Temperature-dependent magnetic and transport properties of gadolinium-dysprosium-iron-garnet (50% vol. GdIG, 50% vol. DyIG) composite.

M. Stan,[1] R. Lach,[1] Paweł A. Krawczyk,[1] W. Salamon,[2] J. Haberko,[3] and A. Żywczak[2]

[1]*Faculty of Materials Science and Ceramics*
[2]*Academic Centre for Materials and Nanotechnology*
[3]*Faculty of Physics and Applied Computer Science*
AGH University of Science and Technology,
al. Mickiewicza 30, 30059 Kraków, Poland

Gadolinium-iron garnet ($Gd_3Fe_5O_{12}$, GdIG) based materials attract growing interest, especially in the advanced electronic industry as waveguide optical insulators or memory devices, and microwave insulators, due to their outstanding magneto-optic properties. There are several recent literature reports regarding enhanced properties of the garnets in one of three forms: polycrystalline, monocrystalline and thin films. Current research efforts arefocused on doping of GdIG with other ions in order to enhance its properties, e.g., the introduction of yttrium ($Y_{3-x}Gd_xFe_5O_{12}$, YIG) or dysprosium ($Dy_{3-x}Gd_xFe_5O_{12}$, DyIG), which improve magnetic properties of gadolinium-iron garnets, where GdIG is a compensated ferrimagnetic insulator. The typical garnet synthesis route involves a solid-state reaction between rare-earth (III) oxide and iron (III) oxide (Fe_2O_3). Thus, although being effortless, such an approach has several disadvantages like extended and energy-consuming grinding or need for elongated sintering time (12h) at elevated temperatures (1400^{o}C). From the industrial-scale production point of view, developing novel, cheaper, and more efficient synthesis routes seems to be of peculiar interest. Additionally, such methods can possibly be further transferred to different types of garnet materials. A major contribution to these attractive properties, Fe ions, are localized in two different crystallographic sites; Fe^{2+} ions occupy the octahedral sites, where Fe^{3+} the tetrahedral sites formed by the nearest oxygen ions. The magnetic moment of Fe is coupled by two spin-antiparallel a-site and d-site Fe through super-exchange interaction. The magnetic moment of a rare-earth element introduced at the c-site is antiparallel to the iron atoms. GdIG/DyIG composite possesses three different magnetic temperatures: compensated (T_{comp}), the magnetocaloric effect (T_o) and the Neel (T_N). These temperatures are between the values of the pure GdIG and DyIG bulk. The composite GdIG/DyIG change from the insulator to semiconductor behavior with energy gap at 1eV, between T_{comp} to T_o. The aim of this work was to obtain dense polycrystalline gadolinium-dysprosium-iron-garnet material (50% vol. GdIG, 50% vol. DyIG) by a reactive sintering method based on a solid-state reaction between dysprosium-iron perovskite ($DyFeO_3$), gadolinium-iron perovskite and iron oxide and characterization of magnetic and transport properties the composite was performed.