DOI: 10.1017/S1431927603443353
Microsc Microanal 9(Suppl 2), 2003

TEM and EELS Study of a Fe_3O_4 / NiO Bilayer

C.E. Rojas*and E. Snoeck**

*CME, Universidad Central de Venezuela, A.P. 47632, Caracas 1041A, VENEZUELA
**CEMES-CNRS, 29 Rue Jeanne Marvig, B.P. 4347, 31055 Toulouse Cedex 4, FRANCE

When a layer of a ferromagnetic material (Curie temperature T_C) is deposited on an antiferromagnetic material (Néel temperature T_N), several magnetic phenomena appear if $T_N < T_C$, which are enclosed under the term "exchange biasing", being the more notorious a shift of the hysteresis loop of the ferromagnetic layer along the field axis. There is evidence that indicates that the exchange biasing phenomena are associated to the antiferromagnetic / ferromagnetic interface [1].

The system we have chosen to study is the bilayer formed by the ferromagnetic material magnetite (Fe_3O_4) deposited on the antiferromagnetic material nickel monoxide (NiO).
Samples were fabricated in a computer controlled sputtering chamber with two face-to-face AC magnetrons, one with NiO targets and the other with Fe_2O_3 targets. The working gas used was a mixture Ar-O_2 and the substrate was monocrystalline MgO exposing the (100) surface which was maintained at 900ºC during the deposition [2].

One of the samples fabricated was prepared in cross section by ion milling for its characterization by conventional and high resolution TEM, including electron diffraction, what indicated that this sample is an epitaxial bilayer of Fe_3O_4/NiO grown on MgO(100). Figure 1 shows a bright field TEM image in which one observes from left to right a 54 nm magnetite layer over a 43 nm nickel monoxide layer over the magnesium monoxide substrate. The sample was also characterized by Electron Energy Loss Spectroscopy (EELS). Figure 2 shows a spectrum image obtained with the Fe $M_{2,3}$ low loss signal in which the bright band corresponds to the Fe_3O_4 layer and the dark band to its right corresponds to the NiO layer. The horizontal dark line across the image corresponds to carbon contamination caused by the electron beam used to collect a sequence of Fe $L_{2,3}$ white lines EELS spectra across the NiO/Fe_3O_4 interface.

Figure 3 shows a sequence of Fe $L_{2,3}$ white lines EELS spectra recorded across the antiferromagnetic-ferromagnetic interface, which can be used to evaluate the branching ratio $L_3/(L_2+L_3)$ related to the local magnetic moment of the iron atoms.

References

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[3] C.E. Rojas acknowledges the support of the CDCH-UCV

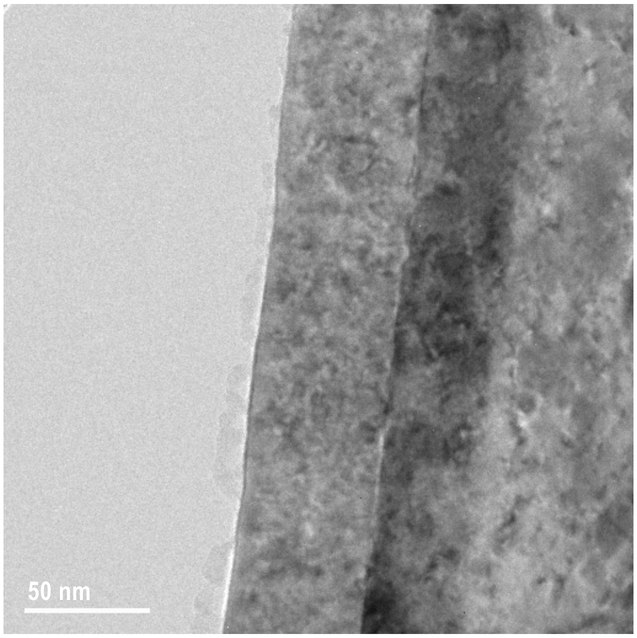

Fig. 1. Bright field TEM image of a Fe_3O_4/NiO/MgO(100) cross section.

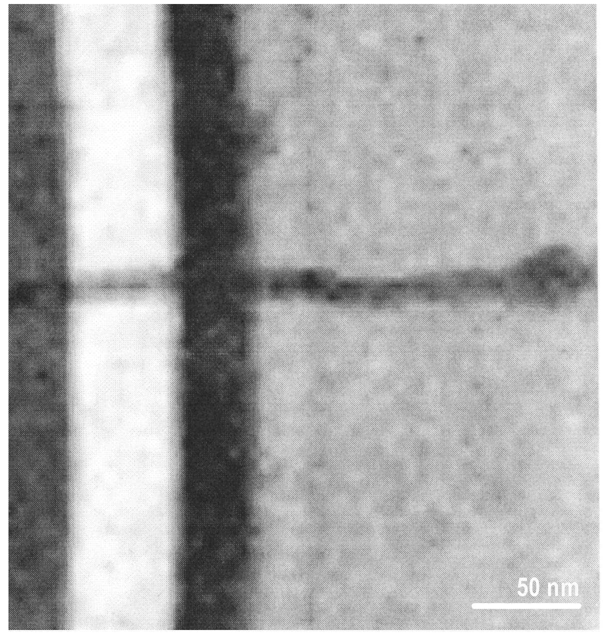

Fig. 2. L Fe EELS spectrum image of a Fe_3O_4/NiO/MgO(100) cross section.

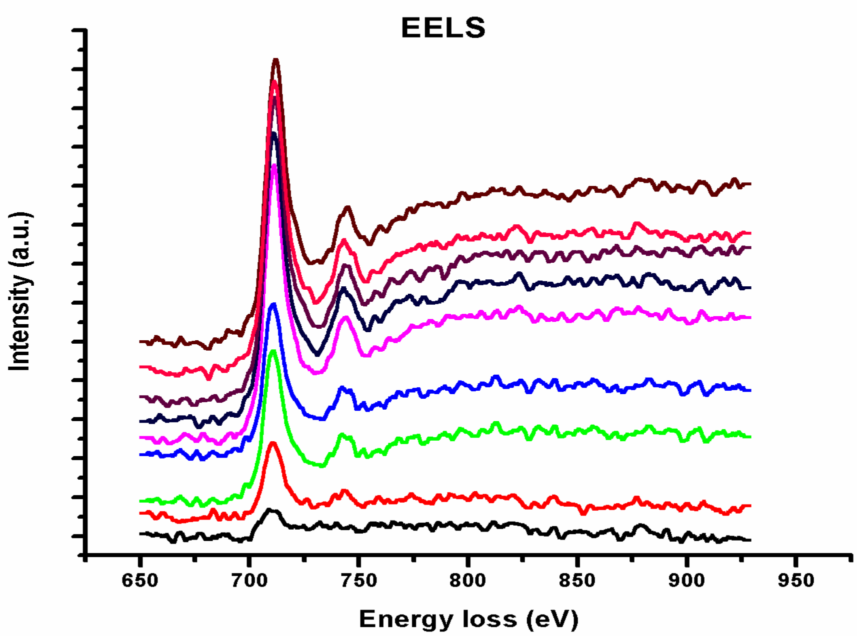

Fig. 3. Sequence of $L_{2,3}$ Fe white lines EELS spectra across the NiO/Fe_3 interface.

https://doi.org/10.1017/S1431927603443353 Published online by Cambridge University Press