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Creating negative ion beams from neutral gases using a negative Hydrogen ion source

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Negative ion beams are valuable for applications where tandem accelerators are used for ion injection [1], such as university research centers in the area of surface analysis using RBS (Rutherford Backscattering Spectrometry) and PIXE (Particle Induced X ray Emission) [2] and for high energy, light ion implantation in semiconductor devices [3]. A typical method for negative ion production uses a charge exchange method where positive (1+) ions are incident upon a vacuum region of alkali or other metallic vapour at an energy of a few tens of keV [1], such that a double charge exchange occurs to produce negative (1−) ions. This technique results in alkali or other metal contamination of vacuum surfaces and is difficult to maintain, and, with regards to ion implantation, the metallic vapour can contaminate the silicon wafers being processed. In this paper, we will be following Doupé and Litherland [4] where a negative ion beam (Y^-) is incident on a neutral vapour (X0) for a single step charge exchange: Y^- + X0 ⟶ Y0 + X^-, where the newly created X^- along with any remaining Y^- are accelerated with an electrostatic accelerator in order to avoid issues with alkali materials and general metallic contamination. We will describe our experimental setup which leverages D-Pace’s H^- ion source [5], and a charge exchange vacuum box with an in-vacuo electrostatic accelerator followed by a 1:500 resolution mass spectrometer system. Neutral non-metallic vapours shall be bombarded with up to 15 mA (DC) H^- beams over the energy range 10-30 keV to create negative ion species to be accelerated by the 10-20 kV electrostatic accelerator. The neutral gases to be studied are He, CO2, H2, CH4 and the resulting conversion rates to He^-, C^-, CO^-, $C2^-$, $CO2^-$, $H2^-$, H^-, O^-, $O2^-$ etc. shall be reported as measured by the spectrometer system. Determination of the cross-sections to form the excitation function of this charge exchange process for the listed gases in the energy range 10 –20 keV is the ultimate purpose of this work.

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