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High-temperature, liquid metal plasma-facing component research and development for the NSTX-U

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Liquid metal plasma-facing components are actively studied as a possible plasma-facing component (PFC) material in current and future fusion experiments. Liquid metals provide a self-healing material that has the potential to eliminate net erosion and damage due to local melting of the plasma-facing surfaces, and separate neutron damage from the plasma-induced damage at the surface. The high vapor pressure of liquid lithium further raises the possibility of intercepting significant plasma-based heat flux into a gaseous target when operating at an elevated temperature (T>500℃). With the innovative use of multiple, differentially pumped chambers, the condensation of lithium vapor can be exploited to separate high-neutral pressure regions from the plasma main-chamber. These benefits would solve several issues associated with the leading solid material, tungsten.

The NSTX-U team has developed a program for transitioning the machine from its current PFCs to surfaces that can provide a comparative assessment between the high-Z and low-Z, liquid approaches. The progressive steps include the implementation of high-Z divertor targets, pre-filled liquid metal targets as an interim study and finally, the implementation of an integrated, flowing liquid metal divertor target. Each of the three steps described above represent significant technological challenges. The practical realization of experiments with pre-filled targets and the development of porous substrates includes aspects such as the choice of porous substrate, methods of fabrication, and maintenance of the liquid and its chemical composition during and between experiments. Design of the NSTX-U high-Z divertor upgrade and laboratory testing of pre-filled targets will be presented.

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