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Quantitative Low-Current Ion Beam Characterization by Beam Profiling and Imaging via Scintillation Screens

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Ion beams with Gaussian cross section are utilized as tools for sub-aperture ion beam figuring. In the context of ultra-precision surface error corrections it is of importance to obtain information about the spatial beam profile as well as the material removal rate distribution. In most cases beam current probes like Faraday cups are used to obtain information about the beam profile. Ion beams can only be detected in un-neutralized state due to the principle of measurement. For material processing the ion beam must be neutralized by using electron injection into the positive space charge which influences the spatial characteristics of the beam.
In this work, low-energy ion beam profiling is the subject of interest via inorganic scintillator screens (YAG:Ce – $Y_3Al_5O_{12}:Ce^{3+}$). Scintillator screens are primarily used as radiation sensors in medical diagnostics and accelerator physics. The scintillator detectors convert the energy of incident charged particles into light. Thus, imaging and characterization of the neutralized ion beam can be achieved. The Ar^+ ions are emitted from a RF ion beam source with currents in the range of 50 – 200 µA and energies of typically 1000 eV. A cooled CCD camera setup allows spatially resolved measurements of the scintillator light output under different ion beam conditions (beam size, working distance, modulation of the average beam intensity). Especially, characterization of the neutralized ion beam has been achieved for defined angles of incidence via difference image analysis. The properties (full width half maximum, light output) of the imaged beam profiles have been compared with profiles obtained using Faraday cup measurements and material removal distributions from corresponding test etchings, respectively. The studies show a correlation between the scintillator light output and the current densities as well as the radial etch rate distribution. Additionally, beam stability and beam induced contaminations on the treated test surface have been evaluated. Consequently, by using the scintillation method we obtained a detailed characterization of the neutralized ion beam. Finally, these findings enable further investigations of various beam diameters and can be applied for developments of advanced ion beam sources.

Keywords
low-current ion beams, beam profiling, scintillator