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スピン軌道トルク磁化反転のパルス幅依存性

Pulse width dependence of a spin-orbit torque induced magnetization switching

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Recently, three-terminal spintronics devices that utilize torque originating from the spin-orbit interaction (spin-orbit torque: SOT) have attracted great attention. In addition to the two conventional structures, which have the easy axis perpendicular to the film plane (type *Z*) or in-plane and orthogonal to the long axis of channel (type *Y*), we proposed in the last meeting a new structure with the easy axis being parallel to the channel (Type *X*) and demonstrated the basic operation using dc current [1]. Here, we study, using the type *X* and type *Y*, the current pulse width τ_p dependence of the SOT switching from dc to sub-ns region. Note that τ_p dependence of SOT switching has been highly controversial; a theory predicted that the threshold current is less sensitive to τ_p for type *Z* (and type *X*) than type *Y* [2], whereas an experimental study showed that the results of type *Z* was well described by a conventional spin-transfer torque switching model that holds true for type *Y* [3].

The film with a stack of Ta/CoFeB/MgO/CoFeB/Co/Ru/Co is deposited on Si wafer by dc/rf magnetron sputtering. The deposited film is processed into three-terminal SOT devices with an elliptic magnetic tunnel junction on a Ta channel by electron beam lithography and Ar ion milling. Type-*X* and type-*Y* devices are fabricated on the same wafer. Current pulses with various τ_p are supplied from a pulse generator. The threshold voltage V_{th} for switching (average of 10-times measurement) is plotted as a function of τ_p for both types *X* and *Y* in Fig. 1. V_{th} of type *Y* steeply increases as τ_p decreases below 100 ns. In case of τ_p = 2 ns, switching is observed only three times in 10-times trials, where voltage pulses up to 2.6 V are applied. In contrast, V_{th} of type *X* gradually increases with decreasing τ_p. We observe 50-times switching for 50-times trials even in τ_p < 500 ps (not shown). These results suggest that type-*X* structure is promising for high-speed applications.

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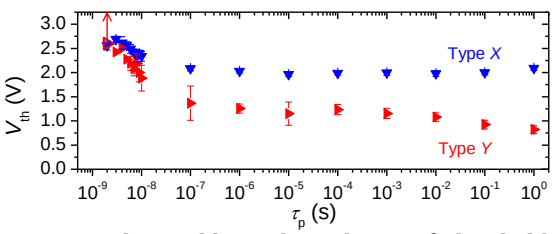

Fig. 1: Pulse width τ_p dependence of threshold voltage V_{th} for type-*X* and -*Y* devices. At τ_p = 2 ns, V_{th} is more than 2.6 V.