4 - 24 Ionization of Ar^{11+} Ions during the Ion-surface Collisions

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X-ray emission analysis provides us an effective method to investigate the inner-shell process of ion-atom collisions. Near the Bohr velocity, the projectile, having enough kinetic energy, interacts with the target atoms at a close distance below the surface. Except for neutralization, it may be ionized. Not only the inner-shell ionization, but also the outer-shell may be multiple ionized. This results in the X-ray energy shift and the change of fluorescence yield[1−3]. Here, we would like to present the evolvement of the Ar^{11+} ions in collisions near the Bohr velocity.

Fig. 1 shows the Ar K-shell X-ray induced by 2.5 MeV Ar^{11+} ions impacting on V target. There are no 1s vacancies and 3d electrons for the projectile. The spectrum is not resulted from the metastable state decay, because the flying time of the projectile is larger than the lifetime of the metastable state. The present results indicated that the inner-shell excited atoms are formed by the combined action of ionization and side feeding.

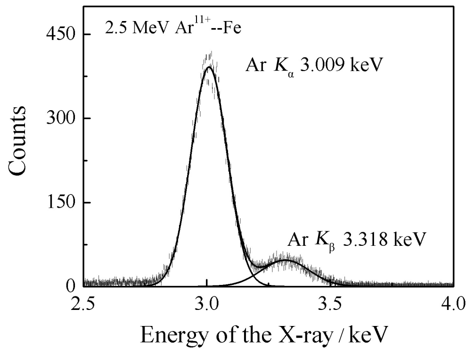

Fig. 1 Typical X-ray spectrum of argon for 2.5 MeV Ar^{11+} ions impacting on V target.

As listed in Table 1, compared to the atomic data, the observed X-ray has an average blue shift of 52 and 125 eV for K_α and K_β X-rays, respectively. That allow us to estimate that the 2p shell of the projectile consist of three vacancies. It is proposed that the ionization of 2p electrons also happen, in addition to the K-shell ionization. The three 2p vacancies are not the initial state of the projectile but the results of the balance of electron capture and ionization for the projectile Ar^{11+} ions.

Table 1 Ar K_α and K_β-ray energy shift, and relative intensity ratio of K_β to K_α X-ray for 1∼3 MeV Ar^{11+} ions interacting with a vanadium target.

E/MeV	$\Delta E(K_\alpha)$/eV	$\Delta E(K_\beta)$/eV	$I(K_\beta)/I(K_\alpha)$
1.0	53	125	0.165
1.5	54	125	0.167
2.0	51	124	0.166
2.5	52	126	0.165
3	50	125	0.169

Another effect of the multiple-ionization is the enhancement of K-M radiation transitions. The K-L radiation transition rate is reduced as the 2p electrons are directly responsible for the K_α emission. Additional, some Auger transitions are forbidden due to the absence of some 2p electrons. This leads to the enlargement of the intensity ratio of K_β to K_α X-ray, compared to the atomic data of 0.067.

References

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