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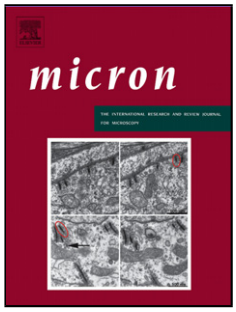

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Hole Free Phase Plate Tomography for Materials Sciences Samples

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Highlights

- A 3D image of a microprocessor chip was observed with Hole Free Phase Plate.
- Roughness of molecular electronic junction was measured with Hole Free Phase Plate.
- Relationship between sample thickness, composition and contrast was measured.

Abstract

We report, for the first time, the three dimensional reconstruction (3D) of a transistor from a microprocessor chip and roughness of molecular electronic junction obtained by electron tomography with Hole Free Phase Plate (HFPP) imaging. The HFPP appears to enhance contrast between inorganic materials and also increase the visibility of interfaces between different materials. We demonstrate that the degree of enhancement varies depending on material and thickness of the samples using experimental and simulation data.

Keywords

Hole Free Phase Plate (HFPP), Electron tomography, Transistor Imaging, Molecular electronic junction, Interface roughness, Transmission electron microscope (TEM).

1. Introduction

Differentiation of the various layers in a semiconductor device is becoming increasingly more difficult as device dimensions decrease. The typical layer thickness in a 22 nm node devices is in the order of a few nanometers, i.e. a few tens of atomic layers. A molecular electronic device may have several carbonaceous layers such as polymers and e-beam deposited layers that have nearly identical chemical composition and nearly no difference in their mean atomic number and their mean inner potential (MIP).

To visualize the layers of such devices in 3D, it is necessary to use an imaging method that provides sufficient contrast between the materials the device is composed of. Often the contrast of bright field transmission electron microscopy (BFTEM) or annular dark field scanning transmission electron microscopy (ADF STEM) is too low and would require high irradiation dose to obtain adequate signal to noise ratio (SNR) for reliable 3D reconstruction (Hayashida and Malac, 2016). The high irradiation dose implies extensive radiation damage