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Structural Origin of Ferromagnetism in Mn- and Co-doped Y$_2$O$_3$ Nanocrystals

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Long-range-order and short-range-order structures in ferromagnetic Mn- and Co-doped Y$_2$O$_3$ nanocrystals prepared by a thermal decomposition method have been probed using x-ray diffraction (XRD) and extended x-ray absorption fine structure (EXAFS) techniques, respectively. These dilute magnetic oxides (DMO) are high-k dielectrics and exhibit ferromagnetism at room temperature. Our EXAFS results indicate that oxygen vacancies are present around the Mn and Co dopant atoms in the Y$_2$O$_3$ DMO host. To investigate the correlation between ferromagnetism and oxygen vacancies, the as-made sample were alternately annealed in oxygen and forming gas at a moderate annealing temperature. The EXAFS data reveals that the average number of oxygen vacancies surrounding magnetic dopant atoms is increased by oxygen annealing and decreased by forming-gas annealing. The XANES results also demonstrate consistent valency variations. Without appreciable changes in particle size, the saturation magnetization was found to increase with oxygen-vacancy concentration in these DMO samples. Our results strongly support the bound magnetic polaron model for ferromagnetism in these DMO nanocrystals.

Keywords: ferromagnetic, high-k, exafs

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Modulation excitation spectroscopy adapted to Crystallography

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Modulation excitation spectroscopy is a powerful and well established technique to investigate the dynamic behavior of chemical