Experiment Brief

K2 IS Camera

Title

Investigation of dynamic charging effects induced by medium energy electron beam of a TEM.

Gatan instrument used

The K2® IS camera, from Gatan, is the fastest and highest performance *in-situ* camera to resolve dynamic details in heating, catalysis, mechanical deformation, STEM diffraction, electrical testing, and chemical reaction experiments.

Background

Beam induced charging is a common challenge in electron microscopy techniques. Due to the various interactions occurring between the electron beam and specimen, the origin of charging varies from material to material and can be very complicated to minimize. The aim of these set of experiments was to collect data on the strength, dynamics, and temperature dependence of charging and discharging processes for different materials. This can then be used to identify the dominant cause of the charging effects and thereby create a theory that can describe them.

Materials and Methods

Dynamic off-axis electron holography was performed on $Si0_2$ insulating films. The holograms were recorded using a K2 IS camera operating at 400 fps (time resolution of 2.5 ms). The spacing of the holographic fringes, which is calculated using an FFT of area of interest, is a direct measurement of the electrostatic potential at the specimen. Thus measuring the change in the holographic fringe spacing, as the electron beam is placed on the sample, can be correlated to the variation of the charge accumulated at the sample surface. An example of such measurements is shown for SiO_2 in Figure 1C. On this specimen, the amount of charge was increasing with time and it fully saturated in about 0.5 s. Fitting the dependence with exponential function confirmed that this charging resembles the R-C circuit and its time constant is t_1 = 84 ±10 ms.

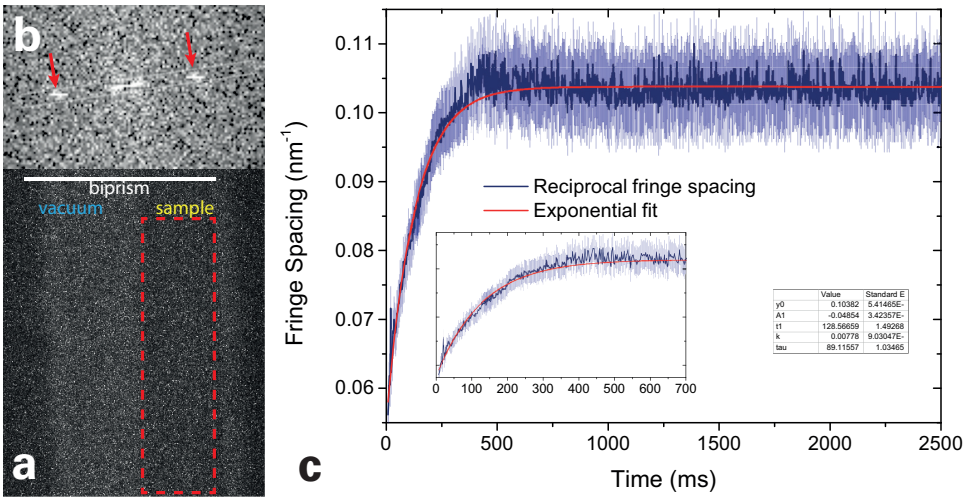

Figure 1. Dynamic charging of $Si0_2$ edge.(a) Experimental hologram showing an edge of $Si0_2$ thin film and holographic fringes marked as "biprism". (b) Center of FFT pattern of the area marked with the red rectangle in (a) red arrows show components of the transform associated with the holographic fringes. (c) Graph showing reciprocal fringe spacing (distance between the red errors in (b)) as a function of time. *Images courtesy of V. Migunov (ER-C, Germany) and M. Beleggia (DTU, Denmark).*

Summary

Using the K2 IS camera, with high detective quantum efficiency (DQE) and fast frame rate, made it possible to collect images with sufficient SNR and resolve the time dependence of the charge accumulation processes. Further experiments are required to study charging effects in different materials and at different temperatures.

Credit(s)

A special thanks to: Dr. Vadim Migunov, Rafal E. Dunin-Borkowski, ER-C; Dr. Marco Beleggia, Center for Electron Nanoscopy, Technical University of Denmark.

Gatan, Inc. is the world's leading manufacturer of instrumentation and software used to enhance and extend electron microscopes—from specimen preparation and manipulation to imaging and analysis.

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