Focused ion beam using a rubidium cold-atom ion source

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Focused Ion Beams are important tools for the semiconductor industry. Essential applications are editing circuits and repairing masks in the development phase, and failure analysis during wafer processing. As a result of the reduction of feature sizes in semiconductor circuits, FIBs also face higher demands in terms of resolution and reduced damage. Here a FIB instrument that may overcome these limitations is presented.

The essential innovation is the use of a cold-atom ion source[1] based on photoionization of a laser-intensified and cooled atomic rubidium beam. The beam is produced by a high-flux Knudsen cell followed by laser-intensification stage consisting of a magneto-optical compressor followed by a polarization-gradient molasses[2]. The resulting high-brightness rubidium atomic beam passes into a dedicated two-stage electrostatic accelerator with integrated optical build-up cavity for efficient photoionization.

The performance of the source was characterized by studying deliverable current, brightness and energy spread. The intensified atomic beam source has an equivalent ion brightness of at least 6×10^6 A/m^2 sr eV, six times higher than that of the Ga-LMIS. Around 75% of the atomic beam can be photoionized, producing ion currents of up to 600 pA[3]. The energy spread of the ion beam can be as low as 0.21 eV FWHM[4], beating the Ga-LMIS by a factor of 18.

The source was then mounted on a commercial FIB system and first ion microscopy and milling experiments were performed. For the measured brightness and energy spread of the ion source, realistic ion-optical simulations show that a probe resolution of order 1 nm is possible for currents of a few pA. In preliminary experiments, a 50% probe diameter of 3.5 nm was found for a current of 1.5 pA and a beam energy of 8 keV.

The current focus is on studying the interaction of rubidium ions with typical materials to investigate the essential suitability of a Rb+ FIB for real-world.

References

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