

SAXS study of hexagonal W-type barium ferrite nanoparticles

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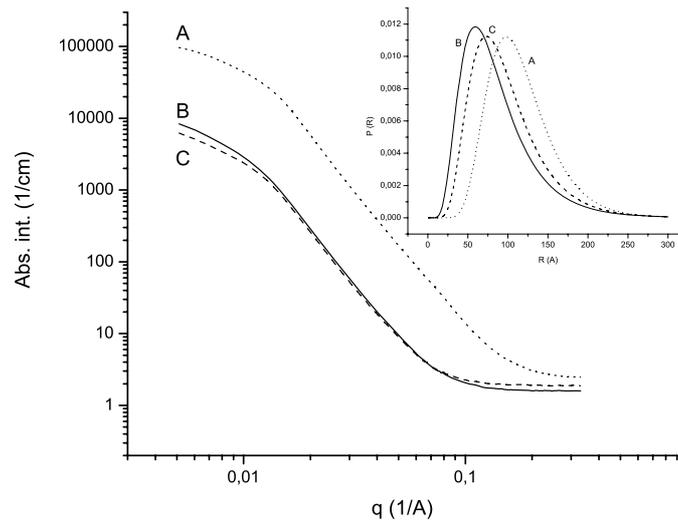
Hexagonal ferrites are a wide family of ferromagnetic oxides, with peculiar and useful properties. The crystal structure of the different known types of hexagonal ferrites (M, W, X, Y, Z and U) is very complex and can be considered as a superposition of **R** and **S** blocks along the hexagonal *c* axis, **RSR*S*** for M-type and **RSSR*S*S*** for W-type, where **R** is a three-oxygen-layer block with composition BaFe₆O₁₁, **S** (spinel block) is a two-oxygen-layer block with composition Fe₆O₈, and the asterisk means that the corresponding block has been turned 180° around the hexagonal axis [1]. Among the hexagonal ferrites W-type compounds with a general formula AMe₂Fe₁₆O₂₇ (A: alkali earth metals, usually Ba, Sr, Ca; Me: d-block metals, like Zn, Co, Ni, etc.) have attracted interest due to the main magnetic parameter values, that are more suitable for microwave applications than those of other hexagonal ferrites [2].

A number of techniques have been developed to synthesize W-type hexaferrites. Nowadays, new wet chemical methods have been developed for the preparation of nanograined hexagonal W-type ferrites. In our work sol-gel auto-combustion method has been used to synthesize a new nanocrystalline, nickel and zinc doped W-hexaferrites [3].

W-type barium hexaferrite powders with nickel and zinc were prepared by nitrate-citrate sol-gel auto-combustion method (NCSAM). The starting materials were Ba(NO₃)₂ (≥ 99%), Ni(NO₃)₂ · 6H₂O (≥ 97%), Zn(NO₃)₂ · 6H₂O (≥ 99%), Fe(NO₃)₃ · 9H₂O (≥ 97%), citric acid anhydrous (≥ 99.5%) and ammonia (≈ 25%), all of analytical purity. All the reagents were purchased from Fluka, and were used without any further purification. The synthesis process and characterization of nanocrystalline ferrites will be published elsewhere.

The measurements were performed at Beamline B1 (Jusifa) at HASYLAB (DESY, Hamburg) in the range of q ($= \frac{4\pi \sin \vartheta}{\lambda}$) from 0.006 up to 0.5 Å⁻¹. Our powder samples were covered with Kapton foils, and each sample had a thickness of 30 μm.

In this report we present SAXS curves which were obtained on three different samples. The samples have the same stoichiometric chemical content but they are heat treated at different temperatures and for different times. The sample “A” was heated up to 900 °C for 8 hours, while the other two ones (“B” and “C”) were heated up to 1200 °C for 4 hours. In the sample “A” the W-type hexaferrite is not present as it was analysed by XRD measurements. This sample exhibits the strongest small angle scattering in the whole observed range, as it can be seen in the Figure, clearly showing that the formations of the W-type hexaferrite falls into the higher temperature domain. The increased temperature results changes in the SAXS curves and the samples treated at 1200 °C render similar patterns (B, C) as it also can be observed in the Figure. The samples, however, contain W-type hexaferrite in different ratios; sample “B” only in 50%, while sample “C” is rich in it (85%). The domain structure of the samples was characterized by the particle size distributions by using a log-normal probability distribution of radii (inset of the Figure). The heat-treatment causes the reduction of the characteristic domain-size and larger particles are formed in the domains in abundance of W-type hexaferrites.



Log-log plot of scattering intensities of the three samples and their particle size distributions

References

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