Applied Magnetic Resonance (2018) 49:1397–1415
https://doi.org/10.1007/s00723-018-1079-x

Applied
Magnetic Resonance

ORIGINAL PAPER

EPR and Magnetization Studies of Polymer-Derived Fe-Doped SiCN Nanoceramics Annealed at Various Temperatures: Blocking Temperature, Superparamagnetism and Size Distributions

Sushil K. Misra[1] · Sergey Andronenko[2] · Ildar Gilmutdinov[2] · Roman Yusupov[2]

Received: 30 May 2018 / Revised: 14 September 2018 / Published online: 11 October 2018

Abstract

X-band EPR spectra on SiCN ceramics, doped with Fe(III) ions, annealed at 800 °C, 1000 °C, 1100 °C, 1285 °C, and 1400 °C have been simulated to understand better their magnetic properties, accompanied by new magnetization measurements in the temperature range of 5–400 K for zero-field cooling (ZFC) and field cooling (FC) at 100C. The EPR spectra reveal the presence of several kinds of Fe-containing nanoparticles with different magnetic properties. The maxima of the temperature variation of ZFC magnetization were exploited to estimate (i) the blocking temperature, which decreased with annealing temperature of the samples and (ii) the distribution of the size of Fe-containing nanoparticles in the various samples, which was found to become more uniform with increasing annealing temperature, implying that more homogenous magnetic SiCN/Fe composites can be fabricated by annealing at even higher temperatures than 1400 °C to be used as sensors. The hysteresis curves showed different behaviors above (superparamagnetic), below (ferromagnetic), and about (butterfly shape) the respective average blocking temperatures, $\langle T_B \rangle$. An analysis of the coercive field dependence upon temperature reveals that it follows Stoner–Wohlfarth model for the SiCN/Fe samples annealed above 1100 °C, from which the blocking temperatures was also deduced.

✉ Sushil K. Misra
sushil.misra@concordia.ca

[1] Department of Physics, Concordia University, 1455 de Maisonneuve Boulevard West, Montreal, QC H3G 1M8, Canada

[2] Institute of Physics, Kazan Federal University, ul. Kremlevskaya, 18, Kazan 420008, Russian Federation