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Crystalline AlOx ultrathin layers grown on permalloy (111)-surfaces for magnetic tunnel junctions

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After the room-temperature tunnel magnetoresistance (TMR) of 10 – 20 % was discovered for *amorphous* AlOx based magnetic tunnel junctions (MTJs) in 1994 [1,2], *crystalline* tunnel barriers brought about remarkable TMR effects such as coherent tunneling with TMR ratios of over 100% [3-5]. Although crystalline barriers should be fascinating for MTJ-based spintronic devices, they have been formed only for limited material systems with the (100)-orientation such as Fe/MgO(100) [3,4], Fe/$MgAl_2O_4$(100)[6], CoFeB/MgO(100) [7] and Co_2FeAl/MgO(100) [8]. In this study, we attempted to fabricate crystalline AlOx barrier layers on a permalloy (111) surface. It is noted that crystalline γ-Al_2O_3 is recently shown to be one of the coherent tunneling barriers with relatively high TMR ratios through an experimental study of Fe/ γ-Al_2O_3/Fe(100) MTJs [9].

(111)-oriented permalloy thin films were prepared on sapphire substrates by using rf magnetron sputtering. AlOx barriers were prepared by the combination of plasma oxidation and heat treatment for 1 nm thick Al layers grown on the (111)-oriented permalloy. The structure of the AlOx barrier layers was investigated with reflection high-energy electron diffraction (RHEED).

Fig. 1 shows RHEED patterns for permalloy(111) and AlOx barrier surfaces. It is found that the AlOx layer formed on permalloy(111) is in a crystalline state with an atomically flat surface. Although it is difficult to analyze the crystallographic orientation of AlOx from the two-dimensional streak RHEED patterns, γ-Al_2O_3(111) plane is probably stacked on permalloy(111).

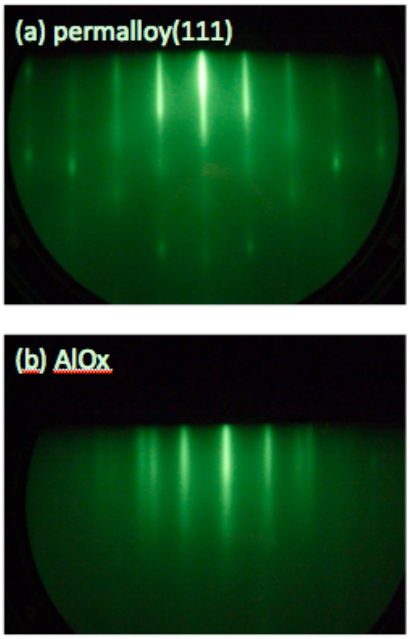

Fig. 1. RHEED patterns for (a) permalloy (111) surface and (b) AlOx ultrathin layer grown on the permalloy.

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