Atom Probe Analysis of Planar Multilayer Structures

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Multilayer structures are an important part of advanced magnetic sensors such as spin valve magnetoresistive elements. As the interfaces between the individual layers in these structures are important in determining the magnitude of the magnetoresistive effect, there exists a crucial need for a characterization technique that accurately maps the composition of these layers, and their interfaces, on the atomic scale. Three-dimensional atom probes have been shown to be capable of generating the required data, but heretofore, research has been limited to structures with layers oriented parallel to analysis direction. The resolution of the atom probe is significantly improved (~1 atomic layer), however, when the interfaces are oriented normal to the atom probe specimen axis. The present work reports atom probe analyses from planar-deposited multilayer structures using specimens fabricated normal to the layers. A multilayer structure consisting of Ta/CoFe/(Cu/CoFe)x15/Ru/(CoFe/Ru)x5/Ru/NiFe (7/13/(3/3)/50/(3/1)/50/150 nm) was sputter deposited on oxidized (100) silicon. Specimens were sharpened into the needle geometry required for atom probe analysis using a combination of photolithography and focused ion beam milling. Atom probe analysis of the NiFe layer showed an average composition of 82.30 at. %Ni-17.45 %Fe-0.15% C-0.10%O, in good agreement with XPS measurements of 82.5 at. %Ni-17.50%Fe. The interface between the NiFe and Ru layers has also been analyzed using the atom probe technique. These results demonstrate that atom probe analyses may be obtained from planar-deposited multilayers in a direction normal to the stack and show the feasibility of this characterization technique for these nanoscale multilayer structures.

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