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Ultra-low work function of caesiated surfaces and impact of specific hydrogen plasma species

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Negative hydrogen ion sources for fusion and accelerators predominantly rely on the surface production mechanism. For that, a low work function surface is required to convert incoming hydrogen atoms and ions into negative ions. Due to the so far unsurpassed performance of caesium in this context [1-2], research on caesiated surfaces is unabated. During ion source operation the caesiated surface is affected by residual gases from the background pressure during vacuum phases (between 10^{-10} mbar for accelerators and up to 10^{-5} mbar for fusion), as well as by reactive hydrogen species during plasma phases comprising the atomic hydrogen radical, hydrogen ions and UV/VUV photons with energies of up to 15 eV. The combined influence can reach from cleaning the caesiated surface [3] to caesium removal from the surface [4]. The complex dynamics during ion source operation necessitates dedicated investigations on specific scenarios, which are performed at a flexible laboratory setup.

The experiment ACCesS is equipped with an in-situ work function diagnostic based on the photoelectric effect and was lately upgraded w.r.t. the threshold sensitivity. The detection limit for photocurrents was lowered by several orders of magnitude which now reveals ultra-low work function values of caesiated surfaces under moderate vacuum conditions [5]. The work function of significantly below that of bulk Cs is attributed to the formation of Cs oxide layers upon reaction of Cs with residual water inevitably present due to the base pressure of 10^{-6}–10^{-5} mbar. The second modification of the experimental setup is an external ICP source with which the surface under investigation can be exposed to fluxes of specific hydrogen plasma species, where magnets and a MgF_2 window are used to select the species (H, H_x^+, VUV). It is revealed that each species can affect the surface separately and that their combined influence leads to a work function after repetitive short plasma pulses that is slightly higher than the ultra-low work function reached under vacuum conditions, but still lower than bulk Cs.

Due to this multitude of influences, a transfer of quantitative work function values to ion source operation is not straightforward. Therefore, a work function measurement system for ion sources was developed and recently installed at the Batman Upgrade ion source; first preliminary results will be shown.

References

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