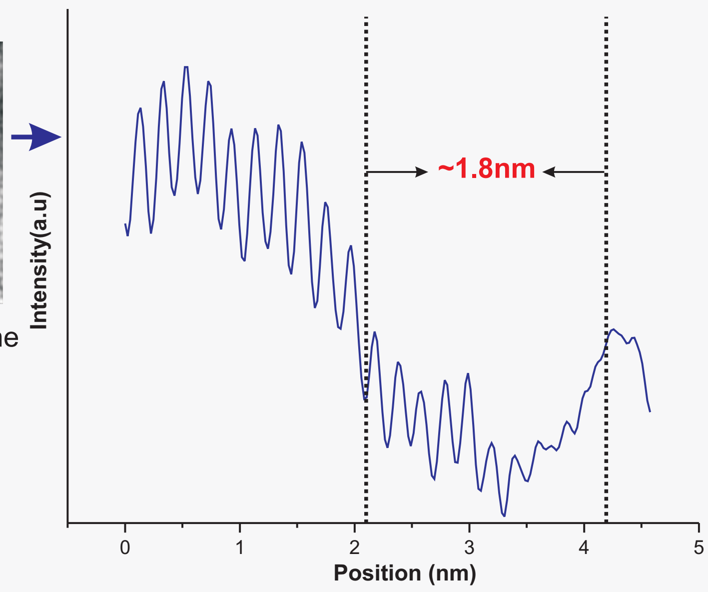
A STEM-HAADF image showing dark layer contrast from the oxide barrier layer. Contrast in the layers is almost uniform due to similarity in atomic number Z between Ni, Mn, Co, Cu



A high resolution STEM-HAADF image showing the layer structure and the Co-Cu-Co-CoO interfaces.

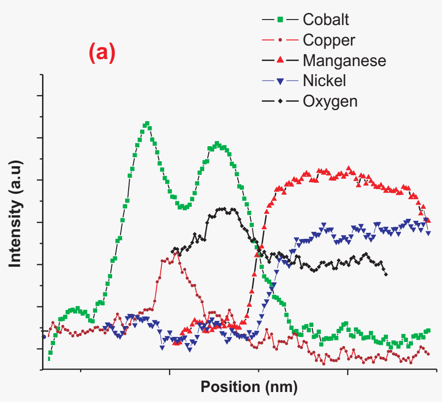


Layer structure at the Co-CoO interface

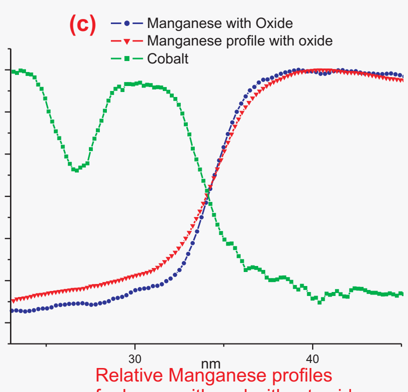


Intensity profile from the High resolution HAADFcontrast image taken along Co-Oxide interface. The width of the oxide layer is estimated to be ~1.8 nm.

Layer Stability- EFTEM reuslts



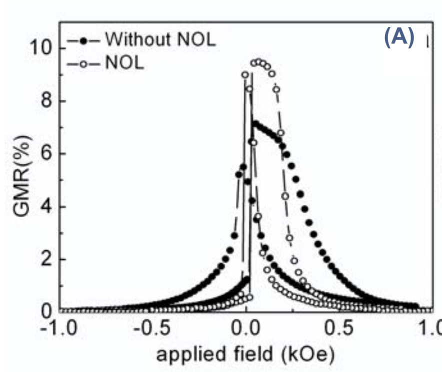
Layer with oxide

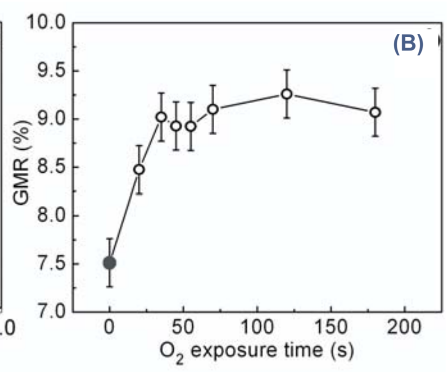


Relative Manganese profiles for layers with and without oxide

EFTEM intensity profiles show that inclusion of the oxide barrier layer blocks the diffusion of Mn and Ni within the Cobalt and Copper layers (a). Without the Oxide layer the intensity profile of Mn (b) shows a tail and broadening indicating some interdiffusion

Magnetic Properties





Giantmagnetoresistance (GMR) increases for the sample with an oxide barrier layer (a) and (b) an increase in the GMR with an increase in the oxidation time

Conclusions

- The thickness of the oxide barrier layer is estimated from STEM-HAADF image to be ~ 1.8nm
- EFTEM results show that the oxide barrier limits the diffusion of Mn and Ni into the Cobalt and Copper layers.
- It was shown that the inclusion of the oxide barrier layer increases the GMR values as compared to the samples without an oxide barrier.

References

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