U.S. Department of Energy

Additive Manufacturing of Advanced Ceramics for Nuclear Applications

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ABSTRACT: We propose to establish additive manufacturing (AM) of ceramic materials via., designing and printing of oxides, carbides, and nitrides for nuclear applications in Alfred University (AU). Such a technology has a potential of saving 20% or more of cost of the nuclear ceramics with increase in human safety due to less time and human exposure. The proposed equipment is a complete system (CeraFab 8500), which builds components using a patented process called Lithography-based Ceramic Manufacturing (LCM). This system will be coupled to extensive 3D printing capabilities at the AU. The AU also has extensive experience and expertise in cutting-edge research on ceramics, colloids/powder processing, sintering, and ceramic manufacturing. The proposed capability can be used for processing many different ceramic materials additively for a variety of applications relevant to nuclear industries e.g., single and mixed-oxide fuels and silicon carbide and carbon composites. Novel ceramic materials and components can be processed at higher throughput with minimal exposure to handlers and health risk. Overall the AM methods will also lead to significant cost reduction. Our main objective is to establish an AM capability that will directly support the missions of the DOE's Nuclear Energy (NE) as well as Nuclear Energy University Program (NEUP). The proposed system provides a 3D printing system that can produce high-performance ceramics and components. The system allows a parallel production of multiple components, meaning that different individual pieces can be produced at the same time, leading to more efficiency in production. In the LCM process, the printed component is pulled out of the vat during the printing process. The amount of used material is minimal and is equal to the volume of the printed layers. The material remaining in the vat is left for further use. Additional advantage of the proposed system is its cartridge system. The LCM process can run with a capacity of as small as 10 ml. Such a low material consumption results in a very low capital commitment for technology adaption. The proposed new capability will initially support two ongoing NEUP projects (one by the PI of this proposal on advanced ceramic waste forms and another by Dr. Nathan Mellot on glass waste form) and concluding this calendar year. In addition, this capability can be used for processing many different ceramic materials for structural and fuel applications relevant to nuclear energy and environment, e.g., mixed-oxide fuels, silicon carbide and carbon composites, boron carbide for shielding, ceramic encapsulation for accident-tolerant fuels, and nitride fuels and structural materials. Novel ceramic materials can be processed at higher throughput with minimal exposure to handlers and health risk. This capability will be a userfacility that will be open current and future NEUP PIs, other scholars, engineers, and other clients, including commercial nuclear power plants. Overall these manufacturing methods will also lead to significant cost reduction. The duration of the proposed project is 12 months. Prof. S. K. Sundaram, the PI at AU, will lead the project. The PI will track the cost and schedule and ensure the work is completed. Lithoz GmbH will be the sole-source provider as the equipment is highly customized for AM of ceramic materials. A total cost of the proposed equipment is $509,850. We are requesting $379,925 from the Department of Energy (DOE)'s Nuclear Energy University Program (NEUP) Infrastructure program. AU's Center for Advanced Ceramic Manufacturing Education (CACME) will match the remaining $129,925 of the total cost of the equipment.