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A New Type of Detector for Electron Microscopy

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Abstract

A new high resolution recording device for transmission electron microscopy (TEM) is urgently needed. Neither film nor CCD cameras are systems that allow for efficient 3-D high resolution particle reconstruction. We tested an active pixel sensor (APS) array as a replacement device at 200, 300, and 400 keV using a JEOL JEM-2000 FX II and a JEM-4000 EX electron microscope. For this experiment, we used an APS prototype with an area of 64 x 64 pixels of 20 μm x 20 μm pixel pitch. Single electron events were measured by using very low beam intensity. The histogram of the incident electron energy deposited in the sensor shows a Landau distribution at low energies, as well as unexpected events at higher absorbed energies. After careful study, we concluded that backscattering in the silicon substrate and re-entering the sensitive epitaxial layer a second time with much lower speed caused the unexpected events. Exhaustive simulation experiments confirmed the existence of these back-scattered electrons. For the APS to be usable, the backscattered electron events must be eliminated, perhaps by thinning the substrate to less than 30 μm. By using experimental data taken with an APS chip with a standard silicon substrate (300 μm) and adjusting the results to take into account the

effect of a thinned silicon substrate (30 μm), we found an estimate of the signal-to-noise ratio for a back-thinned detector in the energy range of 200 - 400 keV was about 10:1 and an estimate for the spatial resolution was about 10 μm. We will also report on our efforts to reduce the pixel size to 5μm x 5μm.

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