CURRENT-INDUCED MAGNETIZTION SWITCHING IN ATOM-THICK TUNGSTEN ENGINEERED PERPENDICULAR MAGNETIC TUNNEL JUNCTIONS WITH LARGE TUNNELING MAGNETORESISTANCE

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I. ABSTRACT

Perpendicular magnetic tunnel junctions (p-MTJs) based on MgO/CoFeB structures are drawing people's attention as their excellent thermal stability, scaling potential, and power dissipation are significant for the study of spin-transfer torque magnetic random-access memories (STT-MRAMs) [1]. In particular, p-MTJs with a MgO/CoFeB/heavy metal (HM) structure have been thoroughly studied for their enhanced perpendicular magnetic anisotropy (PMA) that originates from both MgO/CoFeB and CoFeB/heavy metal interfaces [2]. Then we used the first-principles calculations to investigate the magnetic anisotropy energy (MAE) of the MgO/CoFe/capping layer structures and demonstrated that it is feasible to enhance PMA by using proper capping materials [3]. Moreover, we experimentally investigated the dependence of magnetic properties on different capping materials through time-resolved magneto-optical Kerr effect measurements as well as magnetometry measurements, results showed the Co/heavy metal interface play an important role on the interfacial PMA and damping constant. Especially, the magnetic multilayers with a W capping layer features the lowest effective damping value compared to Ta and Pd [4]. In addition, we calculated the spin resolved conductance and the tunnel magnetoresistance (TMR) ratio in X/CoFe/MgO/CoFe/X MTJ atomic structure with capping material X of W, Ta, or Hf. It can be seen that in the parallel condition of MTJ, sharp transmission peaks (attributed to the resonant tunnel transmission effect) lead to obtain a giant TMR ratio using W buffer and capping layer [5]. In view of high interfacial PMA, low damping and giant TMR are together appearing in MTJ structure with W, the bottom-pinned p-MTJ stack with atom-thick W layers and double MgO/CoFeB interfaces was deposited using magnetron sputtering with 410° post-annealing. Then a large TMR of 249%, a resistance area product as low as 7.0 $\Omega\cdot\mu m^2$ and relatively low J_{C0} at room temperature were presented in nanopillars. Furthermore, by using the first-principle calculation, we found that atom-thick W layers can induce resonant tunnelling transmission that are more efficient than Ta layer, providing a comprehensive explanation to the origin for this large TMR [6]. In summary, we demonstrated for the first time current-induced magnetization switching in p-MTJs with atom-thick W layers, the experimental investigations and theoretical analyses provide an insight into the role of atom-thick W layers in determining high performance in p-MTJs. We expect that this work can contribute to the research and development of STT-MRAMs.

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