High throughput mechanical testing of additively-manufactured materials

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ABSTRACT:

Additive manufacturing (AM) processes have matured from research techniques to viable production routes for nuclear related applications. Numerous commercial companies produce AM tools suited for large scale industrial production leading to numerous AM technologies including ones specific to the nuclear industry. AM exists in different forms distinguishable by heat source (laser, vs. e-beam vs. arc), materials delivery systems (wire, direct deposition or powder bed) and materials. Each technique has different benefits and disadvantages leading to different product geometries or quality. Property gradients and variations can be a feature if desired, they can be a bug if they emerge as a function of shape and are unwanted. Therefore, a thorough understanding on the processing parameters and the resulting materials properties must be establish to either use property variations as advantage or avoid them if undesired.

It is the objective of this proposal to quantify the microstructure and mechanical properties from both full prints and targeted locations in additively-manufactured components, and compare the data obtained to the process data acquired during the in-situ monitored additive manufacturing process. These datasets will be used to build a database allowing for cross-comparison and statistical approaches for analysis and future machine learning methods. We aim to utilize a newly-developed rapid sample manufacturing and testing approach that increases the sample throughput significantly at relevant length scales. This will allow us to provide materials properties associated with the processing to build relevant and statistically-robust databases that will lead to robust models and prediction of component performance.

It is the aim of this proposal to characterize both the microstructure and mechanical properties of the AM print in a high throughput fashion and link these to in situ print data and parameters to ensure the produced component fulfills the required properties and quality control standards.

The proposing team unifies production of nuclear components and samples in commercial and experimental tools which allow to perform in-situ monitoring with leading experts in materials property and structure characterization. Novel laser based sample processing and automated mechanical testing techniques developed by the team will be deployed generating the wealth of data in a short timeframe guided by computational approaches