Synthesis of Various Magnetic Nanostructures and the Microwave Characterizations

by Yang Yang

Date: 22\textsuperscript{nd} April 2013 (Monday)
Time: 2 pm to 3 pm (1\textsuperscript{st} hour of defense)
Venue: EA-02-14

Abstract

Magnetic materials have a wide range of uses in fundamental science and in technological applications. The nanostructure impacts greatly on the properties of magnetic materials. The primary objective of this work was to synthesize various magnetic nanostructures, such as core/shell structure, flakes and nanocrystals (nanoctahedra, nanorings, nanotubes and nanorods) for microwave absorption. Investigations on the synthesis techniques, such as high energy ball milling, jet milling, thermal decomposition and chemical reduction methods, were carried out to achieve high-quality nanostructured products. Subsequent studies on the microwave performance were performed on the as-synthesized nanostructured particles. The insulating SiO\textsubscript{2} shell layer is effectively to suppress the skin effect of Fe particles, which improves the impedance match when under the microwave irradiation. As a result, the resonance peak corresponding to the lowest reflection loss shifts to higher frequency band. Compared to the spherical Fe/Al alloys, the Fe/Al flakes show two advantages on the microwave absorption. The one is that the thickness of the flakes is rather smaller than the skin depth, thus the incident microwave can permeate into the particles. The other one is that the introduction of shape anisotropy could enhance the Snoek's law limitation, resulting in a higher resonance frequency. Therefore a great improvement has been made on the microwave absorption by shaping the metallic alloy into flakes. The frequency peak shifts to higher band with decreasing the lateral size of flakes. By studying the microwave absorption performance of various Fe\textsubscript{3}O\textsubscript{4} nanostructures, we also found that the shaped structures (ring, tube and rod) could greatly enhance the resonance frequency to higher band. Especially for the Fe\textsubscript{3}O\textsubscript{4} nanorods, the resonance peak shifts to 4.82 GHz. As for effective microwave absorption, a balance between the high resonance peak and the high permeability should be found. Fe\textsubscript{3}O\textsubscript{4} rings with an outer diameter of 154 nm show a moderate resonance frequency (4.01 GHz) but a relative low reflection loss (-28 dB) compared to Fe3O4 particles with other structures. Zn-ferrite particles with very high saturation magnetization (104 emu/g) show a very high permeability value of 1.4 at the resonance frequency 3.45 GHz, resulting in the lowest reflection loss of -38 GHz in this work.

Speaker Yang Yang

Biography
Miss Yang Yang comes from ChangChun City, Jilin province, China. She was born in year 1983 and was conferred Bachelor Degree with major in Materials Science and Engineering in Dalian Jiao Tong University in 2005. Yang first started doctorate degree in Dalian University of Technology, but later restarts her PhD career in NUS in year 2008. Presently, Yang is a part-time final year PhD candidate in NUS department of Materials Science and Engineering, and is working as a Research Engineer in NUS.

ALL ARE WELCOME! Assoc Prof Daniel J. Blackwood Host