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æ'˜è¦ (è‹±)	The in-situ electrical characterization of Al thin films (< 20 nm), which were fabricated by magnetron sputtering system, was performed by AC resistance bridge measurement. Further, we studied variations of electrical properties of oxidized Al thin films by pure oxygen gas and oxygen plasma, respectively. The AFM (atomic force microscopy) images and X-ray diffraction were used to measure our sample morphology and crystalline structure information. We found that the F-S model (Fuchs-Sondheimer model) and the modified F-S model, which considers the roughness influence on F-S model, does not explain our results exactly. We used semi-empirical formula to fit our data to discuss the variation of the resistivity under oxidation. The oxidation depth of Al is about 1nm for dry oxidation of Al. This is different from the wet oxidation of Al, which is larger than 5nm. The depth of Al-O prepared by oxygen plasma oxidation of Al is stable to about 1nm after ten to twenty minutes. The stabilized thickness of Al-O is due to the competition of the diffusive depth of oxygen ions and the resistive distance by Al-O layer. In the application, we fabricated spin-dependent tunnel junction (TMR) with our best condition of preparation of Al-O, and measured their cross-section structure, surface topography, and crystalline structure by TEM (transmission electron microscopy), AFM, and X-ray, respectively. TMR junction with the low interface roughness (~0.9nm) and amorphous structure of 26Å thickness of Al-O has the following properties: 1 eV of barrier height, 2.2nm of barrier width. We had used above technology to fabricate TMR junction with independent magnetic behavior, and 8% of TMR ratio. Hence, the preparation of Al-O by our method can be appreciated to the fabrication of TMR successfully.
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	â€œOxides and Oxide Filmsâ€ , Vol. 5, P105~166. 24. J. M. Eldridge and D. W. Dong, Surf. Sci. 40, 512(1973). 25. J. E. Hatch, 1984, â€œAluminum Properties and Physical Metallurgyâ€ , P252~254, American Society for Metals. 26. J.S.Moodera, L.R.Kinder, T.M.Wong, and R.Meservey, Phys.Rev.Lett, 74, 3273, (1995) 27. C. H. Ho et al. unpublished. 28. J. G. Simmons, J. Appl. Phys., 35, 2655 (1964).
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