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High Pressure Structural Studies on EuS nano particles up to 52 GPa

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BACKGROUND

Crystal size reduction in bulk materials changes the structural and magnetic properties considerably [1]. More importantly the transition pressure is strongly influenced by temperature, pressure, and the crystallite size effect. Rare earth europium chalcogenides crystallize in the NaCl (rock salt) type structure. The interest in Eu nanomaterials is motivated by the possibility of their use in magnetic devices [2,3]. Recent studies suggest that europium chalcogenide nanocrystals exhibit significant changes in their structural and magnetic properties, compared to bulk chalcogenides, when the nanocrystal diameter decreases. The crystal structure and phase transition behavior of Eu nanoparticles have been investigated and compared as a function of pressure with the bulk material.

EXPERIMENTAL

EuS nanoparticles (7 nm) were prepared and characterized by Dickerson’s group of Vanderbilt University were used for high pressure experiments. The nanoparticles in the powder form were loaded with few ruby grains in a R. gasket with a 150 μm hole of a symmetric type diamond anvil cell (culet 320 μm). Helium pressure medium was loaded at Sector 13 GSECARS. The diamond anvil cell was then fitted into a gear box and placed on the sample stage at BM-D station. The pressure in the cell was measured with an online ruby system. The data collection was performed at room temperature with an incident synchrotron x-rays of wavelength 0. 40548 Å and using a MAR 345 imaging plate up to 52 GPa. The XRD images were integrated using FIT2D. The structural analysis of the patterns was carried out using the JADE software package.

RESULTS

Analysis of the x-ray diffraction images at nearly ambient pressure and temperature conditions showed the NaCl type cubic structure for EuS nanoparticles. The cell parameter obtained was 5.8553(5) Å compared well with literature value reported earlier for this material [4]. The x-ray diffraction patterns collected at various pressures are shown in Fig.1 (c). The variation of d-spacings as a function of pressure observed for the NaCl type phase of EuS nano particles is shown in Fig.2 (a). From the cell parameter values the volume has been obtained for each pressure and plotted as shown in Fig. 2(b). A third order Birch Murnaghan equation was used to fit the P-V data.

CONCLUSIONS AND SUMMARY

Bulk EuS and rare earth chalcogenide materials undergoes a pressure induced structural phase transition from NaCl type to CsCl type cubic structure above 15 GPa [4,5]. In our experiments the diffraction peaks corresponding to the CsCl phase (B2) found to emerge as early as 5 GPa and the B2 phase coexists with NaCl phase up to 52 GPa. The complete phase transformation was not inferred in this experiment. This may be due to the size reduction or phase purity of the nanoparticles from Bulk and more experiments are required to understand further. The lower bulk modulus obtained (B0 = 45 GPa with B0' = 4) showed the nanoparticles are more compressible than the bulk.

REFERENCES


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