Influence of insulating barrier thickness on the magnetoresistance properties of the magnetic tunnel junction with Zr-alloyed Al-oxide barrier

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Microtructural and interfacial quality of the barriers in the magnetic tunnel junction (MTJ) play a prime role in device perfomances and stability. Recently, we developed a new barrier alloys which had an ultrasmooth interfaces and homogeneous single amorphous phase in the pre-oxidation state. A highly stable MTJ with an ultrahigh-quality Zr-alloyed Al-oxide (ZrAl-oxide) barrier could be fabricated with a bias voltage of 711 mV at half (V_h) tunnel magnetoresistance (TMR) accompanying TMR ratio of 40% [1]. In the present study, we investigated the magnetoresistive properties of MTJ with high-quality ultra thin barrier of below 1 nm. In addition, we analyzed stability and electrical properties of the MTJ with sub-nanometer thick barrier. A MTJ consisting of Si/SiO_2/Ta 5/CoFe 17/IrMn 7.5/CoFe 3/ZrAl-oxide 0.6-1.6/CoFe 3/Ta 5 (nm) was fabricated using a four target sputtering system. As shown in Fig.1, the resistance of the MTJ sharply drops from 1850 to 72 Ω as the barrier thickness decreases from 1.6 to 0.6 nm. We could fabricated the MTJ with ultra-thin 0.6 nm thick barrier which showed a TMR value of 8% and the junction resistance of 72 Ω. The resistance of the MTJ with 1.0 nm barrier reduced 80% lower than that of the MTJ with 1.6 nm barrier, while the TMR value reduced only 10%. The resistance of the MTJ with ZrAl-oxide barrier could be effectively reduced by the barrier thickness control without significant sacrifcing the TMR. ZrAl-oxide barrier was proven to be structurally and electrically very stable new material so that it could be used in MTJ instead of traditionally used Al-oxide.

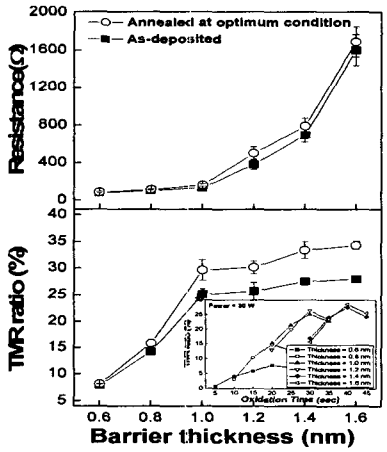

Fig. 1 TMR ratio and resistance variations of the MTJ with ZrAl-oxide barrier as a function of barreir thickness. Samples were annealed at optimum temperatures as a function of barrier thickness for 10 min.

[1] Seong-Rae Lee, Chul-min Choi, and Young Keun Kim, Appl. Phys. Lett. 83, 317 (2003).