Magneto-elastic effect on ferromagnetism induced by quantum-well states in Pd thin film

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While Pd is a paramagnetic metal in bulk, a Pd(100) thin film shows ferromagnetism, which is dependent on the film thickness in an oscillatory manner. The appearance of ferromagnetism is attributed to the 4d electron quantum-well states. This suggests that the magnetism of Pd thin films can be switched through modification of quantum-well states due to change in the film thickness by introducing strain. In this work, the change in magnetism of epitaxial Pd thin layers in Pd (4.1 nm)/$SrTiO_3$ (10nm)/$BaTiO_3$ heterostructures, which is accompanied by deformation of $BaTiO_3$, is studied using magnetization measurements and first-principles calculations. As shown in Fig. 1, $BaTiO_3$ has four distinct temperature-dependent structural phases and the structural phase transitions can induce a large strain in the adjacent Pd layer. Fig. 2 shows clear changes in the magnetization of a Pd thin layer around the structural phase transition temperatures of $BaTiO_3$. Such a change is mainly attributed to a variation in the Pd thickness, which intrinsically contributes to the appearance of ferromagnetism in Pd thin films, due to the stress from $BaTiO_3$. As shown in Fig. 2, the observed magnetization change depends on temperature change process. This is due to the coexistence of two types of the ferroelastic domains, a-domain and c-domain, in $BaTiO_3$; the strain effects on magnetism of Pd thin films are considered to be dependent on a ratio of these domains appeared at the interface, accordingly. The ratio changes from one phase transition to another, giving rise to an indeterministic change in magnetization as seen in Fig. 2. The magneto-elastic effect on magnetism originating from quantum-well states in Pd(100) thin film can be elucidated under voltage application to induce the formation of a single ferroelastic domain. Revealing the mechanism brings a new concept of electric-field control of magnetism.

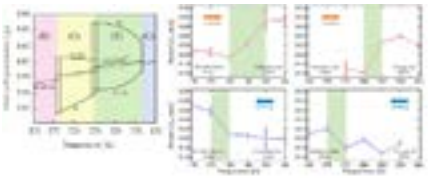

Figure 1: Structural phase transitions of $BaTiO_3$. The letters, "C", "T", "O", and "R" represent cubic, tetragonal, orthorhombic, and rhombohedral phases, respectively.

Figure 2: Temperature dependence of the saturation magnetization of Pd(100) thin films. The green patched regions denote the magnetization jumps associated with the structural phase transitions of $BaTiO_3$.

Biography

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