

Double and single differential cross sections for secondary electron production in 6.0 MeV/u O^{8+} + H_2O collisions

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Synopsis We discuss double and single differential cross sections (DDCSs and SDCS) for secondary electron production (30-1000 eV and 20-160°) in collisions of 6.0 MeV/u O^{8+} ions with water vapor. All the DDCSs and SDCS were compared with previous experimental results obtained with 6.0 MeV/u C^{6+} ions. The DDCSs of O^{8+} ions showed nearly symmetric angular distributions around 90° in the energy range of 30-700 eV, which was quite consistent with those of C^{6+} ions, while the SDCS of O^{8+} ions showed about 1.7 times larger yield than that of C^{6+} ions, due to a greater ionizing power of high-Z projectile. Comparison with theoretical calculations using CDW-EIS is also presented at the conference.

Although secondary electron emission from water by ion impact has been of great interest in fields such as radiobiology and atomic physics, there is only a few data, particularly for heavy-ion impact with incident energies of several MeV/u or higher. Motivated by this situation, considerable effort has been devoted into this study since 1994. Our previous papers [1, 2] reported in detail on an apparatus for measuring secondary electrons from water vapor, along with the deduction of the experimental parameters. Absolute double and single differential cross sections (DDCSs and SDCS) obtained with He^{2+} ions were also discussed by comparing them with a simple Z^2 -scaling of the semi-empirical Rudd model. In this measurements, observation angle ranged from 20° to 160° for both 6.0 and 10.0 MeV/u He^{2+} ions, while electron energy from 7 eV to 10 keV for 6.0 MeV/u and from 20 eV to 10 keV for 10.0 MeV/u. Subsequently, the measurements with 6.0 MeV/u C^{6+} ions were made at electron energies of 10-400 eV. Theoretical investigations were also performed for them, showing meaningful and significant discrepancies [3, 4]. Then, the following modifications were mainly made; the cylindrical cooling cover (made of Cu) surrounding the interaction region was changed to that made of μ -metal in order to suppress the effects of stray magnetic fields, and collimators covered with thin graphite plates were installed immediately upstream the MCP in order to avoid the injection of scattered electrons produced within the spectrometer housing into the MCP. Such modifications allowed us to measure the DDCSs at electron energy down to

1 eV as well as up to 10 keV with sufficiently reduced background level. Recently, the measurements with 6.0 MeV/u C^{6+} and C^{4+} ions were made, and obtained DDCSs and SDCS with C^{6+} ions were compared with the continuum distorted wave-eikonal initial state model (CDW-EIS), showing good agreement with them, particularly in the low-energy region of 1-50 eV [5, 6].

In this conference, we discuss DDCSs and SDCS obtained with 6.0 MeV/u O^{8+} ions. The DDCSs of O^{8+} ions showed nearly symmetric angular distributions around 90° in the energy range of 30-700 eV as well as K-LL Auger peak of oxygen at ~500 eV for all angles, which were quite consistent with those of C^{6+} ions. The SDCS of O^{8+} ions, which was deduced from the measured DDCSs by integration with respect to the ejected angle, showed about 1.7 times larger yield than that of C^{6+} ions, due to a greater ionizing power of high-Z projectile. Comparison with both a simple Z^2 -scaling ($x8^2$) of the Rudd model and CDW-EIS will also be given at the conference. In the near future, experiments with Ne^{10+} ions will be carried out, after those with O^{8+} and O^{5+} ions. This work was partially supported by a Grant-in-Aid for Scientific Research Contract(C) no. 21540408 from the Ministry of Education, Science, Sports and Culture of Japan.

References

- [1] D Ohsawa *et al* 2005 *Nucl. Instr. Meth. B* **227** 431
- [2] D Ohsawa *et al* 2005 *Phys. Rev. A* **72** 062710
- [3] C Champion *et al* 2007 *Phys. Rev. A* **75** 32724
- [4] C D Cappello *et al* 2009 *Nucl. Instr. Meth. B* **267** 781
- [5] D Ohsawa *et al* 2012 *J. Phys. Conf. Ser.* **388** 102029
- [6] D Ohsawa *et al* *Phys. Scr. in press*

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