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Single and double electron capture cross sections for Sn3+ ions impacting on H2/D2 molecules in the energy range 50 eV –50 keV

State-of-the-art nanolithography machines work with light in the extreme ultraviolet (EUV) regime. This light is generated by a laser-produced plasma (LPP) of Sn. Apart from the EUV photons, the LPP also emits highly charged Sn ions with up to several tens of keV of energy that may damage plasma-facing surfaces. Therefore, industry uses a buffer gas of H_2 to slow these ions. In consecutive charge exchange reactions, the charge state of the Sn ions is reduced. Stopping cross sections are known to be charge-state dependent. Models used for optimization of industrial EUV sources therefore require accurate atomic data in the form of both charge exchange and stopping cross sections.

We have been working on generating this missing data at the ZERNIKELEIF facility where we can generate a beam of Sn ions of a pre-selected energy, charge state, and mass (isotope). At a high-voltage platform, we let the Sn ions traverse a jet of H_2 gas and subsequently analyze the ion beam characteristics with a retarding field analyzer (RFA). By setting appropriate voltages on the RFA grid, we can separate and measure the different charge states that result from the charge exchange reactions. Using this new setup, we have measured the single electron capture cross section ($_{32}$) for Sn^{3+} on H_2 over the wide energy range of 50 eV to 50 keV. Moreover, by varying the pressure of H_2 gas we obtained the double capture cross section σ_{31} as well. The single capture cross sections are found to peak at around 1 keV, whereas the double capture cross sections show a remarkable increase towards our lowest energies. On top of that, a large and unexpected difference between H_2 and D_2 is observed. We also calculate the cross sections using a semi-quantal framework.

We will present the experimental and theoretical data and discuss the possible origins of the observed behavior. In addition we will discuss the relevance of our data to state-of-the-art EUV nanolithography machines.

Presenting Author

Klaas Bijlsma

Presenting Author Affiliation

University of Groningen

Presenting Author Gender

Male

Country

The Netherlands

Presenting Author Email Address

k.i.j.bijlsma@rug.nl

Primary author: BIJLSMA, Klaas (University of Groningen)

Co-authors: DE WIT, Emiel (University of Groningen); RABADÁN, Ismanuel (Universidad Autónoma de Madrid); ASSINK, Luc (University of Groningen); MÉNDEZ, Luis (Universidad Autónoma de Madrid); SALVERDA, Mart (University of Groningen); VERSOLATO, Oscar (Advanced Research Center for Nanolithography); HOEKSTRA, Ronnie (University of Groningen); RAI, Subam (University of Groningen)

Presenter: BIJLSMA, Klaas (University of Groningen)

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