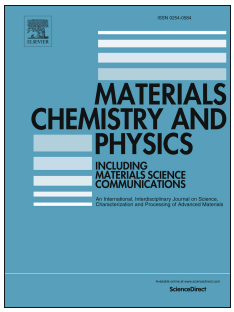
Accepted Manuscript



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PII: S0254-0584(16)30616-2

DOI: 10.1016/j.matchemphys.2016.08.014

Reference: MAC 19108

To appear in: *Materials Chemistry and Physics*

Received Date: 12 November 2015

Revised Date: 19 June 2016

Accepted Date: 12 August 2016

Please cite this article as: C. Ruan, J. Wang, M. Gao, G.-m. Zhao, The influence of structural size on thermal stability in single crystalline hematite uniform nano/micro-cubes, *Materials Chemistry and Physics* (2016), doi: 10.1016/j.matchemphys.2016.08.014.

The influence of Structural Size on Thermal Stability in Single Crystalline Hematite Uniform Nano/Micro-cubes

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Abstract

We have successfully synthesized monodisperse α-Fe_2O_3 nano/micro-cubes with sizes ranging from 40 to 840 nm. High-temperature magnetic measurements under a high vacuum were used to systematically study the size dependence of phase transition from α-Fe_2O_3 to Fe_3O_4. Through a series of characterizations, we concluded that the different sizes of particles have a significant impact on their thermal stability. The data shows a clear correlation between the onset temperature of the phase transition and the size of particles. This phenomenon can be well explained in terms of the dependence of enthalpy on surface area. Moreover, Morin transition of the α-Fe_2O_3 phase also have been measured for our products at the nanoscale. The result reflects that the Morin transition temperature decreases with decreasing the size of the particle, which supports finite-size scaling law according to previous findings. Our conclusions provide an important insight into many other size-dependent structural phase transitions.

Key words: Hematite nano/micro-cubes; thermal stability; phase transition; Morin transition.

1. Introduction

Recently, with nano-devices decreasing in size, the study of limited quantum size effect and surface effect becomes increasingly important. It is known that, when the size of the magnetic material is close to or smaller than the size of characteristic parameters, the small size effect can affect important physical properties of nanostructures, such as structural phase transition temperature or magnetic ordering temperature. For example, Jiang's group found that the change of dimension and size of metal and alloy grain can alter the temperature of thermal phase transition [1]. Li et al. investigated the relation between magnetic properties at low temperatures and nanostructures of $La_6Pb_{0.4}MnO_3$ with the size of 5 to 100 nm [2]. In our previous work, many of our experiments were focused on the size effect upon magnetic transition temperature [3-5]. Besides, our group studied the thermal stability of α-Fe_2O_3 nanoring and nanotube, and found it to be closely related to the surface fraction of the (001) plane in the nanostructures [6]. We also found that the different thicknesses of α-Fe_2O_3 nanoring can affect their thermal stability [7]. Recently, many experimental studies have been conducted to research the size effects of phase transitions [8-14].