Population of some excited states of projectile ions inside matter probed by zero-degree electron spectroscopy

Alex M Imai* [1], **M Sataka**†, **K. Kawatsura**‡, **K. Takahiro**‡, **K. Komaki**§, **H. Shibata**¶

* Department of Nuclear Engineering, Kyoto University, Nishikyo, Kyoto 615-8540, Japan,
† Tandem Accelerator Complex, University of Tsukuba, and Japan Atomic Energy Agency (JAEA)
‡ Department of Chemistry and Materials Technology, Kyoto Institute of Technology,
§ Atomic Physics Laboratory, RIKEN,
¶ Institute of Scientific and Industrial Research, Osaka University.

Synopsis Electrons emitted from high-Rydberg states ($n > 7$) of 2.0 MeV/u Si, S, Ar, and Ti ions through C-foil targets were observed at zero-degrees. Population of some excited-states of the projectile ions inside the foil, including their charge-states, were examined from these spectra as functions of initial charge state of the projectile ions and target thickness. Results are compared to these populations after foil exit.

As has been discussed in the previous ISIAC in Barcelona, in which the authors presented "quasi-equilibrium" in charge-state evolution of 2.0 MeV/u C and S ions after C-foil penetration [1], elucidation of the density effect is one of our ultimate goals. To mark another milestone to the study of the density effect, we have derived populations of some excited-states of penetrating ions inside carbon foils as a function of projectile initial charge-state and foil thickness utilizing the zero-degree electron spectroscopy [2]. We have measured electrons emitted from high-Rydberg states formed via penetration of 2.0 MeV/u Si, S, Ar, and Ti ions through C-foil targets of various thicknesses (0.9 – 20 μg/cm^2). Intense series of Coster-Kronig (C-K) peaks due to transitions of Be-like $1s^22p(^2P_{3/2,1/2})nl$ – $1s^22s(^2S_{1/2})\varepsilon l'$, B-like $1s^22s2p(^3P_{2,1,0})nl$ – $1s^22s^2(^1S_0)\varepsilon l'$, and so on have been clearly observed. Formation of the initial states for these C-K transitions are understood that the core states of the initial states, Li-like $1s^22p(^2P_{3/2,1/2})$ and Be-like $1s^22s2p(^3P_{2,1,0})$ states for the examples above, as well as electrons in the continuum states, accompanying the projectile ions at the same velocity of the ions, are formed inside the target as a result of successive collisions between the projectile ion and target atoms, and upon exiting the target, these core states capture one of these accompanying electrons to form the high Rydberg states, Be-like $1s^22p(^2P_{3/2,1/2})nl$ and B-like $1s^22s2p(^3P_{2,1,0})nl$ for the examples above, because of a sudden shake off in the ion potential from the screened Coulomb potential inside the foil to the pure Coulomb potential [3]. The intensity ratio of these C-K peaks can be, therefore, considered as a measure of the population of these excited states inside the target matter, including their charge-states. We already presented a part of the results for $Ar^{6+,13+,14+,15+}$ projectile ions in the ISIAC2005 in Rio de Janeiro [4], and extensive results for the other projectile ions will be presented and compared to these populations measured after foil exit [1].

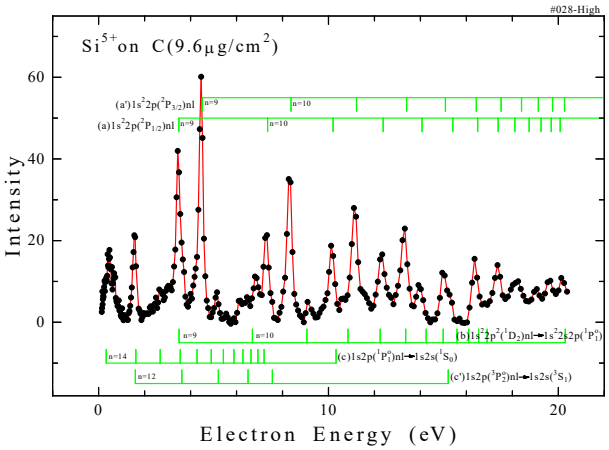

Figure 1. Electron energy spectrum emitted from $1s^22p(^2P_{2/3,1/2})nl$, $1s^22p^2(^1D_2)nl$, and $1s2p(^1P_1, ^3P_2)nl$ Rydberg states of Si^{5+} ions charge-stripped and excited through 9.6 μg/cm^2 C-foil, observed at zero-degrees. Energy refers to the projectile-rest frame.

References

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[1] E-mail: imai@nucleng.kyoto-u.ac.jp