Experimental study of inverse photon efficiencies and level populations for atomic tungsten produced by plasma-wall interaction

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Tungsten (W) has been chosen as plasma-facing material in the ITER divertor. However, the W impurity which is produced by plasma-wall interaction can significantly influence the core plasma performance because of the strong radiative loss[1,2]. Therefore, accurate evaluation of the sputtered W atom flux into plasma is important to estimate the components lifetime and the W accumulation in core. Optical emission spectroscopy (OES) is one of the few available diagnostics that provides in situ access to the W sputtering flux, which is based on the application of empirical inverse photon efficiency ($S/XB$) on neutral W line emission to convert the line intensity into a particle flux[3,4]. Previous investigations indicate that $S/XB$ values depend not only on electron temperature and electron density, but also on W atomic level population[5]. However, data on photon efficiencies of W atomic lines (W I) are rare and there have been no studies investigating the statistical probability of sputtered W atomic energy-level population, due to the absence of available and quantitative atomic W sources for calibration purposes and suitable diagnostic methods for measurement of W I level population. Therefore, the influence of incident ion energy, electron temperature and electron density on $S/XB$, and the effect of W I level population on $S/XB$ will be systematically investigated by combination of cavity ring-down absorption spectroscopy and OES in this paper, which aim at quantitative study of W sputtering flux. The results will be able to improve our understanding of the relationship between particle flux and its line intensity, and resolve bottlenecks of measuring the sputtered W atomic energy-level population. This work will provide related database and experimental supports for plasma-wall interaction diagnose in tokamak.


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