In-situ thermal desorption spectroscopy of deuterium in tungsten in the scanning electron microscope

H. F. Song[1,2,*], L. CHENG[1,2], S. J. Hao[1,2], Y. Yuan[1,2], G. H. Lu[1,2]
[1]School of Physics, Beihang University, Beijing 100191, China
[2]Beijing Key Laboratory of Advanced Nuclear Materials and Physics, Beihang University, Beijing 100191, China

Understanding hydrogen isotopes retention and release in plasma-facing materials is essential for the development and safety assessment of future fusion reactors. In this study, we present an integrated experimental system that coupling a differentially pumped mass spectrometry module into a scanning electron microscope (SEM), enabling in-situ heating, real-time gas analysis, and simultaneous surface morphology observation of fusion-relevant materials.

To address the vacuum limitations of conventional SEM chambers, a differential pumping design was implemented. This allows the connection of a quadrupole mass spectrometer at 10^{-5} Pa to the SEM chamber at 10^{-4} Pa. The setup enables in-situ thermal desorption analysis of hydrogen isotopes and helium from irradiated materials—similar in function to traditional thermal desorption spectroscopy —while allowing concurrent SEM imaging of surface morphological changes.

We will show examples studying gas release behavior in tungsten samples irradiated by plasmas. During controlled heating up to 1200°C inside SEM, time-resolved mass spectra (1-100 amu) of released deuterium were acquired and correlated with surface morphology evolution. This dual-mode analysis provides direct evidence of the coupling between gas release dynamics and defect evolution on the material surface.

The developed setup offers a practical and efficient platform for investigating hydrogen-material interactions in plasma-exposed materials. By linking gas desorption with microstructural and surface morphology changes during thermal treatment, this system contributes to a comprehensive understanding of irradiation effects in candidate materials for fusion applications.

*Corresponding author: tel.: +86 18201183861, e-mail: shf2024@buaa.edu.cn (H. F. Song)