Physica Status Solidi - Rapid Research Letters 2017 vol.11 N5

Room temperature ferromagnetic-like response in “bulk” Y-doped CeO2

Rakhmatullin R., Sen S.

Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

Abstract

© 2017 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim Strong ferromagnetic-like response is observed at room temperature in “bulk”- and nano-crystalline Y-doped CeO 2 . The saturation magnetization for “bulk” (~600 nm) crystallites of CeO 2 doped with 25 at.% Y is more than an order of magnitude higher compared to its nanocrystalline (~10 nm) counterpart. High frequency electron spin resonance and 89 Y nuclear magnetic resonance measurements indicate clustering of electronic defects in the “bulk” crystallites. The remarkable size dependence of the magnetic behavior likely originates from a collective magnetic response of defect-lined nanodomain interfaces in the “bulk” crystallites, consistent with the giant orbital paramagnetism model.

http://dx.doi.org/10.1002/pssr.201700010

Keywords

CeO 2, defects, electron spin resonance, ferromagnetism, nanoparticles

References

[1] M. Mogensen, N. M. Sammes, and G. A. Tompsett, Solid State Ion. 129, 63 (2000).

[2] J. Kaspar, P. Fornasiero, and M. Graziani, Catal. Today 50, 285 (1999).

[3] T. Stefanik and H. L. Tuller, J. Eur. Ceram. Soc. 21, 1967, (2001).

[4] H. L. Tuller, Solid State Ion. 131, 143 (2000).

[5] C. Sun, H. Li, and L. Chen, Energy Environ. Sci. 5, 8475–8505 (2012).

[6] A. Sundaresan, R. Bhargavi, N. Rangarajan, U. Siddesh, and C. N. R. Rao, Phys. Rev. B 74, 161306R (2006).

[7] A. Sundaresan and C. N. R. Rao, Nano Today 4, 96–106 (2009).

[8] M. Y. Ge, H. Wang, E. Z. Liu, J. F. Liu, J. Z. Jiang, Y. K. Li, Z. A. Xu, and H. Y. Li, Appl. Phys. Lett. 93, 062505 (2008).

[9] V. Fernandes, R. J. O. Mossanek, P. Schio, J. J. Klein, A. J. A. de Oliveira, W. A. Ortiz, N. Mattoso, J. Varalda, W. H. Schreiner, M. Abbate, and D. H. Mosca, Phys. Rev. B 80, 035202 (2009).

[10] V. Fernandes, P. Schio, A. J. A. de Oliveira, W. A. Ortiz, P. Fichtner, L. Amaral, I. L. Graff, J. Varalda, N. Mattoso, W. H. Schreiner, and D. H. Mosca, J. Phys.: Condens. Matter 22, 216004 (2010).

[11] J. M. D. Coey, M. Venkatesan, and C. B. Fitzgerald, Nature Mater. 4, 173 (2005).

[12] J. M. D. Coey, K. Wongsaprom, J. Alaria, and M. Venkatesan, J. Phys. D: Appl. Phys. 41, 134012 (2008).

[13] J. M. D. Coey, P Stamenov, R. D. Gunning M. Venkatesan, and K. Paul, New J. Phys 12, 053025 (2010).

[14] R. M. Rakhmatullin, V. V. Pavlov, and V. V. Semashko, Phys. Status Solidi B 253, 499–503 (2016).

[15] M. J. Calderón and S. D. Sarma, Ann. Phys. (N.Y.) 322, 2618 (2007).

[16] H. Bednarski, J. Magn. Magn. Mater. 349, 281, (2014).

[17] M. Coey, K. Ackland, M. Venkatesan, and S. Sen, Nature Phys. 12, 694–699 (2016).

[18] S. Sen, K. L. Gupta, and J. M. D. Coey, Phys. Rev. B 92, 155115 (2015).

[19] A. Hernando, P. Crespo, and M. A. García, Phys. Rev. Lett. 96, 057206 (2006).

[20] R. K. Singhal, P. Kumari, A. Samariya, S. Kumar, S. C. Sharma, Y. T. Xing, and E. B. Saitovitch, Appl. Phys. Lett. 97, 172503 (2010).

[21] R. K. Singhal, S. Kumar, A. Samariya, M. Dhawan, S. C. Sharma, and Y. T. Xing, Mater. Chem. Phys. 132, 534–539 (2012).

[22] R. M. Rakhmatullin, L. K. Aminov, I. N. Kurkin, R. Böttcher, A. Pöppl, H. Avila-Paredes, S. Kim, and S. Sen, J. Chem. Phys. 131, 124515, (2009).

[23] L. K. Aminov, I. N. Kurkin, R. M. Rakhmatullin, R. Böttcher, A. Pöppl, and S. Sen, Phys. Solid State 51, 2282 (2009).

[24] S. Sen, H. J. Avila-Paredes, and S. Kim, J. Mater. Chem. 18, 3915 (2008).

[25] P. Jain, H. J. Avila-Paredes, C. Gapuz, S. Sen, and S. Kim, J. Phys. Chem. C 113, 6553 (2009).

[26] W. Lee, S.-Y. Chen, Y.-S. Chen, C.-L. Dong, H.-J. Lin, C.-T. Chen, and A. Gloter, J. Phys. Chem. C 118, 26359 (2014).

[27] T. Mori, J. Drennan, Y. Wang, G. Auchterlonie, J.-G. Lic, and A. Yago, Sci. Technol. Adv. Mater. 4, 213 (2003).

[28] Z-P Li, T. Mori, F. Ye, D. Ou, G. J. Auchterlonie, J. Zou, and J. Drennan, J. Phys. Chem. C 116, 5435−5443 (2012).

[29] P. Yan, T. Mori, Y. Wu, Z. Li, G. J. Auchterlonie, J. Zou, and J. Drennan, Microsc. Microanal. 19, 102–110 (2013).

[30] A. Martinez-Arias, J. C. Conesa, and J. Soria, Res. Chem. Intermed. 33, 775–791 (2007).

[31] F. Seitz, Rev. Mod. Phys. 26, 7 (1954).

[32] R. H. Bartram, C. E. Swenberg, and S. Y. La, Phys. Rev. 162, 759 (1967).

[33] A. Abragam and B. Bleaney, Electron Paramagnetic Resonance of Transition Metal Ions (Clarendon, Oxford, 1970).

[34] S. A. Altshuler and B. M. Kozyrev, Electron Paramagnetic Resonance in Compounds of Transition Elements (Nauka, Moscow, 1972 [in Russian]; Wiley, New York, 1974), p. 223.

[35] A. I. Smirnov and S. Sen, J. Chem. Phys. 115, 7650–7656 (2001).

[36] E. Reijerse, P. P. Schmidt, G. Klihm, and W. Lubitz, Appl. Magn. Reson. 31, 611–626 (2007).

[37] R. S. de Biasi and M. L. N. Grillo, J. Solid State Chem. 178, 1973 (2005).