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P36 - Improvement of spatial resolution and detection efficiency by control of secondary-electron in single-event three-dimensional time-of-flight Rutherford backscattering spectrometry

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A single-event three-dimensional time-of-flight (TOF) Rutherford backscattering spectrometry (RBS) system has been developed using 150 keV focused Be+ beam [1, 2]. Signals from a secondary electron detector (SED) and a micro channel plate (MCP) were used for the start and stop triggers in single-event TOF-RBS. The achieved time resolution was 4.4 ns, corresponding to the depth resolution of 12 nm, which was slightly longer than that with a beam chopping system [3]. The fluctuation of the secondary-electron flight-path affects the time resolution in single-event TOF-RBS. When the secondary electron is not detected, the stop signal is uncounted to the TOF-RBS data, resulting in the prolonged measurement time. Therefore, the flight-path and detection efficiency of the secondary electron are important factors for single-event TOF-RBS. In our recent study, the shorter time resolution and measurement time were achieved with positive sample bias voltage [1]. However, the reason of the improvement was not clarified. In this study, the secondary-electron flight-path from the sample to SED were simulated using a boundary element method for clarify the reason of the improvement and the simulated results were compared with the experimental them.
Applied voltages used in the simulation were +10 kV, -1.6 kV, and 0 V for SED, four MCPs and the outer part of the focused ion beam (FIB) column, respectively. Sample bias voltages were ranging from -200 to + 200 V. When negative sample bias voltage was applied, electric field between the sample and the outer part of the FIB column accelerates the electrons, most of the electrons impinge the outer part of the FIB column and few electrons were detected at SED with long flight paths, resulting in the long time resolution and low detection efficiency. When positive sample bias voltage was applied, the secondary electrons were not spread around the sample and pulled by high voltage at SED before electron return to the sample, resulting in the short time resolution and high detection efficiency. In the experiment, with sample bias voltage of +100 V, the depth resolution of Pt stripes under a SiO2 layer was 6 nm smaller and the measurement time was 65 % shorter than those without sample bias voltage. These results were good agreement with the simulated them.
[1] S. Abo et al., ICNMTA2012, O-30, Lisbon, July 2012
[2] S. Abo et al., Nucl. Instr. Meth. B 273 (2012) 262
[3] H. Takayama et al., Nucl. Instr. Meth. B 210 (2003) 108

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