Magnetic properties of Co ultra-thin film deposited directly on polar ZnO substrates

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Magnetic properties of ultra-thin Co films deposited directly on polar ZnO substrate have been investigated. Magnetic anisotropy and Curie temperature $T_C$ of the system were found to be strongly dependent on the polarity of the substrate. It is well known that a gate electric field can change the magnetic properties in the ferromagnetic metals [1-4] through the modulation of carrier density. In our system, the carrier density of the Co near the interfacial surface of ZnO depends on its polarity, i.e., the “built-in backside gate” effect is expected. This effect and structure may give a useful hint to design magnetic properties of the materials as well as offer an ideal system to test the Rashba-related phenomena.

0.4-0.6 nm Co ultra-thin film with 2.4 nm Pt cap layer was deposited on Zn- or O-polar surface of a ZnO (0001) substrates by rf sputtering. The X-ray diffraction experiments showed that the Pt cap layer has fcc(111) texture. Figure 1 shows typical magnetization curves of a simultaneously-deposited pair of samples. Clear perpendicular anisotropy was observed in the samples deposited on O-polar surface, whereas the easy axis of the Zn-polar sample was in-plane. This anisotropy switching was reproduced in more than five pairs of samples. In addition, $T_C$ in Zn-polar ones were always 40-60 K higher than that in O-polar ones. This trend ($T_C$ increases when electron density of the Co layer increases) is consistent with our previous electric field effect experiments [3,4]. Further results of structural investigation and possible mechanism of the anisotropy switching will be discussed.

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