1. Research Title: Development of a Mathematical Model for Fusion of Extruded Thermoset Resin Tracks

2. Individual Sponsor:

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3. Academic Area / Field and Education Level: Materials Science and Engineering, Chemical Engineering, Chemistry, or Physics (MS or Ph.D. level)

4. Objectives: develop a theoretical or semi-empirical mathematical model for predicting the fusion of sequentially deposited tracks of uncured thermoset resin. The main focus here is modeling how 3D-printed "lines" or tracks of thermoset resin fuse together to form a solid, self-supporting structure in the vitrified state with acceptable dimensional tolerance. These are created in 3D printing machines involving a movable syringe head that deposits viscous liquid monomers, oligomers, or filled resins onto a solid substrate. The 3D structure is oven cured to provide the final article. Ultimately this information will be used to help understand the process phenomena to optimize the final materials.

5. Description: This topic will support current efforts in AFRL to develop additive manufacturing processes for thermosetting polymers. There are several commercially available machines for producing thermoplastic polymers structures, as well as UV-cured epoxy, but none suitable for producing articles from aerospace grade thermoset resins. These resins generally have better mechanical strength, creep resistance, and high temperature stability that thermoplastic polymers and UV-cured epoxy. The on-going research goal is to develop a fundamental understanding of the complex simultaneous phenomena that take place in the layered deposition of thermoset monomers, such as: fluid flow/rheology, heat transfer, curing, gelation and vitrification, shrinkage, and residual stress. This information can eventually be incorporated into a process model that will help users to understand how the process can be controlled in real time so that the final object reaches a uniform degree of cure with maximum interlayer adhesion and minimum differential cure shrinkage.

6. Research Classifications/Restrictions: Unclassified, but requires student to be a U.S. Citizen in order to perform experiments within the Materials and Manufacturing Directorate

7. Eligible Research Institutions:

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