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The study of rhodium substituted ε-iron oxide nanomagnets exhibiting gigantic coercive field, high frequency millimeter wave absorption

Asuka Namai

The University of Tokyo, Japan

Abstract

Our research group has reported ε-iron oxide (ε-Fe_2O_3) nanomagnets, which exhibits a large coercive field (H_c) of 20 kOe and high-frequency electromagnetic wave absorption due to zero-field ferromagnetic resonance at 182 GHz. Furthermore, we found that metal substitution of ε-Fe_2O_3 with non-magnetic ions, such as Al^{3+} or Ga^{3+}, can control the absorption frequency from 182 GHz to 35 GHz. In this work, we studied the synthesis, crystal structure, magnetic properties, millimeter wave absorption properties and millimeter wave rotation of rhodium substituted ε-Fe_2O_3 (ε-$Rh_xFe_{2-x}O_3$) nanomagnets. ε-$Rh_xFe_{2-x}O_3$ nanomagnets were prepared by a chemical nanoscale synthesis using mesoporous silica as template. X-ray diffraction pattern and Rietveld analysis indicated that ε-$Rh_xFe_{2-x}O_3$ has an orthorhombic crystal structure with space group of $Pna2_1$. ε-$Rh_xFe_{2-x}O_3$ showed a large magnetic hysteresis loop at room temperature. The H_c value increased with rhodium substitution from 22 kOe (x= 0) to 27 kOe (x= 0.14). Furthermore, a crystallographically oriented sample recorded a gigantic H_c value of 31 kOe. Terahertz time domain spectroscopy system was used to measure electromagnetic wave absorption properties in the millimeter wave region, 30–300 GHz. ε-$Rh_xFe_{2-x}O_3$ showed high-frequency millimeter wave absorption. The observed resonance frequency (f_r) was increased up to 209 GHz with rhodium substitution. The rotation angle and ellipticity were measured using a magnetized ε-$Rh_{0.14}Fe_{1.86}O_3$ pellet sample. Irradiating millimeter wave causes the rotation angle to display a dispersive spectrum centered at f_r= 209 GHz, and the minimum and maximum values are −10º and +10º at 196 GHz and 220 GHz, respectively, whereas the ellipticity exhibits a peak at f_r with the value of +0.3. The present material should be useful for high frequency millimeter wave absorbers and rotators, since the frequency of the magnetic rotation corresponds to the highest frequency of windows of air.

Biography

University Education. M.Sc.: 2010, The University of Tokyo.

Professional Career. 2010-2011; JSPS Research fellowship for Young Scientists (DC1)., 2011-present; Assistant professor, Ohkoshi Laboratory, The University of Tokyo.