Design and preliminary test of the new linear plasma device with in-situ transient grating spectroscopy and X-ray diffraction at Beihang University

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Plasma-surface interaction (PSI) is a key process determining the safety and economics of a fusion reactors. Research activities rely on both large devices such as Tokamaks and laboratory devices, allowing testing under comprehensive and dedicated conditions, respectively.

At School of Physics, Beihang University, the linear plasma device laboratory has run a compact linear plasma device called STEP since 2014 for PSI research, which could deliver plasmas with a flux up to 10^{23} $m^{-2}s^{-1}$ using a disk LaB_6 cathode. An updated compact device of STEP called STEP II is under construction using all new components including magnets, vacuum chambers, pumps and a graphite-heated LaB_6, a preliminary test running helium plasma has been achieved in June, 2025.

The next generation of STEP is designed and constructed since 2023, with the aim to enable in-situ and real-time measurement of surface mechanical and thermal responses during high flux plasma exposures. The in-situ measurements include transient grating spectroscopy (TGS) and X-ray diffraction (XRD) techniques to measure surface acoustic wave velocity and X-ray diffraction on the surface during plasma irradiation, which yields the temporal evolution of the mechanical and thermal properties including Young's modulus, strain, and thermal diffusivity. The design of the device and preliminary tests of deuterium plasma, TGS and XRD will be presented.

The linear plasma device laboratory at Beihang University is about to run two new linear plasma devices mentioned above in late 2025, and now operating comprehensive characterizations of hydrogen and material microstructure including TDS, TOF-SIMS, XPS, FIB-SEM, HRTEM. And using the newly developed in-situ capabilities, the laboratory will contribute to the acceleration of the development of new materials for fusion applications, and the discovery of the time-dependent dynamics of plasma irradiation effects.

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