Magnetization Studies of Europium Chalcogenide Nanocrystalline Materials

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Introduction

Europium chalcogenide nanocrystals (EuX, X = O, S, Se, Te) are a class of magnetic semiconducting nanomaterials that exhibit interesting size-dependent magnetic within a specific range of nanoscale diameters. Among these materials, europium sulfide (EuS) is the most widely investigated of these Heisenberg ferromagnetic materials. Recent studies by the Dickerson group have suggested that EuS nanocrystals will exhibit unique, size-dependent magnetization properties within specific nanocrystal diameters (d_{NC}), deemed the *nanocrystalline* (2.0 nm $\leq d_{NC} \leq$ 100 nm), and *quantum-confined* ($d_{NC} \leq$ 2.0 nm) regimes.[1-2] Our interests are to continue to probe the magnetization properties of EuS nanocrystals in sizes not previously investigated.

Experimental

Magnetic measurements on EuS nanocrystals were conducted at the National High Magnetic Field Lab with a Quantum Design 16-Tesla Physical Property Measurement System (PPMS). Key experiments included the zero-field-cooled and field-cooled magnetic moment measurements as functions of temperature, and magnetization hysteresis measurements, conducted on powders of the EuS nanocrystals.

Results and Discussion

The magnetization response of 14nm nanocrystal across a temperature range from 2 to 21K was measured. At 2 K, the counterclockwise hysteresis curve, typical for the ferromagnetic materials, was observed. Such a hysteresis yields a positive remanent magnetization (M_R). When the temperature increased, the hysteresis curve reversed direction, becoming clockwise. Magnetization measurements performed on 4 nm EuS nanocrystals are comparable to previously reported measurements in which a reversal in MR was observed as a function of temperature.[1] Investigation of magnetic properties for 14 nm EuS nanocrystals has shown a similar reversal phenomenon. The magnitude of M_R as a function of temperature for both 4nm and 14nm are displayed in Fig. 1. The data confirmed the magnetization reversal phenomena. For 4nm nanocrystal, M_R was positive for 2K, and negative with higher temperatures.

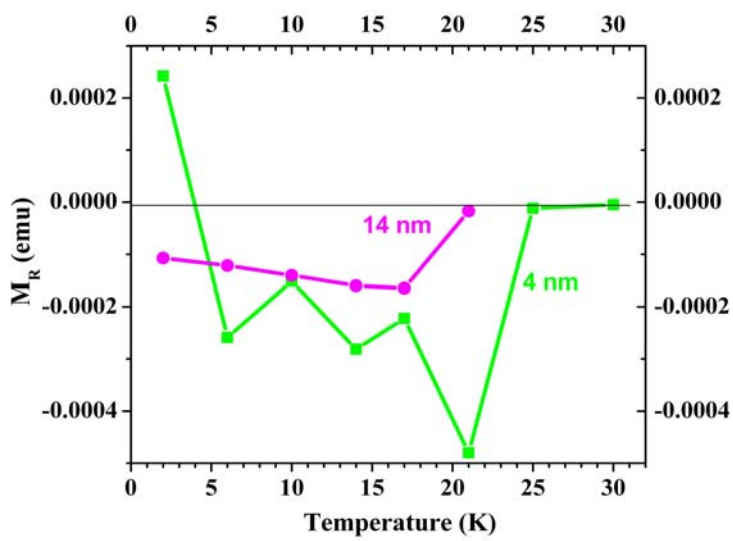

Fig. 1. Remnant magnetization versus temperature for 4 nm and 14 nm europium sulfide nanocrystals. For the majority of the temperatures, M_R is reversed.

Conclusions

Remanent magnetization measurements for 14 nm EuS nanocrystals were in agreement with the results observed for other *nanocrystalline* EuS materials. [1] Additional measurements are warranted to determine the full extent of the correlation between nanocrystal size and the magnetic characteristics.

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References

[1] Redígolo, M.L *et al*., Applied Physics Letters, 89, 222501 (2006)
[2] Redígolo, M. L. *et al*, Physica Status Solidi C, 4, 406 (2007)