Extraction of desired phase information in dark-field electron holography

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Dark-field electron holography (DFEH), which uses a Bragg reflection for the phase retrieval, allows for precise strain mapping from thin-foiled crystals [1]. This method is in principle sensitive to the lattice imperfections (*i.e.* source of the additional, geometric phase shift) in addition to the magnetic and/or electric field of specimens. Those multiple sources of the phase shift make the analysis of DFEH complex, in particular, for magnetic materials. We report on the methods that allow for extracting only desired phase information from the DFEH observations, and the applications to the issues of materials science.

We attempted to separate the strain information from the magnetic information using a thin-foiled Nd-Fe-B magnet. Actually, strain mapping is a key for the improvement of coercivity (*i.e.,* critical magnetic field to induce unwanted magnetization reversal) in this sintered, polycrystalline magnet. In order to depress the undesired magnetic information, we have acquired a set of dark-field electron holograms using Bragg reflections 002 ($\boldsymbol{g}$) and $00\bar{2}$ ($-\boldsymbol{g}$) as shown in Fig. 1 [2]. Using the latter Bragg reflection reversed the sense of the strain information (*i.e.,* geometric phase shift due to lattice strain) although the sense of the magnetic information remained unchanged. A subsequent image processing allowed for extraction of the strain information. A strain map shown in Fig. 1(f) revealed lattice distortion of approximately 1 % near the α-Nd precipitate. Another examination is of suppression of a diffraction contrast that hampers an accurate magnetic flux density measurement from an interface region. Regarding antiphase boundaries (APBs) produced in ordered crystals, it appears difficult to suppress completely the diffraction contrast; *i.e.,* the residual diffraction contrast influences the precision of phase shift analysis in conventional electron holography. DFEH provided a set of reconstructed phase images which were respectively determined by using 002 fundamental and 001 superlattice reflections from a Fe-Al alloy (CsCl-type ordered crystal). The superlattice reflection was indeed advantageous for suppressing the undesired diffraction contrast in the APB regions. The result indicates the usefulness of DFEH in the electromagnetic field analysis from narrow interface regions.

This study was supported by JST, CREST (JPMJCR1664) and JSPS International Research Fellow (Postdoctoral Fellowships for Research in Japan (Standard)).

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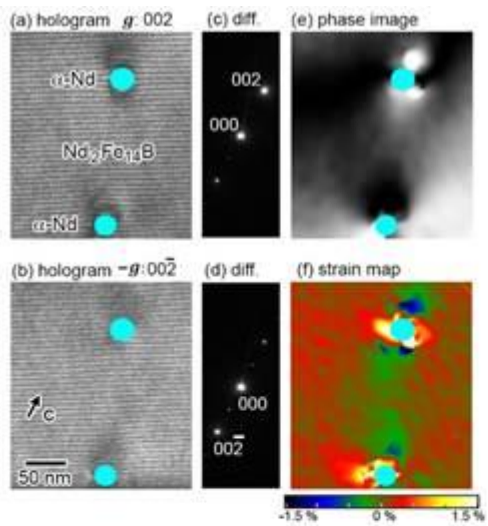

Fig. 1. (a),(b) Dark-field electron holograms produced using 002 and $00\bar{2}$ reflections, respectively. (c),(d) Electron diffraction patterns obtained while acquiring dark-field holograms. (e) Phase image showing the contribution from lattice strain. (f) Strain map representing change in the interplanar spacing of *c* plane. [2]