Microsc. Microanal. Vol. 13 Suppl. 3 (2007) 404.

Investigating the Oxide Barrier Layer in Ta-Co-Cu-Co/Oxide/Co-NiMn Spin Valve Structures.

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A Spin valve typically consists of two ferro-magnetic layers separated by non-magnetic layer. One of the ferromagnetic layers has its magnetization pinned by an anti-ferromagnetic layer. Spin valves show changes in electrical resistance due to external magnetic field variations and/or changes in the layer alignment [1, 2]. In a Ta (Tantalum) –Co (Cobalt)-Cu (Copper)-Co-NiMn (Nickel Manganese) multilayer system, the ferromagnetic Co layers are separated by a spacer Cu layer with one of the Co layers being pinned by the anti-ferromagnetic NiMn. Multilayer structures consisting of NiMn are usually annealed to induce the phase transformation from the disordered face centered cubic (FCC) NiMn to the anti-ferromagnetic Face Centred Tetragonal (FCT) structure of NiMn. This process is associated with diffusion processes which result in layer degradation and alloying and consequently affecting the magnetic properties.

We introduced an oxide barrier layer to a Ta-Co-Cu-Co-NiMn spin valve system by exposing the Co surface to oxidation for 2-4 min during deposition and then capping the oxidized surface with a thin Cobalt layer [3]. The purpose was to prevent diffusion and alloying between Mn and Ni and the Co layer. The schematic of the multilayer is shown in Fig1 (a). Using Energy Filtered Transmission electron microscopy (EFTEM) we observed that the oxide barrier hinders diffusion of manganese and nickel into the cobalt layer as shown using Ni, Mn, Co and O intensity profiles in Fig 1(b). There are no Ni and Mn intensities within the oxide barrier and the cobalt layers. The NiMn-Co interface as shown in Fig 2 is quite regular indicating low interdiffusion between Co, Ni and Mn. Fig 3 presents some results from Z-contrast scanning transmission electron microscopy (Z-STEM) investigations on the multilayer. We found the oxide layer to be quite irregular and discontinuous with an average thickness of 3.3 nm (0.61). The Z-STEM results on the oxide layer will also be compared with results obtained using Fresnel contrast analysis.

References:

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[4] Supported by the Landesshwerpunkt „Funktionale Nanostrukturen" Baden Württemberg

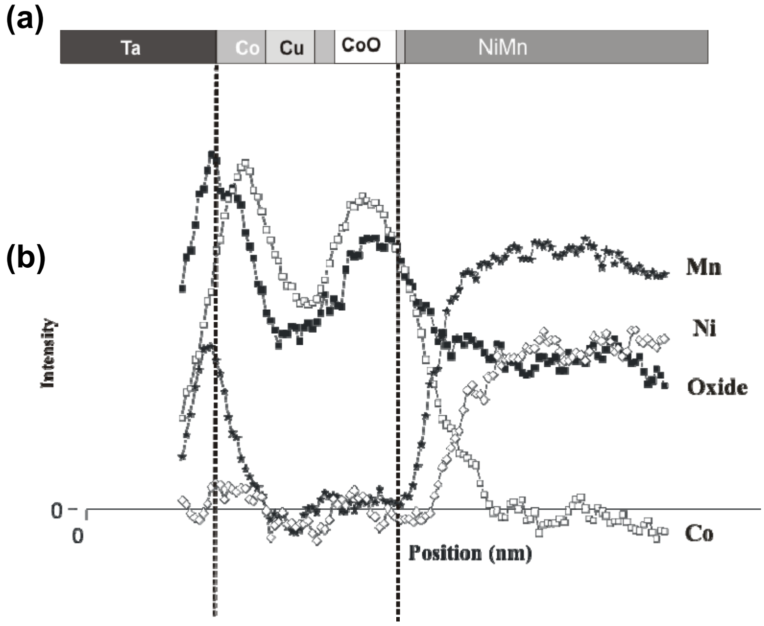

Fig 1: **(a)** A schematic of the Multilayer system. **(b)** EFTEM intensity profiles for Mn Ni, O and Co as a function of position. The oxide barrier reduces the diffusion of Mn and Ni into the Co layers.

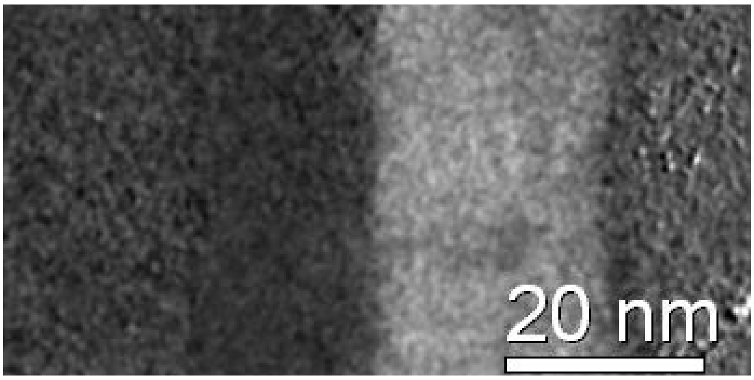

Fig 2: Manganese jump ratio map showing the NiMn-Co interface.

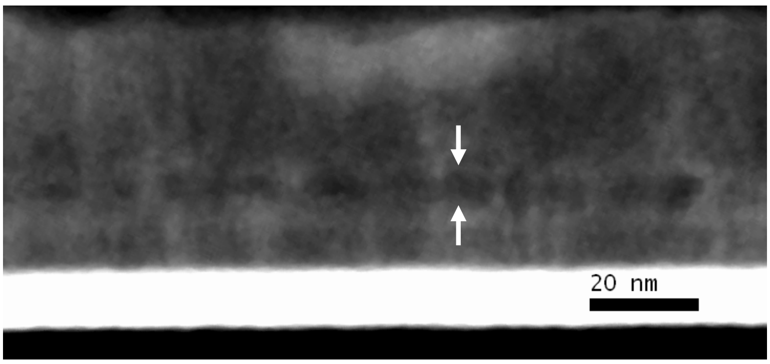

Fig 3: Z-STEM image indicating the position and the nature of the oxide layer. The oxide layer is shown to be irregular and discontinuous.