Type of presentation: Oral

MS-12-O-2073 Electron holographic tomography reveals the three-dimensional magnetic field distribution of Co2FeGa Heusler nanowires

Simon P.[1], Wolf D.[2], Sturm S.[2], Lichte H.[2], Levin A. A.[1], Qian J.[1], Fecher G. H.[1], Wang C.[1], Felser C.[1]

[1]Max-Planck-Institut für Chemische Physik fester Stoffe, Nöthnitzer Str. 40, 01187 Dresden, Germany, [2]Institute of Structure Physics, Triebenberg Laboratory, Technical University of Dresden, Zum Triebenberg 50, 01328 Dresden Zaschendorf, Germany

Email of the presenting author: Paul.Simon@cpfs.mpg.de

The ferromagnetic Heusler compounds, with a L21 ordered structure, emerge as fascinating multifunctional materials exhibiting appealing physical properties that are interesting to versatile research fields such as spintronics [1], magnetic shape memory [2], and topological insulators [3,4]. Specifically the predicted half-metallicity in many Heusler compounds enable them as promising electrodes (spin injection sources) for spintronic devices based on giant magnetoresistance or magnetic tunnel junction. The properties of Heusler compounds may be enhanced by accessing the nanoscale-size regime [5]. The unique one-dimensional geometry of nanowires has been reported to give birth to novel structural and physical properties. For example, in the regime of semiconductor spintronics, nanowire morphologies have been used to demonstrate fundamental spintronics functionality such as tunneling spin injection and two-terminal spin-valve in heterojunctions. We report the first synthesis of L21 ordered Co2FeGa nanowires using SBA-15 silica as the templates. The well-ordered Heusler structure of Co2FeGa nanowires are verified by X-ray diffraction and extended X-ray absorption fine structure. We employ electron holographic tomography to study the local magnetic configurations of free-standing Co2FeGa Heusler nanowires [6-8]. The magnetic dipole stray fields of Co2FeGa nanowires are observed by electron holography indicating single magnetic domains. The internal and outward magnetic inductions flux distribution of the nanowires are visualized by electron holography and the magnetic phase shifts give rise to intrinsic magnetic induction magnitude lying in the range of 0.4 - 0.7 T as lower limit taking into account the shielding effect of the stray field, the induction reaches a value of up to 1.1 T. By acquiring electron holographic tomography, the three-dimensional distributions of the x-component of electrostatic and magnetic field inside the nanowire are mapped for the first time.

[1] C. Felser, G.H. Fecher, Spintronics: From Materials to Devices (Springer Netherlands 2013)

[2] K. Bhatacharya, S. Conti, G. Zanzotto, J. Zimmer, Nature, 428, 55 (2004)

[3] S. Chadov, X.L. Qi, J. Kübler, G.H. Fecher, C. Felser,S.C. Zhang, Nat. Mater. 9, 541 (2010)

[4] X.L. Qi, R. Li, J. Zang, and S.C. Zhang, Science 323, 1184 (2009)

[5] W. Lu and C.M. Lieber, Nat. Mater. 6, 841 (2007)

[6] G. Lai, T. Hirayama, A. Fukuhara, K. Ishizuka, T. Tanji, A. Tonomura, J. Appl. Phys. 75,4593 (1994)

[7] R.E. Dunin-Borkowski, T. Kasama: Proc. Micr. Microanal. 10, 1010–1011 (2004)

[8] D. Wolf, A. Lubk, F. Röder, H. Lichte, Curr. Op. Sol. State & Mater. Sci. 17, 126 (2013)

Acknowledgement: Financial support by the DFG is gratefully acknowledged (Project TP 2.3-A in research unit FOR 1464 ‘ASPIMATT’).

