A QUANTITATIVE INVESTIGATION OF QUASI-RESONANT NEUTRALIZATION OF HE^{+} IONS AT A GERMANIUM SURFACE

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1. INTRODUCTION

Low Energy Ion Scattering (LEIS) is an excellent tool to probe the composition and structure of the outermost atomic layers of a given sample [1]. However, to obtain quantitative information one needs detailed understanding of the involved charge exchange mechanisms. Typically, charge exchange may be due to Auger-Neutralization (AN) or resonant neutralization/reionization in a close collision (RN/RI). Additionally, there is a certain class of ion-target systems for which a different charge exchange process can be observed: quasi-resonant neutralization (qRN). This process was discovered by Erickson and Smith and occurs for materials with electrons of binding energy almost resonant with a projectile level, e.g., Ge*3d* – He*1s* [2]. A characteristic feature of this type of charge exchange is an oscillatory behavior of the ion yield with ion energy. Theoretical models explained these oscillations as consequence of quantum mechanical interference [3, 4]. Up to now, quantitative information on the efficiency of this process is astonishingly scarce.

2. EXPERIMENTAL RESULTS

We have measured the ion fraction, P^+, of He^+ scattered from a Ge(100) surface, by LEIS using time-of-flight (TOF) and electrostatic-analyzer (ESA) spectrometers. We used 1 – 8.5 keV He^+ ions and double alignment geometry to determine P^+ from the scattered yields of ions and neutrals, A_+ and A_0, as obtained by the TOF-LEIS setup ACOLISSA. This approach has the advantage that P^+ can be evaluated without detailed knowledge of surface structure and experimental parameters (e.g., primary current, scattering cross section). Complementary experiments performed with an ESA-LEIS setup were carried out to extend the energy range towards lower energies. In Fig. 1, deduced ion fractions are displayed as a function of the inverse initial velocity. One can clearly observe the oscillations in P^+, which are characteristic for charge exchange by qRN. Note, that for the He^+-Ge system P^+ is very low compared to results obtained for materials which do not feature qRN charge exchange. Cu is known to neutralize He^+ exclusively due to Auger-neutralization for He energies below 2 keV. In this case, the ion fraction is almost one order of magnitude higher than for He-Ge.

Additionally, we determined P^+ as a function of the polar angle of the incident beam. From such a polar scan the information depth can be estimated. These experiments revealed that only the outer atomic layer contributes to the ion yield.

These experimental results indicate that qRN is a very efficient neutralization mechanism, with considerably higher neutralization rate as compared to AN. To gain further insights, it would be interesting to disentangle the relative contributions of AN and qRN, and to determine the threshold energy for reionization.

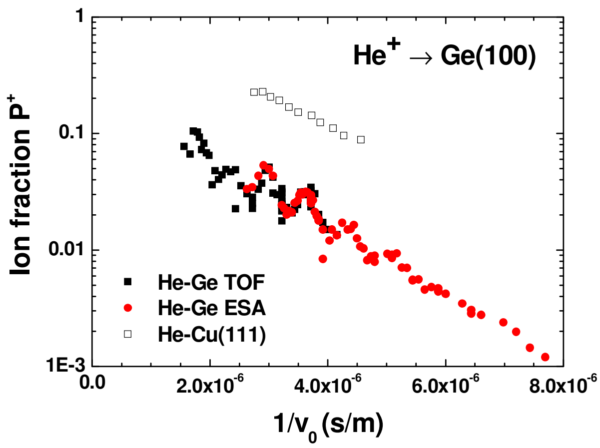

Figure 1: Ion fraction of He^+ scattered from a Ge(100) surface as a function of inverse initial velocity. Measurements were performed with TOF-LEIS (black) and ESA-LEIS (red) setups. P^+ for He^+-Cu (open squares) is shown to illustrate the efficiency of qRN.

3. REFERENCES

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