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Diffraction mapping of the verwey transition at magnetite

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Introduction: Ferromagnetism shows various phenomena at low temperature. The story of the Verwey Transition in magnetite has been investigated over a period of about one century. In 1941, Verwey et al. found for the first time that Magnetite undergoes a rapid rising of heat capacity at the temperature of less than 125 K, and also its magnetization and resistivity varies significantly [1]. Along with the development of advanced materials characterization methods, more research groups have a new interpretation to explain the magnetic performance of magnetite such as Jahn–Teller distortions, coupled distribution of a minority-spin electron and Trimeron distribution in the low-temperature magnetite structure [2].
Objectives: This report focuses on the immobile select electronic diffraction by nano-beam and dynamical evolution of crystallographic structure of magnetite during magnetic phase transitions at low temperatures.
Materials and Methods: Lamellar specimens of magnetite were cut along the <001> and <011> zone axes by focused ion beam milling. The changes in morphology and diffraction patterns were continuously recorded around Verwey temperature by in-situ transmission electron microscopy. The heating effect of electron beam was also confirmed in the in-situ experiments. The nano-beam provides us the high spatial resolution for diffraction mapping, despite the HAADF detector cannot acquire the image on charge ordering twins efficiently. It is a method to extract the local information by Bright Field in scanning transmission electron microscope during High-speed camera captures.
Results: About 96 K, the stripes of twin can be captured on the magnetite lamellae, these observation is generally consistent with previous studies of Verwey phase transition. Investigating the different regions of contrast, the orientation relationship of crystal demonstrates the imperceptible select electronic diffraction pattern. Furthermore, the super-lattice diffraction spots had disappeared after electron irradiation damaged on the surface immediately, whereas the stripe still existed on the region of spot size.
Conclusion: One encouragement is that the result evidences relationship between crystallographic structural phase transition and charge-ordering, which exist the phase coexisting region during the Verwey Transition of magnetite. The aim of the present study is to generate the charge ordering twins without internal diffractive dynamics, which builds upon correct various statements of physical mainstream.

References:
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