On the role of d-electrons in electronic stopping of slow light ions

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When ions traverse matter, they lose energy according to the stopping power S = dE/dx. These energy losses can be attributed to either collisions with target nuclei (nuclear stopping, S_n) or excitations of electrons (electronic stopping, S_e). For a free electron gas and projectile velocities below the Fermi velocity, S_e is expected to scale linearly with projectile velocity: $S_e = Q \cdot v$, with the friction coefficient Q as proportionality factor [1]. In recent years, many experiments have revealed, that for light ions and low projectile velocities the specific band structure of a target may lead to pronounced deviations from velocity proportional stopping [2,3].

This investigation focuses on the particular role of the d-electrons in the interplay between band-structure and electronic stopping. It has been shown for Au and Cu that the onset of the excitation of d-electrons may cause a significant increase in Q. This behavior leads to a pronounced kink in S_e at a certain projectile velocity. To gain a complete picture of the correlation between d-electrons and stopping power, materials with a different d-band configuration have been investigated, namely Ag and Pt. Ag is very similar to Au and Cu, except that the onset of the d-electrons is ~ 4 eV below E_F compared to ~ 2 eV for Au and Cu. Pt, on the contrary, features d-electrons with energies ranging from 8 eV below E_F up to E_F.

Experiments have been performed in backscattering geometry employing thin film targets. Electronic stopping has been deduced in two ways. First, at sufficiently high energy, electronic stopping was deduced from the width of the peak due to backscattering from the thin film, taking the influence of nuclear stopping and multiple scattering into account. The film thickness was determined quantitatively by RBS. Second, relative measurements were performed, relating the height of the backscattering spectrum to that of Au. In this case, no information on the film thickness was needed, but the absolute value of gold stopping was required instead.

Results are presented on electronic stopping of H and He ions in Ag and in Pt. To elucidate the role of the d-electrons, the present results are compared to the corresponding stopping values in gold. It is analyzed, to which extent surface impurities or the correction for nuclear stopping may introduce an uncertainty to the presented data.

References

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