Time-resolved monitoring of erosion and deposition using quartz crystal microbalance in EAST

Y. Zhang\textsuperscript{a,c,*}, J. Peng\textsuperscript{a,b}, R. Ding\textsuperscript{a}, S. Brezinsek\textsuperscript{b}, G. Sergienk\textsuperscript{b}, J. Chen\textsuperscript{b}

\textsuperscript{a}Institute of plasma physics, Chinese academy of sciences, 230031 Hefei, China
\textsuperscript{b}Forschungszentrum Jülich GmbH, Institut für Energie und Klimaforschung – Plasmaphysik, 52428 Jülich, Germany
\textsuperscript{c}University of Science and Technology of China, 230026 Hefei, China

E-mail: yuzhang@ipp.ac.cn

Erosion and deposition are one of the key issues in future fusion reactors, such as ITER. With the capability of time-resolved measurements of erosion and deposition amount with an ultra-high accuracy of angstrom in thickness, quartz crystal microbalances (QMBs) have been widely used for plasma-wall interaction studies in tokamaks [1-2]. A QMB diagnostic system has been installed in the mid-plane of EAST at a major radius of about 4900 mm. As the most significant factor affecting the accurate measurements of QMB systems, the effect of temperature on the frequency of QMB systems was tested prior to the exposure. It is revealed that the QMB system with an active cooling water can reliably work at the optimal temperature region.

With the aim of measuring material erosion rates by energetic particles, the crystal of the QMB was coated with a 100 nm Al film as a proxy for beryllium, which is used as the ITER first wall material. In the 2018 EAST experimental campaign, the QMB system was exposed to 849 discharges with total exposure duration of 6268s during 15 days. The total measured erosion and deposition amount are about 5.25 g/cm\textsuperscript{2} and 1.48 g/cm\textsuperscript{2}, achieving an average erosion rate of 0.6 ng/(cm\textsuperscript{2}s). The net erosion amount has been validated by the results of Rutherford backscattering as an independent post-mortem measurement. Among 849 discharges, 551 discharges end with disruptions. The net erosion amount is 2.14 g/cm\textsuperscript{2} in disruptive discharges, corresponding to an average erosion rate of 0.62 ng/(cm\textsuperscript{2}s). Disruptions cause surprisingly serious erosion, even up to a thickness of 0.19 g/cm\textsuperscript{2} during a discharge. As for 298 discharges without disruptions, the total erosion and deposition mass are 2.11 g/cm\textsuperscript{2} and 0.48 g/cm\textsuperscript{2}, obtaining an average erosion rate of 0.57 ng/(cm\textsuperscript{2}s). The measured erosion and deposition rates of the 298 discharges show complicate features. As the electron density increases, there is a lower possibility for the occurrence of high erosion and deposition rate, showing a “screen” effect of electron density on material erosion. The erosion and deposition rates don’t show obvious dependence on the total heating power and the plasma stored energy. The data provided by the He-BES diagnostic indicates that a higher density of neutral particles in the scrape-off layer is prone to lower erosion and deposition rates, showing a similar effect to that of the electron density. Different discharges with almost identical plasma parameters and plasma operation conditions have shown that drastic increasing of impurities (like W, Cu, C, Fe, etc) in the core plasma leads to higher impurities deposition and accordingly reduces the erosion effect.