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High-Speed Terahertz Scanning System for Additively Manufactured Ceramic Materials and Composites for TCR Core Materials

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Collaborators: Oak Ridge National Laboratory (ORNL)

ABSTRACT:
Additive Manufacturing (AM) or 3D printing of materials encompasses a wide range of methods used in manufacturing where layers of materials are built up to produce a monolithic solid product at the end. AM continues to be developed for printing large parts for nuclear industry applications at AU. We propose to ***procure and install a custom-made high-speed terahertz (THz) dual scanner system that will demonstrate non-destructive imaging of AM ceramic materials and composites for TCR core application***. The system consists of a dual scanner with ~ 100 GHz and ~280 GHz sources that helps rapid screening and identification of inhomogeneities and defects in 3D-printed and consolidated materials and composites at various stages of the AM. The dual mode enables rapid screening of large areas of AM parts using ~100 GHz source followed by detailed screening of specific areas of interest using ~280 GHz source. Such a scanner system can easily be adapted as a high throughput characterization tool for AM nuclear fuel and materials. In addition, proposed capability has potential advantages of time and cost savings via defect minimization and elimination with an increase in human safety due to reduced human exposure in production of materials and components via AM. Our main objective is to ***establish high-speed THz scanner capability as a high-throughput characterization tool complementing AM capabilities in national laboratories that directly supports the missions of DOE's Nuclear Energy (NE) and Nuclear Energy University Program (NEUP)***. The proposed equipment will be primarily used to support users from DOE FFRDCs, NEUP, and nuclear industries. In addition, this equipment will also be used for education and research. Undergraduate and graduate research and exploration will use surrogate oxides and materials to test and optimize AM of nuclear fuels and materials. Specific ceramic materials of interest are SiC and YHx for TCR core materials. The equipment will particularly strengthen and ensure the success of the pre-application, RPA-21-24390 submitted in collaboration with Oak Ridge National Laboratory (ORNL) for support of NEUP. Early testing and demonstration of this capability will be completed using AM TCR core samples from ORNL, supporting development of thermophysical and mechanical properties-microstructure-processing correlations of these materials. Advanced material characterization tools at AU (e.g., scanning electron microscopy (SEM), wavelength dispersive spectrometry (WDS), electron backscatter diffraction (EBSD), and in operando Raman spectrometry) can provide additional data supporting the correlations. Expected major outcomes are proof-of-principle/concept results, support as a user-facility for all intended users, publications in peer-reviewed journals, and the training of engineers and scientists for nuclear industries. Professor S. K. Sundaram, the PI at AU, will lead the project and brings over 25 years of experience in advanced materials research focused on ceramics, glass, and AM for energy applications, specifically for nuclear waste, treatment, and sensing in national laboratory and academia. The proposed project is a procurement project with a duration of 12 months. The AU has received one quote for a customized scanner system from Terasense – Terahertz Imaging System at San Jose, CA with a price of $85,100. Once funded, a sole-source procurement process will be implemented. We are requesting $90,000 from the Department of Energy (DOE)'s Nuclear Energy University Program (NEUP) General Scientific Infrastructure (GSI) program for installation with a dedicated computer system.