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### Surface Ferromagnetism of CeO<sub>2</sub> Nanoparticles

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Pure CeO<sub>2</sub> nanoparticles were synthesized by water-in-oil microemulsion method. The ceria precursor and the precipitants were Ce(NO<sub>3</sub>)<sub>3</sub>·6H<sub>2</sub>O and NH<sub>4</sub>OH, respectively. X-ray diffraction and Raman spectroscopy reveal that the as-prepared CeO<sub>2</sub> nanoparticles are in a fluorite structure without impurity phases and the grain size is 6nm obtained by the full width at half maximum (FWHM) of a diffraction peak. Ferromagnetism (FM) was observed in as-prepared samples at room temperature with the saturation magnetism (Ms) of 5 memu/g. The mild reduction treatments with 1.5% H<sub>2</sub> in Ar were performed on the as-prepared samples between 200 °C and 600 °C with incremental steps of 50 °C. For each step, the as-prepared samples were kept for 1 h at the temperature before cooling to room temperature to measure the magnetism. Magnetic results show a relationship between the Ms and the reduction temperature, as shown in Fig.1. The Ms reaches a maximum (65 memu/g) for the reduction at 350 °C, which is close to the value of as-prepared CeO<sub>2</sub> nanoneedles (80 memu/g) reported by Y Liu et al [1], and then decreases with increasing the reduction temperature. It was reported by C. Binet et al [2] that the reduction is limited to the surface for reduction temperatures in the 200-600°C range, and Ce<sup>3+</sup>-Ce<sup>4+</sup> pair defects reach a maximum in their surface concentration for a temperature in this range. Based on above results and the charge-transfer model proposed recently by Coey et al [3] for the FM of defective oxide nanoparticles, we suggest that the FM of the CeO<sub>2</sub> nanoparticles arises from the double exchange interaction through charge transfer between the surface mixed valent Ce<sup>3+</sup>-Ce<sup>4+</sup> pair via O<sup>2-</sup> ion.

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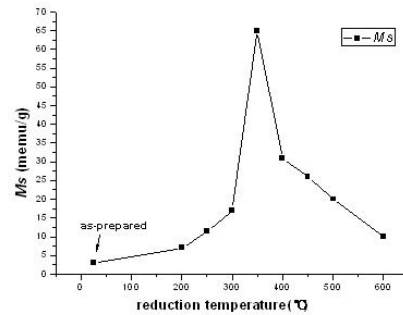


Fig. 1. Saturation magnetization (Ms) as a function of the reduction temperature (1 h at each temperature).

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### The Study of Annealing Effect on Co Implanted ZnO Epitaxial Films

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The Co:ZnO epitaxial thin film was successfully growth grown on Al<sub>2</sub>O<sub>3</sub> substrates by ion beam sputtering deposition and 100 KV cobalt ion implantation in the ZnO thin film. The Co-doped ZnO thin film was annealing in a vacuum environment at 600, 700 and 800 degree C using RTA after implantation. The crystal structure was measured by x-ray diffraction (XRD) and local environment of the Co was investigated by x-ray absorption spectroscopy (XAS). The XRD pattern shows typical wurtzite structure of the Co-doped ZnO. The magnetization of the Co-doped ZnO was measured by SQUID. The resistance of the Co-doped ZnO shows different characterizations of samples with annealed and without annealed. For instance, the Co-doped ZnO shows a cobalt cluster effect before annealed. After annealing process, the resistance that was increase as a function as the temperature increase to relate to spontaneity magnetic property was measured. The XAS result of Co also shows a cobalt-oxide-like-structure in the Co-doped ZnO after annealed. An intrinsic DMSs were grown by controlling the annealing process and the implanted sample has a good chacterication for the applications to of spintronics.

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