Studies of ion escape velocity and conversion electrode material affecting H^- production in surface conversion ion sources

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The negative ion formation probability of particles ejected from a metal surface can be estimated with two different theoretical approaches [1], often referred as probability and amplitude models. Both theories suggest that the rate of negative ion formation depends strongly on the velocity of escaping ions, the work function of the surface and the electron affinity of the negative ion. We present experimental results and theoretical estimates studying the velocity dependence and the role of the work function on surface production of H^- ions.
The formation of H^- ions in the LANSCE negative ion source occurs on cesiated surface of a negatively biased electrode (converter), exposed to a flux of positive ions incident from a cusp-confined, filament-driven discharge. We have studied the velocity dependence of the negative ion formation process with the LANSCE H^- ion source by varying the converter voltage under optimized cesium coverage. We discuss the results and compare them with predictions of the theoretical models.
The lowest obtainable work function ϕ of different metal surfaces covered with cesium can be estimated with the semiempirical formula: $\phi \approx 2.707 - 0.24\phi_0$, in which ϕ_0 is the work function of uncesiated metal surface [2]. It is somewhat counterintuitive that metals with high intrinsic work function turn out to be the best candidates for H^- conversion surfaces. This is due to the strong electric field formed between the cesium layer and the metal surface enhancing the electron tunnelling through the potential barrier. We present calculations of estimated H^- yields for different cesiated metal surfaces and discuss the role of hydride formation affecting the H^- production. We also discuss the predicted effects, caused by fluctuations of cesium concentration, on the stability of H^- production for different metal-cesium combinations.
Finally, we present a novel idea of utilizing so-called negative electron affinity (NEA) materials for the surface production of H^- ions. In NEA materials the bottom of the conduction band is above the vacuum level allowing electrons to be emitted from the surface forming negative ions with atoms adsorbed on the surface. Diamond exhibits negative electron affinity under exposure to UV-light, which makes it a suitable candidate for cesium-free surface production of H^-. We have initiated a project at the University of Jyvaskyla to study the feasibility of the approach for application in H^- ion sources. As a first step we will characterize the UV-emission properties of different plasma generators. The status of the project is discussed.

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