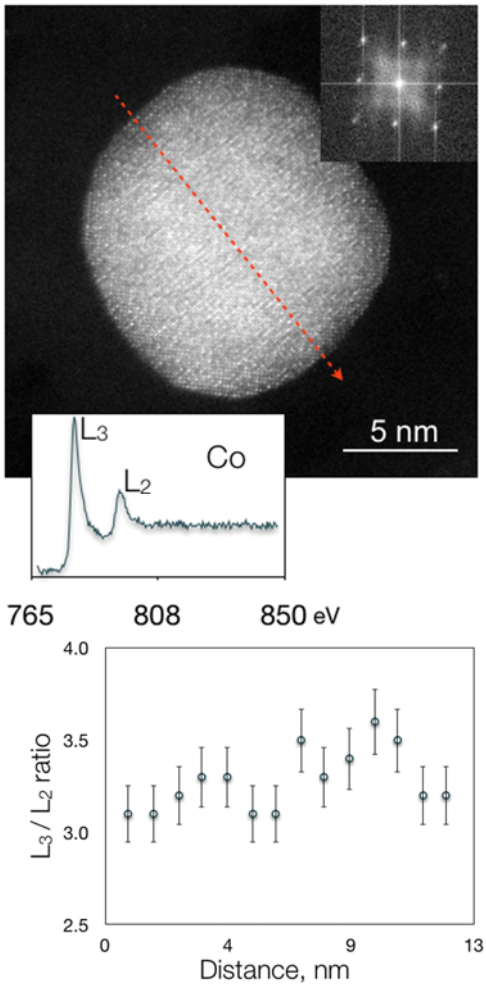
# High-resolution chemical, structural and magnetic study of hard magnetic nanocrystals using advanced transmission electron microscopy

*Understanding the magnetic properties of nanometer-sized $L1_0$ crystals requires detailed structural, chemical and magnetic characterizations. In this work we studied soft and hard magnetic ($L1_0$) alloys of Co-Pt nanocrystals [1] using high-angle annular dark-field (HAADF) scanning transmission electron microscopy (STEM) and electron energy-loss spectroscopy (EELS) techniques at the IMR.*

Magnetic nanocrystals have attracted much interest for future spintronics devices due to their unique magnetic and magnetotransport properties. Chemical properties such as alloy composition and chemical bonding as well as electron spin state can be elucidated using a combination of HAADF STEM and EELS methods. In this work we used energy-loss near-edge structure to determine the peak ratio of the L3 and L2 Co edges as a function of the nanocrystals size and chemical order. Aberration-corrected STEM was used in order to do the chemical characterization in high-spatial resolution. Co-Pt amples with different chemical composition and ordered states were studied. The Co-Pt nanocrystals were deposited using sequential electron beam deposition onto freshly cleaved NaCl substrates and covered by alumina in order to potect the surface from oxidation. The (S)TEM/EELS studies of as-deposited $Co_{26}Pt_{74}$ nanocrystals showed an averaged L3/L2 Co peak ratio of 3.1 at the alloyed regions, however it revealed a thin CoO surface layer formation on the surface of Co that increased the peak ratio to 3.5. A homogenous chemical composition and a L3/L2 peak ratio of 3.3 were found in the annealed Co-Pt nanocrystals with the same composition. Co-Pt nanocrystals with $L1_0$ structure showed an averaged L3/L2 peak ratio of 3.2. In order to validate the peak ratio determination of Co-Pt nanocrystals, we compared the results to pure Co and CoO that were used as references.

Future studies of the magnetic field distribution around the Co-Pt and Co-Fe-Pt nanocrystals using electron holography will be performed at the Forschungszentrum Jülich, Germany.




**Aberration-corrected HAADF STEM image of a $Co_{26}Pt_{74}$ alloy nanocrystal. Inset is a fast Fourier transform pattern showing no structural ordering. Background subtracted Co L-edge is shown in the next image that was used to determine the L3/L2 peak ratio along the nanocrystal as marked by red arrow.**

**References**

1. K. Sato, K. Yanajima and T.J. Konno, Philosophical Magazine Letters 92, (2012) 408

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**Contact to**

András KOVÁCS (ER-C, PGI-5, Forschungszentrum Jülich, 52425 Germany)
E-mail: a.kovacs@fz-juelich.de
http://www.er-c.org