RX20-7

1. **Research Title:** Enabling Science and Technology for the Additive Manufacturing of Ultra High-Temperature Ceramics
2. **Individual Sponsor:**

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3. **Academic Area/Field and Education Level**
Chemistry, Materials Science and Engineering, Chemical Engineering, and related disciplines (working towards MS or PhD degrees)

4. **Objectives:** To advance state-of-the-art methodologies in the additive manufacturing (30 printing) of non-oxide ceramics for high-temperature structural applications through the development of innovative printing techniques, preceramic polymer chemistries, and post-print processing.

5. **Description:** Ultra High-Temperature Ceramics (UHTCs) can possess unique and attractive combinations of properties for extremely high temperature aerospace applications, including rocket exhaust nozzles, hot gas valves, and heat shields. Though the refractory nature of these carbide, nitride, and boride materials is advantageous for demanding applications, it also renders the materials difficult to fabricate in complex 3- dimensional shapes. Though advances in the additive manufacturing (AM) of ceramics have recently been attained (e.g., Eckel, et al., *Science,* 2015), such studies have largely focused on the production of materials that operate at intermediate temperatures (i.e., SiOC). Ultimately, we seek to develop both the knowledge and methodologies required to prepare complex-shaped UHTCs via AM processes (e.g., stereo lithography (SLA), fused deposition modeling, or selective laser sintering (SLS)). For example, the printing of UHTCs by SLA will require the synthesis of organometallic polymers that are i) photopolymerizable and ii) may be converted, via heat treatment, into structural carbide, nitride, or boride materials. The synthesis of such pre-ceramic polymers should be highly controlled to yield macromolecules of specified chemistry and architecture. These polymers should be capable of being patterned with high fidelity in SLA processes and yield stoichiometric ceramic materials of after pyrolysis. Precise synthesis and characterization methods will be utilized to facilitate the elucidation of structure/property relationships of the polymer and its corresponding ceramic (after pyrolysis). Studies in the production of UHTC components by SLS and related methods

(using controlled chemistry powders) will require design-of-experiments methodologies to build process maps that lead to the identification of conditions that yield dense ceramic monoliths or coatings with optimized microstructures and properties.

6. **Research Classification/Restrictions:** Unclassified research. Eligible for public release.

7. **Eligible Research Institutions:** Indicate to what organizations this topic should be provided

DAGSI (Wright State University, AFIT, Ohio State University, University of Dayton, Miami University, Ohio University, and University of Cincinnati)
NOTE: Topics submitted to DAGSI must be approved for public release.
Need PA Approval#
AFIT (only)

USAFA (only)
If you are submitting a topic for the USAFA, indicate if you are also interested in sponsoring a USAF Cadet in summer 2015 (Average cost for USAF Cadet for 33 days is $5000)

D Yes D No