Target Orientation Dependence of the Backscattered Intensities and Charge Fractions Observed for Large-angle Quasi-binary Collisions of Ar^{q+} Ions with Au(110)

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Large-angle ion scattering from solid surfaces is a well known experimental technique for studying ion-surface interactions. To date the bulk of such measurements for multicharged incident ions focused on the analysis of charged scattered particles. By utilizing a linear time-of-flight (TOF) analyzer with a floatable drift tube [1] we have extended the technique to permit measurements of backscattered neutrals as well, permitting the determination of absolute scattered charge fractions, even cases, including the present, where the dominant scattered charge state is neutral. In this contribution we report on studies of projectile neutralization during120° backscattering of low energy (few keV) Ar^{q+} (q=2-11) ions incident on a Au(110) surface. The measurements were carried out at the ORNL Multicharged Ion Research Facility (MIRF).

Typically the energy loss spectra of backscattered projectiles exhibit rather sharp peaks at energies very close to those calculated for binary collisions between the incident projectiles and individual target atoms. These collision peaks usually sit on top of broad structures resulting from multiple collision events. For scattered neutrals we have found that for a fixed incident angle the quasi-binary collision peak area depends strongly on target azimuth angle (with variations of a factor three observed at 5 keV incident energy). To try to understand these variations, computer simulations using the MARLOWE code [2] were carried out. The Au(110) surface was modeled assuming the standard (2x1) surface reconstruction for this surface and incorporated the effects of lattice vibrations. The simulation results showed excellent agreement with the experimental data for scattered neutrals, and suggested that the azimuthal intensity variations of the scattered neutrals is completely accounted for by the azimuthal variations in the number of those pure binary collisions (BC) and "quasi-binary" double collisions from the first three target layers, that lead to scattered energies included in the observed energy loss peaks. The "quasi-binary" double collisions contributing to the BC peak are usually a combination of large angle and grazing angle events.

The measured energy loss spectra for charged scattered particles consist essentially of single BC peaks (i.e., without the broad structures associated with high multiplicity collisions), although in the case of singly charged ions a small contribution from low multiplicity collision events are typically visible on the high energy regions of the spectra (it is worth pointing out that this second peak is more pronounced in case of Ar^{2+} incident ions). The corresponding target azimuth dependence of the peak area is remarkably different from the neutral peak dependence mentioned above. In particular, for case of Ar^{2+} incident ions, it is practically independent of azimuth angle. This observation, together with further details of our simulation results to be discussed in greater detail at the conference, leads to the conclusion than ions can survive not only at most a single collision but, that this single collision must be in the topmost target layer. Our target azimuth dependence results for incident Ar^{11+} ions indicate that even for high incident charge states, the probability for ions to survive single collisions with second or third layers is dramatically suppressed as well. The presence of the second high-energy peak in the ion energy loss spectra mentioned above indicates that re-ionization of a neutralized projectile, e.g., in the second collision of a double collision event is an additional channel leading to a scattered +1 ions. This and several other interesting facts will be presented in greater detail at the conference.

*Managed by UT-Battelle, LLC, for the USDOE under contract No. DE-AC05-00OR22725.

[1] V.A. Morozov and F.W. Meyer, *Rev. Sci. Instrum.* **70**, 4515 (1999).
[2] M.T. Robinson, *Phys. Rev.* **B 27**, 5347 (1983) .