Asuka Namai et al., Chem Sci J 2016, 7:2(Suppl)
http://dx.doi.org/10.4172/2150-3494.C1.003



# Tunable magnetic property and millimeter wave absorption property of ε-$Fe_2O_3$ by metal substutution

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Epsilon-iron oxide (ε-$Fe_2O_3$) is one of the polymorphys of $Fe_2O_3$, which exists as a stable phase in nanometer-size ~ sub-micrometer-size region.[1] ε-$Fe_2O_3$ receives much attention as a hard mangeitc ferrite, since it exhibits the largest coercive field ($H_c$ > 20 kOe) among magnetic ferrites. In addition, it shows a high frequency millimeter wave absorption at 182 GHz due to zero-field ferromagnetic resonance.[2] Herein, we report the synthesis, magnetic properties, and millimeter wave absorption properties of metal substituted ε-$Fe_2O_3$ nanomagnets.[2,3]

A series of ε-$M_xFe_2$-$xO_3$ (M= Al, Ga, In, and Rh) were prepared by several nanoparticle synthesis methods, such as a combining method between a reverse-micelle and a sol-gel methods. Crystal structure analyses based on X-ray diffraction pattern indicate that subsistution site differs between substitution metal. Among four non-equivalent sites in ε-$Fe_2O_3$ ($Fe_A$, $Fe_B$, $Fe_C$, and $Fe_D$), $In^{3+}$ substitutes distorted octahedral $Fe_A$ and $Fe_B$ sites, $Rh^{3+}$ substitutes regular octahedral $Fe_C$ sites, and $Al^{3+}$ and $Ga^{3+}$ substitute tetrahedral $Fe_D$ sites, which can be understood by the difference of ionic radii. Magnetic properties are also affected by metal substitution. The $H_c$ value is reduced with $Al^{3+}$, $Ga^{3+}$, $In^{3+}$ substitution from 20 kOe to 2 kOe, but $H_c$ value is enlarged by $Rh^{3+}$ substitution and a large $H_c$ value of 31 kOe was observed. Millimeter wave absorption frequency decreased from 182 GHz (ε-$Fe_2O_3$) to 35 GHz by $Al^{3+}$, $Ga^{3+}$, $In^{3+}$ subsutitution, but increased up to 222 GHz by $Rh^{3+}$ substitution. Such a largely tunable magnetic property and millimeter wave absorption property of ε-$Fe_2O_3$ is useful from the viewpoint of material design.

## Biography

Asuka Namai is currently an Assistant Professor of Department of Chemistry, School of Science at The University of Tokyo. She received her PhD. in Science at the University of Tokyo, Japan, in 2013. Her research focuses on the development and physical and chemical characterization of functionalized nanomaterials, with particular interest in iron oxide-based nanomagnets and magnetism.

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