Tunnel magnetoresistance in ultrathin Mn-based perpendicular magnetic tunnel junctions grown on highly mismatched sapphire substrate

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Tetragonal Mn-based alloy thin films attract attentions as perpendicularly magnetized electrodes of perpendicular magnetic tunnel junctions (p-MTJs) for memory, high frequency, and sensor applications [1,2]. However, their excellent properties have been reported only in single crystalline thin films grown on unpractical and expensive MgO single crystalline substrates. Therefore, the development of new epitaxial technique using practical substrates may also be important for commercial applications. In this study, we focus on single-crystal sapphire (r-plane) substrates for the epitaxial growth of the Mn-based alloys thin films, because sapphire substrates have been widely used for mass production of epitaxial growth of compound semiconductors. Recently, we have reported the high-quality single crystalline $L1_0$ MnGa films grown on sapphire (r-plane) substrates with Ta/Cr/CoGa buffer layer [3]. Based on this growth technique, here we demonstrate the p-MTJs with ultrathin electrodes of single crystalline $L1_0$ MnGa grown on the sapphire (r-plane) substrate.

All samples were prepared with ultra-high vacuum magnetron sputtering. The stacking structure of the p-MTJs were sapphire substrate (r-plane) /Ta (10)/Cr (40)/CoGa (30)/MnGa (3)/Mg (0.4nm)/MgO (2)/CoFeB (1.4)/Ta (3)/Ru (5) (thickness in nm). Ta and Cr layers were deposited at a substrate temperature of 600 and 400℃, respectively. Other layers were deposited with the conditions same as used in the previous report [4]. After microfabrication using conventional photolithography and Ar ion milling, the p-MTJs were annealed at 250℃ in a vacuum furnace. TMR measurements were performed with four-probe method at room temperature.

Figure 1 shows the TMR curves of the p-MTJs grown on MgO and sapphire substrates. The p-MTJ on the sapphire substrate shows the TMR curve comparable to that for the p-MTJ on MgO substrates, promising for high-frequency and sensor applications. The TMR ratio is smaller in case of the sapphire substrate, indicating that microstructure of the MnGa film may be different from the case of MgO substrates and further process optimization is necessary. The details will be discussed in the presentation.

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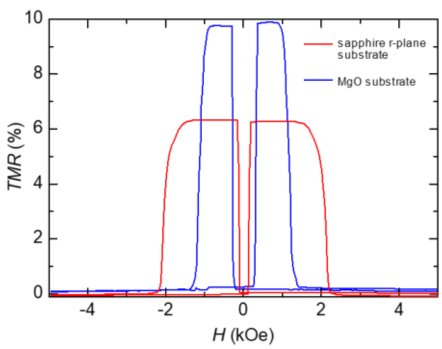

Fig.1 TMR curves measured at room temperature for the MnGa-based p-MTJs on different substrates.