Liquid metal plasma-material interaction science and component development toward integrated demonstration

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Liquid metal plasma facing components (PFCs) provide several key advantages over solid PFCs: immunity to thermo-mechanical stresses, elimination of dust, separation of plasma-facing material from a substrate material, and the possibility for new methods of power exhaust and operating regimes. To date a direct comparison of the benefits and costs of the liquid metal (LM) PFC approach vis a vis solid PFCs is hampered by the relative lack of study and deployment of LM PFCs in confinement systems operating with reactor-relevant conditions. We propose to advance the science of LM PFCs to the point where they can be confidently deployed in high-power confinement devices and inform on material and technological choices for next-step devices such as the FNSF/Pilot plant.

This talk covers one of three components ("thrusts") of an overall liquid metal PFC initiative that covers the plasma physics and component engineering required for deployment on confinement devices (see associated abstracts by R. Maingi and J.P. Allain). We identify key topics of research necessary to the deployment of LM PFCs and how a combination of linear and toroidal test-stands; high-power, short pulse; and long-pulse devices can address the advancement toward an FNSF. These research needs, as well as the particular needs of liquid metal handling technologies, motivate dedicated facilities capable of simulating divertor and first-wall conditions as well as addressing steady-state power exhaust, particle handling and liquid metal inventory control. The relative lack of invested resources in LM PFCs makes this research highly leveraged, with the ability of the US to provide international leadership for moderate investments.