AFRL RESEARCH TOPIC CALL FOR FY13

1. **Research Title:** Adaptive Origami: Patterning Mechanically Responsive Substrates for Sequential Fold-Unfold Processes

2. **Individual Sponsor:**

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3. **Academic Area/Field and Education Level:** Materials Science and Engineering, Chemical Engineering, Mechanical Engineering, Additive Manufacturing. (MS or Ph.D. level)

4. **Objectives:** Research and develop print technologies to pattern features on mechanically responsive substrates that will provide localized transduction of light or current to thermal energy so as to control location and rate of substrate recovery. This will include: (a) development of inks that are compatible with adaptive manufacturing techniques as well as result in sufficient electrical conductivity or absorptivity; (b) control routines to automate printing of arbitrary patterns with high precision and reproducibility; and (c) correlate key recovery characteristics of the substrates with input power and properties of printed features, including the rate and ability to precisely define recovered structure and folds.

5. **Description:** Origami is the art of folding an uncut sheet of paper into interesting and beautiful shapes. It has traditionally been used to create a wide variety of artistic structures, but more recently, it has garnered the interest of mathematicians, scientists, and engineers due to the potential to make unique structures that can 'fold up' or 'flatten out'. Recently it has extended beyond a hobby to providing useful engineering solutions, impacting technologies from packaging and shipping of commodities, to creating deployable airfoils. For the DoD, the ability to create complex multifunctional materials from a simple 2-D sheet is very attractive. The reversible nature of an active folding process suggests numerous applications including energy harvesting/absorbable systems, expandable stents, air bags, expandable shelters, heat exchangers, reconfigurable ISR, packaging for logistics and supply, and precision drop via deployment of control surfaces. For all of these applications, however, one must first develop and understand the fundamental materials systems and strategies that will be used to create such multifunctional designs. Numerous mechanically adaptive materials, including shape memory polymers and photomechanical resins, are available; however their integration into an origami-like technology has not been assessed. The goals of this research project will be to assess these mechanically responsive materials for folding and unfolding of flat sheets using triggering patterns that are printed. Key questions to be addressed include (1) what are the relationships between the properties of the printed features, triggering motif and the limits to precision and accuracy in creating the folded structures; (2) what are the figures of merit for the feature and substrate that are necessary to minimize strain gradients surrounding the neutral plane during folding; and (3) what are the relationships between the printing technologies and ink properties to achieve the performance and precision of the printed features, as constrained by the above considerations?

6. **Research Classification/Restrictions:** This research has no ITAR restrictions.

7. **Eligible Research Institutions:** Place an X in all that apply.
   X Universities (DAGSI) ☐ AFIT (only) ☐ USAFA

8. **Interest in Summer USAFA Cadet: No**