Nanostructured magnetic materials – XAS studies

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keywords: XAFS, ferrite oxides, magnetism, nanostructurization

BACKGROUND

Size and shape of material can greatly influence its electronic structure and thus material's functional properties relevant for applications. Lowering the dimension of magnetic materials and introducing structural damage to outer layers during nanostructurization not only enhances the impact of surface states but it may also change the volume properties, e.g. magnetic anisotropy. Understanding those processes and how they influence the properties known from bulk samples, cannot be achieved without the knowledge on structural defects, especially of those related to nanostructurization.

METHODS

Using HERFD XAS technique we measured local structure and electronic configuration of iron in different types of nanoscale oxide samples formed from magnetite, maghemite and/or hematite. Thin epitaxial layers obtained by means of PLD, nanostructured by either electron lithography combined with ion etching or direct lithography using Focused Ion Beam, and nanocomposites obtained using reactive magnetron sputtering were studied using 1s2p HERFD XAS, which is a sensitive probe of local atomic environment. It is especially favorable in resolving the pre-edge structures that are sensitive to crystal field symmetry and formal valence of the ensemble of metal ions [1].

RESULTS

The experimental results show, that in general, the outcome of XAS spectra of nanoscale iron oxides can be divided in two types, based on pre-edge shape changes. The first type is related to the main pre-edge peaks, which resembles either magnetite (single peak), hematite (double peak) or maghemite (single peak with energy shift) [2]. The second type is observed in the spectra of the samples after nanostructurization. They show additional peaks at the high energy side of the pre-edge range, tentatively attributed to local structure distortion and vacancies. Evolution of the pre-edge shape is confronted with that of the main edge. The latter remains intact for most of the samples studied. Its shape resembles the one known from magnetite spinel structure, but is shifted in energy, suggesting different oxidization state of iron, namely a variable proportion of Fe^{3+} and Fe^{2+} ions and/or vacancies [3].

CONCLUSION

HERFD XAS proved to be an useful probe of nanostructurized ferrite oxides allowing to differentiate oxygen stoichiometry and observe influence of the processing involved in modification in local crystal structure.

Acknowledgments: This work was supported by National Science Center of Poland (grants: 2014/14/E/ST3/00026 and 2015/17/D/ST3/00968).

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