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Production of negative helium ions via transmission through nano-foils

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The production rate of negative helium ions (He^-) was measured for the case of passing positive helium ions (He^+) through a nano-foil, used as a charge exchange medium. Ratios of the amount of transmitted positive, neutral, and negative helium particles to total transmitted particles were measured when using different nanometer-thick foils including carbon, Formvar, silicon nitride, and gold with an incident He^+ beam energy of 25 keV and sub-pico-amp beam currents. Results have given He^- production ratios of 0.01% to 0.05% consistent with previous reports.

Experiments were performed using a helium ion microscope (HIM) with the foil mounted at the beam-limiting aperture, and transmitted ions detected by an added CMOS camera mounted below the sample stage. Transmitted particles were initially separated by charge with the HIM's internal electrostatic deflectors into distinct beams, and the intensity of each beam measured by the CMOS sensor. Current experiments with previous foils, as well as titanium oxide, platinum, and palladium, are using a new custom-designed sample holder mounted on the HIM sample stage that contains the nano-foil and a magnetic deflector. These experiments are performed at incident beam energies from 10 to 30 keV.

This work endeavours to find an alternate method of producing He^- ions from He^+ with non-metallic materials at a comparable rate to the existing method of using vapour charge exchange with alkali or metallic atomic vapours. A non-metallic, foil-based method could greatly reduce or eliminate the problems associated with containing vapours within vacuum systems, and for semiconductors manufactured with He^- and metallic vapours, the problem of contamination in the implantation process.

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