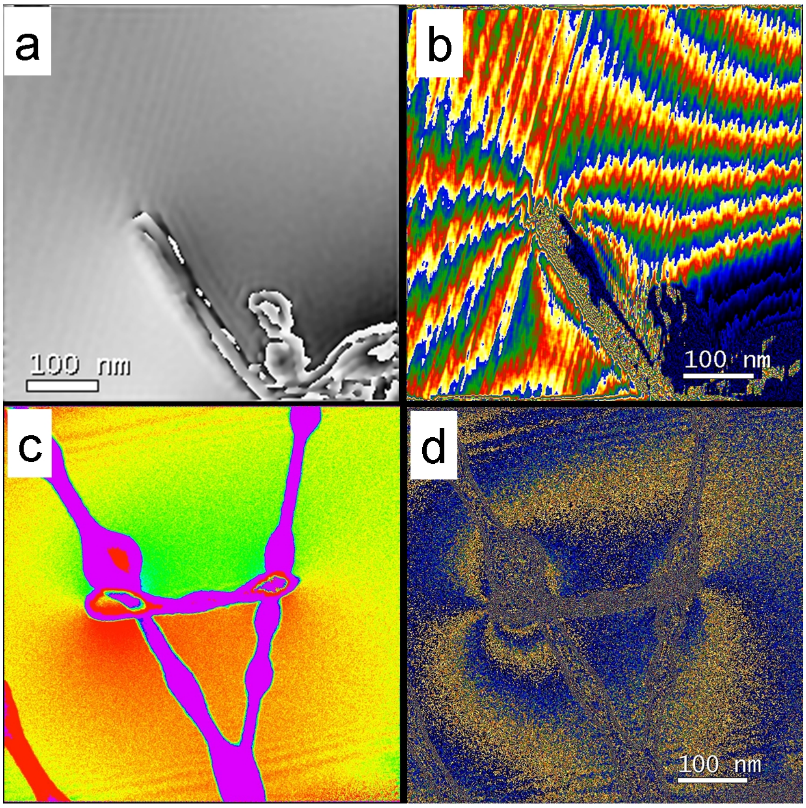

Fig. 1: Figure 1. Imaging of magnetic stray fields of the Co2FeGa dipole: (a) reconstructed phase of hologram. (b) Phase 14 times amplified. (c) Short wire of 300nm length placed horizontally on Y-shaped bars of a lacey grid surrounded by vacuum. The wire is visualized with complete dipole stray field. (d) Phase 20 times amplified.

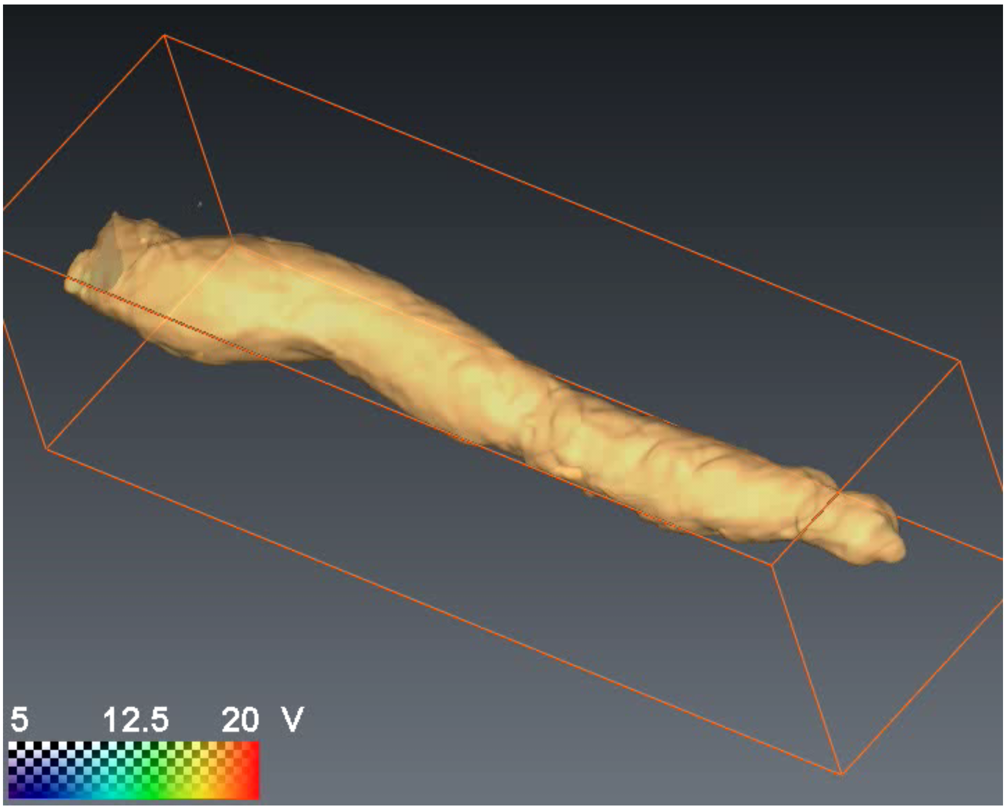

Fig. 2: Electrostatic 3D potential of Heusler nanowire.