PL-04-1-PL-F

Spintronics nano-devices for VLSIs applications

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The challenge VLSIs currently face is managing ever increasing power. For example, Internet-of-Things (IoT) requires low standby-power, whereas current working memories such as DRAM and SRAM are “leaky,” draining power constantly just to keep the memory content. It is clear that nonvolatile working memory is much needed; no such technology exists except spintronics nonvolatile nano-devices that are capable of handling virtually unlimited rewrite, a critical attribute for working memory [1]. Magnetic tunnel junction (MTJ), a two-terminal spintronic device that can be scaled beyond 20 nm with the CoFeB-MgO system showing magnetic perpendicular easy axis [2, 3] is the device most studied and developed to date. I go over the development of such devices and discuss the models put forward to understand the device size dependence of the thermal stability of MTJs; one being nucleation [3] and the other domain wall propagation [4]. Three-terminal devices, which is another important entity suitable for high speed operation, are then discussed. We have investigated three-terminal devices utilizing current-induced domain wall motion [5] and more recently its variant using spin-orbit torque [6-9]. Here, I focus on the latter and discuss about the torques involved in the operation and a material stack that utilizes the spin Hall effect of an antiferromagnet to eliminate the need for the external magnetic field [8]. If time allows, I will discuss electric-field switching of magnetization in perpendicular CoFeB-MgO magnetic tunnel junctions [10].

Work supported in part by the FIRST Program from JSPS, ImPACT from JST, and by the R & D for Next-Generation Information Technology of MEXT

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