Tunnel magnetoresistance in ultrathin MnGa-based perpendicular magnetic tunnel junctions utilizing bcc-Co based interlayers

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Tetragonal Mn-based perpendicular magnetic tunnel junctions (p-MTJs) attracts attention for magnetic random access memory and advanced THz devices[1]. Past studies of Mn-based p-MTJs have been reported small TMR ratio at room temperature below 32% without magnetic interlayer[2], and maximum of 60% even if FeCo interlayers were used[3]. Thus, it is crucial to find new interlayer materials to further enhance the TMR ratio for realizing Mn-based p-MTJs for practical applications. In this study, we focused on bcc-CoMn binary alloy possessing highly spin-polarized $\Delta 1$ band[4] as new interlayer material for ultrathin MnGa-based p-MTJs[5], and investigated its TMR properties[6]. The stacking structure of the p-MTJs are MgO(001) substrate/Cr(40)/$Co_{55}Ga_{45}$(30)/ $Mn_{61}Ga_{39}$(3)/ Co_xMn_{100-x}(0.8) /Mg(0.4)/MgO(2)/ $Fe_{60}Co_{20}B_{20}$ (1.2)/Ta(3)/Ru(5) (thickness is in nanometers). After microfabrication using conventional photolithography and Ar ion milling process, the MTJs were annealed at 250 ℃ in a vacuum furnace. TMR measurements were performed by a PPMS. Figure 1 shows the TMR curves of the MTJs with $Co_{80}Mn_{20}$ interlayer measured at 300 and 10K. The $Co_{80}Mn_{20}$ interlayer shows the TMR ratio up of approximately 85% (209%) at 300 and 10 K. respectively. Meanwhile, the shape of the TMR curve and the significant increase of coercivity indicate that $Co_{80}Mn_{20}$ interlayer strongly and antiferromagnetically couples with perpendicularly-magnetized MnGa layer. The TMR ratio of 209% is larger than the value expected from Julliere's relation with spin-polarization of fcc-Co and CoFe(B). Thus, this high TMR ratio would originate from coherent tunneling between highly spin-polarized Δ 1 bands in bcc-Co (Co-Mn) and CoFe(B) electrodes, even though the Co-Mn interlayer thickness is very small, 0.8 nm.

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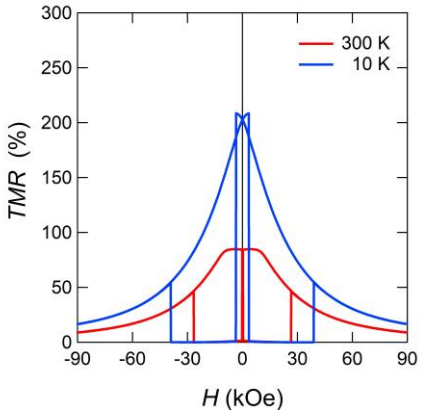

Figure1 TMR loops the MTJs with $Co_{80}Mn_{20}$ interlayer measured at 300 K and 10 K