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# Room-temperature ferromagnetism in pure and $Fe^{2+}$( $Fe^{3+}$) doped $CeO_2$ nanocrystals

Z. Dohčević- Mitrović(1)*, N. Paunović(1), M. Radović(1), N. Lazarević(1), B. Matović(2), Z. V. Popović(1)

(1) Institute of Physics, Center for Solid State Physics and New Materials, Belgrade, Serbia, e-mail: zordoh@phy.bg.ac.rs
(2) Institute of Nuclear Sciences 'Vinča', 11001 Belgrade, Serbia
* Corresponding author.

Abstract – We have measured the magnetization and Raman scattering spectra of pure and iron doped ceria nanocrystals at room temperature. Contrary to bulk materials, nano crystals of these samples show room-temperature ferromagnetism. Saturation magnetization increases with an increase of Fe valence state. Raman $F_{2g}$ mode shows softening and broadening by doping with different Fe valence state. The Raman mode intensity of oxygen vacancies increases with Fe valence state too, suggesting that Fe doping favors the formation of oxygen vacancies in ceria lattice. The presence of both magnetic ions and oxygen vacancy complexes is crucial for the appearance of room-temperature ferromagnetism.

There is an ongoing quest for ferromagnetic semiconductors with a Curie temperature well above room temperature, which could be used for a second generation of spin electronics. The room temperature ferromagnetism (RT-FM) was observed in thin films of nonmagnetic oxides like $HfO_2$, $TiO_2$ and nanoparticles of metal oxides such as $CeO_2$, $Al_2O_3$, ZnO [1] while the corresponding bulk samples are diamagnetic. The oxygen vacancies play a crucial role for the appearance of ferromagnetism in these oxide materials. Recently, research has been focused on metal cations-doped ceria materials (Cu, Co, Zr, La, Sm, Y, etc.) because the incorporation of metal cations into the ceria lattice can induce plenty of oxygen vacancies. Nanocrystalline pure and doped $Ce_{1-x}Fe^{2+}_x(Fe^{3+}_x)O_{2-y}$ (x=0.12 and 0.06) samples were prepared by a SPRT synthesis [2]. The aim of this work was to determine the influence of $Fe^{2+}$/$Fe^{3+}$ doping on structural and vibrational properties of cerium dioxide nanocrystals using Raman spectroscopy and to clarify the role of oxygen vacancies and transition metal (TM) doping on magnetic properties of this nonmagnetic oxide. With an increase of oxidation state of Fe dopant there is evident redshift and broadening of the $F_{2g}$ Raman mode (Fig.1). This can be a consequence of electron molecular vibrational coupling. Saturation magnetization of doped samples increases with an increase of oxidation state of Fe dopant and is almost three times higher in $Fe^{3+}$ doped sample than in pure ceria (Fig.2). The observed RT-FM in Fe doped samples originates from a combination effect of oxygen vacancies and TM doping through the F-centre exchange coupling mechanism [3].

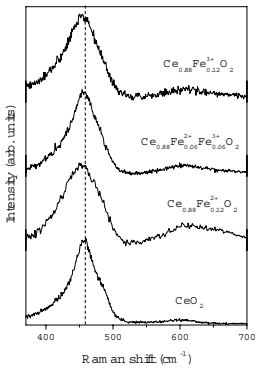


**Figure 1:** Raman spectra of $Ce_{1-x}Fe^{2+}_x(Fe^{3+}_x)O_{2-y}$ samples.

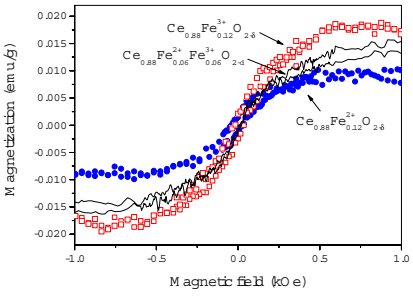


**Figure 2: a**) Room temperature magnetization of $Ce_{1-x}Fe^{2+}_x(Fe^{3+}_x)O_{2-y}$ samples.

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## References

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