Spin-dependent Tunneling in the Plasma Oxidized Cr_2O_3 Barrier Magnetic Tunnel Junctions

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There has been growing interest in the antiferromagnetic spintronics due to the high-speed operation, no stray fields, and so on. [1] The magnetic tunnel junctions (MTJs) with the Cr_2O_3 barrier would show the intriguing spin-dependent transport phenomena such as magnetoresistance (MR) effects based on antiferromagnetic and/or magnetoelectric nature of the Cr_2O_3. [2] However, it has not been addressed to the characterization of the ultrathin Cr_2O_3 films to date. In this work, the spin-dependent transport properties in the MTJs with a Cr_2O_3 barrier were investigated.

We fabricated the samples by a sputtering technique. The plasma oxidation was performed to form the Cr_2O_3 barrier using the 90° off-axis cathode. The structural property of Si/ SiO_2/ Ta(5)/ Ru(20)/ Co(4)/ Cr_2O_3(20)/ Ta(5) was characterized by using x-ray diffraction (XRD). The MTJ stack was composed of Si/ SiO_2/ Ta(5)/ Ru(20)/ Co(4)/ Cr_2O_3(2)/ Co(3)/ $Ir_{22}Mn_{78}$(10)/ Ta(3)/ Ru(7) (thickness in nm). The microfabrication of the MTJs were carried out using the photolithography and Ar ion milling, followed by post-annealing at 523 K under a magnetic field of 2 kOe. The transport properties were measured using the 4-terminal prober and the physical property measurement system.

The XRD $2\theta/\omega$ scans showed the Cr_2O_3 (006) peak although the (006) diffractions in the corundum oxides were weak in contrast to other peaks, indicating high orientation of Cr_2O_3 to the (001) direction. For instance, the intensity ratio between (006) and (104) diffractions, $I_{(006)}/I_{(104)}$, in the Cr_2O_3 powder sample was 0.15. On the contrary, sputtered Cr_2O_3 showed the $I_{(006)}/I_{(104)} \sim 8.8$. The plasma oxidation for Cr_2O_3 improved the dielectric breakdown strength from 0.3 V to 1 V, indicating the reduction of the oxygen vacancies in Cr_2O_3. The MTJs with the plasma oxidized Cr_2O_3 barrier showed the tunnel magnetoresistance (TMR) ratio of 1% (4%) at 300 K (10 K). As the temperature decreased to < 100 K, the TMR curves showed the increase of coercive fields and anisotropy in the Co layer, indicating antiferromagnetic order of Cr_2O_3.

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References

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