

## NIST WORKSHOP

### Materials Research & Measurement Needs for Ceramics Additive Manufacturing

Location: National Institute of Standards and Technology, Gaithersburg MD 20899

Dates: **November 13-14, 2019**

After several decades of development, current global markets for additive manufacturing (AM) of polymers and metals have each reached an annual multibillion-dollar range, with these technologies showing every indication of becoming mainstream. By comparison, the market for ceramics AM is an order of magnitude smaller although most economic models predict a ten-fold growth over the next decade. This positive perspective is reflected in the steep growth in the number of research publications on ceramics AM over the last five years, their total number in 2018 being only a factor of four smaller than that for metal and alloy AM research. Additive technologies have been successfully commercialized for fabrication of ceramic parts and components in niche applications for industries ranging from aerospace and automotive to biomedical and dental. However, the efforts are fragmented – realistic, far-reaching, applications with the potential to drive AM technologies into the mainstream of ceramic manufacturing remain to be identified.

In this connection, some potential areas of development have been identified at a NIST-led Discussion Panel during the American Ceramic Society's ICACC19 meeting in Daytona Beach, FL. While AM of dense ceramic products appears to be a long-term challenge, the situation is different for green-body fabrication or for porous materials, where there is already a significant AM component that will become more important with better controlled processes and materials/processes characterization. Indeed, the three current major applications for ceramics AM identified during the Discussion Panel involve partially-dense parts. One is the application of porous-scaffold ceramics with customized complex shapes and gradient microstructure geometries for cutting-edge medical or dental implants. Another area is in components for energy generation and sustainability, such as SOFCs where anode, electrolyte and cathode are sequentially AM-built by changing the feedstock mix in the binder-jet or other AM process. Finally, a major AM ceramic application that already plays a major role, although not very visible due to the final product not being an AM ceramic, is the use of AM ceramic technology to produce molds and casting cores for non-ceramic components such as scaffolds for turbine blades of complex but highly tuned geometries.

With these points in mind, the goal of the NIST workshop is to bring together leading experts from early industrial adopters of ceramics AM, AM-equipment manufacturers, government agencies, as well as academia, to identify the most promising broad-impact applications of ceramics AM and the associated materials measurement needs which, if addressed, would accelerate the incorporation of AM methods into commercially viable ceramic manufacturing technologies. This 2-day all-invited meeting will critically review the opportunities and challenges for ceramics AM in key market sectors with discussions focused on formulating the materials research directions to bridge critical knowledge gaps that presently hinder the broader deployment of ceramics AM technologies. The program will also include discussions of the lessons learned from AM of metals & polymers, prospects for AM manufacturing of hybrid ceramic/metal and ceramic/polymer materials or gradient-microstructure ceramics. An emphasis will be on potential cross-cutting research efforts to address ceramics AM measurement needs across a range of application areas.

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