Microstructural Evolution of Tunneling Magnetoresistive Junctions

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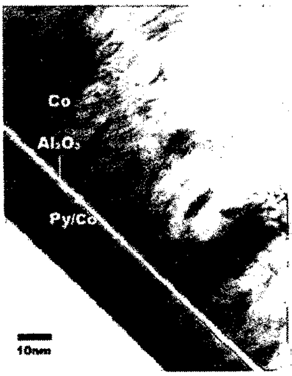
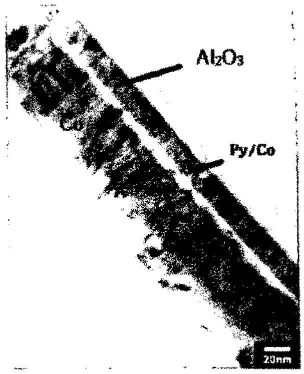
Tunneling Magnetoresistive(TMR) Junctions consist of ferromagnet/insulator/ferromagnet structure in which TMR ratio changes as a function of an applied magnetic field. It depends upon spin arrangement of ferromagnetics(parallel or anti-parallel) separated by an insulating layer. It is applicable to novel high density read-head for HDD and MRAM(Magnetoresistive Random Access Memory) because it exhibits a large MR ratio. In order to utilize it commercially we have to control the thickness of insulating layer within a few angstrom range. Thus, microstructural control is of crucial importance. We investigated microstructural characteristics of oxide layer during oxidation process and interface morphology to establish reliable and reproducible processing conditions for TMR junction fabrication.

We made ferromagnetic tunneling junctions which employ either Al-oxide or Ta-oxide as insulating layer with different thickness using magnetron sputtering. NiFe and Co layers evolve into polycrystalline columnar structure with fairly good flatness. Cross sectional TEM exhibits complete oxidation of Al layer in contrast to Ta. Both Al and Ta-oxides are confirmed to be amorphous. The roughness of Al-oxide increases with thickness. It appears that roughness is dependent on the pressure of oxygen during oxidation process. In case of Ta, Ta-oxide remains flat regardless of thickness. TMR characteristics of these samples show that the sample with thin and flat Al-oxide has 15% MR ratio and MR ratio decreases with thickness and roughness. In case of Ta the largest MR ratio of 9% was obtained in the limited range of thickness and decreases with thickness rapidly.

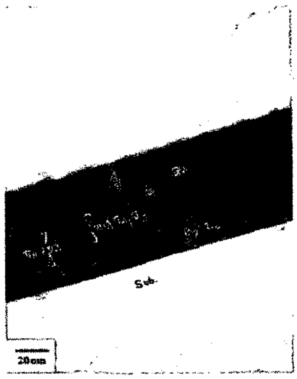


(a)

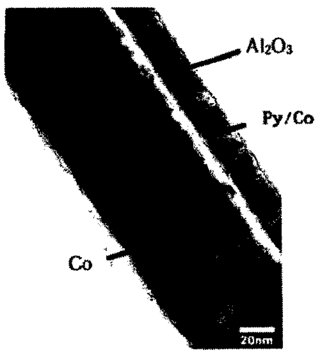


(b)

(c)



(d)



(e)

Fig. 1. Cross Sectional Transmission Electron Micrograph for
(a) Py*/Co/Al(13Å)-oxide/Co(plasma oxidation),
(b) Py/Co/Al(43Å)-oxide/Co(plasma oxidation),
(c) Py/Co/Al(63Å)-oxide/Co(plasma oxidation),
(d) Py/Co/Ta(63Å)-oxide/Co(plasma oxidation),
(e) Py/Co/Al(63Å)-oxide/Co(natural oxidation)
Tunnel Junctions
*Py(Permalloy) : $Ni_{80}Fe_{20}$