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Advanced characterization of tungsten-steel multi materials for plasma facing components produced with additive manufacturing techniques.

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AM has a high potential to become one of the leading manufacturing methods in the nuclear industry, especially for complex components for fission and fusion reactors that are difficult to machine with conventional techniques and are not considered for mass production, but only in a limited number. Among proposed Plasma Facing Components (PFCs) materials in fusion reactors, tungsten (W) is the leading first-wall armor candidate to cover and shield the structural Reduced-Activation Ferritic-Martensitic (RAFM) steel structural components of the reactor core. However, joining two very dissimilar materials like steel and tungsten implies a number of challenges. Laser Powder Bed Fusion (LPBF) or Laser Directed Energy Deposition (L-DED) processes are envisioned to produce such parts, however, the properties of alloys produced with these techniques can strongly differ from those produced by conventional methods, which in turn can affect their performance in the context of nuclear applications. Therefore, it is crucial to understand the possible formation of minor crystalline phases, as well as the internal residual stresses in as-built components or columnar/anisotropic grain structures. Minor phases, such as retained austenite grains and intermetallic precipitates in the steel, as well as intermetallic phases at the W-steel interface affect the mechanical, corrosion and irradiation resistance and can act as nucleation sites for radiation damage.

We aim to gain fundamental understanding of the microstructure and morphology development in such materials produced using AM, with a focus on the interface between steel and tungsten. This is realized by using multimodal imaging of the produced samples. µXRD and µXRF microscopy performed at beamlines of SLS and DESY synchrotrons provided the insight into formation of the minor phases and chemical composition with spatial resolution. Neutron Bragg Edge Imaging performed at the POLDI instrument of SINQ neutron source allowed to get insight into texture and residual strains in the vicinity of the interface. Additionally, we are developing methodology for operando synchrotron and neutron studies of AM processes, which includes development of a new infrastructure for operando studies of laser-based AM. The results of the ex-situ advanced characterization, as well as the first results from the commissioning of the operando infrastructure will be presented.

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