IHPC's ''Digital Twin'' platform for additive manufacturing: seamless, multiscale high-fidelity forward-backward simulation of powder-bed fusion additive manufacturing

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Despite tremendous efforts in improving metal 3D printers' accuracy and reliability, mainstream insertion of powder-bed fusion additive manufacturing (PBF-AM) in industrial shopfloors is still limited by uncertainty and inconsistency in the PBF-AM process. Computer modeling and simulation is the natural answer to address such issues before printing, thus reducing the cost of trial-and-error. However, an exhaustive feature-rich, high-fidelity simulation of PBF-AM is extremely challenging, due to the tight coupling between different length scales (from part-scale to powder-scale) and time scales (from build time to scan vector time). By leveraging on IHPC's in-house capabilities, we have developed an integrated digital platform which combines a thermal simulation at the scale of the part, a discrete element method simulation of powder spreading, a ray-tracing simulation of laser-matter interaction, a powder-scale simulation of powder melting and solidification and microstructure evolution, two phase-field simulations of dendritic and precipitates formation, a crystal plasticity calculation for prediction of mechanical properties, and a part-scale simulation of residual stress and distortion, to provide a multiscale simulation platform for PBF-AM. Such rich set of capabilities were seamlessly integrated into a single, end-to-end platform tailored to the IN718 alloy and the EOS M290 printer, with more materials and printers in pipeline to be added. For model validation, a wide range of test coupons were printed and analyzed in terms of porosity, microstructure, and mechanical properties. Backed by the successful launch in Singapore early this year, in this talk we present our technology in Europe for the first time, with the intent to show that all the supply chain – from powder makers, to equipment makers, and end-users – can benefit from advanced simulation software for PBF-AM, thus further increasing its industrial adoption.