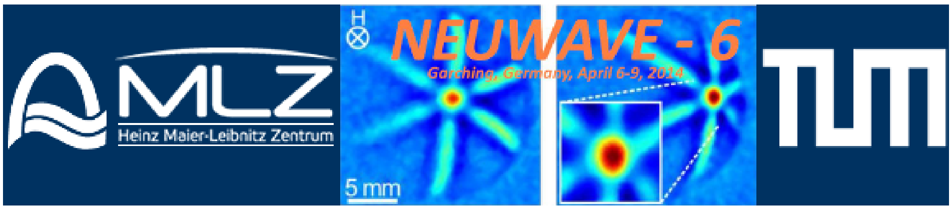

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Visualization of bulk magnetic properties by Neutron Grating Interferometry

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see attached

Summary

The neutron Grating Interferometer (nGI) is a standard user instrument at the cold neutron imaging beamline ICON [1] at the neutron source SINQ at Paul Scherrer Institute (PSI), Switzerland. The setup is able to deliver simultaneously information about the attenuation, phase shift (DPC) [2] and scattering properties in the so-called dark-field image (DFI) [3] of a sample. Due to the interaction of neutrons with the nucleus only, they are able to penetrate deeper into matter, in particular heavier materials, than X-rays do. A further advantage of neutrons compared to X-rays is the interaction of the neutrons'magnetic moment with magnetic structures that allows for the bulk investigation of magnetic domain structures using the nGI technique [4].
In the contribution, the nGI-setup and its technique for imaging with cold neutrons will be presented.
The main focus will further be on magnetic investigations of electrical steel laminations. Both, grain-oriented (GO) and non-oriented (NO) laminations will be presented in two parts. GO-laminations are widely used in industrial transformer applications, while NO-sheets are common in electrical machines.
For grain-oriented sheet, domain walls were visualized as well as their dynamic displacement process in external applied magnetic fields. In figure 1a) a dark-field image of a grain oriented transformer sheet is shown in the absence of an external applied magnetic field. In well-oriented Goss grains single domains walls are visible (horizontal dark lines), the corresponding domains have a size of several milimeters. Furthermore, dark areas are observed. These are misoriented grains where wide basic domains are superimposed by supplementary domains [compare: Magnetic Domains, A. Hubert, R. Schäfer (1998)] that destroy the dark field image by multiple scattering. By applying a magnetic field, favorably magnetized domains grow and less domain walls become visible. In a magnetic field of 6000 A/m (see figure 1b)), the well-oriented grains are saturated and only the misoriented grains show a remaining contrast. This contrast indicates that supplementary domains are still present in these grains. By further increasing the external magnetic field, also these areas become transparent and the whole sample is in the saturated state.
The resolution of the nGI is limited in terms of resolving domain walls individually in non-oriented sheets. Here a relative density distribution of domain walls is rather imaged. The darker the DFI-signal, the more domain walls are present at this particular point. For non-oriented sheet the influence of treatment and cutting processes was investigated. On the one hand mechanical cutting was compared with laser cutting techniques. On the other hand magnetic flux properties were investigated and the ability to influence the flux propagation by laser treatment was verified. With the possibility of decreasing the magnetic flux, together with the capability of visualizing the magnetic flux density itself in these laminations spatially resolved, new insights in the magnetic behavior of bulk samples become possible.

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