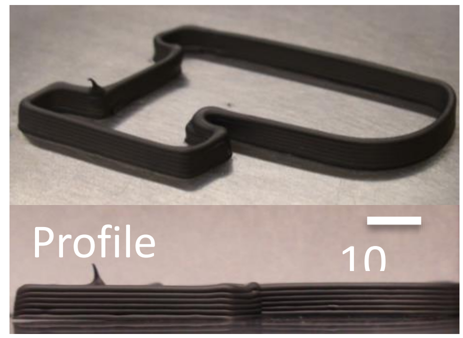
Additive Manufacturing of Transparent Alumina Using Shear Flow Through a Capillary
Army Research Office Apprenticeship Program

PIs: Profs. Rod Trice, Ph.D., Jeff Youngblood, Ph.D., Purdue University, School of Materials Eng.

Transparent ceramics are an essential part of military applications, providing enhanced protection versus ballistic threats for windows. These materials can be made from polycrystalline ceramics such as Y_2O_3, ALON, $MgAl_2O_4$, $Y_3Al_5O_{12}$, and α-Al_2O_3. Over the past 10 years, Profs. Youngblood and Trice have developed a processing technology that affords the fabrication of intricate parts made of ceramics to include alumina, silicon nitride, zirconium diboride, and boron carbide. The strategy has been to prepare highly-loaded (>50 vol.%) aqueous ceramic suspensions, all of which are flowable at room temperature. Profs. Youngblood and Trice have investigated additive manufacturing of ceramics for the past 4 years, publishing one of the first papers on 3D printing of boron carbide, and on equiaxed alumina (non-platelet forms). The image shows a part manufactured using 3D printing of boron carbide. After 10 years of research in the preparation of highly-loaded aqueous ceramic suspensions, we feel uniquely qualified to take on a new challenge, mainly using the type of shear flow that occurs when our suspensions are moved through a nozzle (e.g. a capillary) to align platelets of alumina. Our goal will be to use these stresses to form rectangular billets of aligned platelet forms of alumina by additive manufacturing to improve transparency. The Army Research Office has recently funded a summer research program for and undergraduate student (URAP) and a high school student (HSAP). *We are looking for one undergraduate and one high school student to work with us this summer.*



<u>URAP Student</u>: We envision the undergraduate research apprentice working on the development of flowable suspensions with platelet forms of alumina. The important research question is the following, “How will the shape of the alumina affect the flow characteristics of the suspension?” We anticipate the important variables to include: powder loading, dispersant amount, and amount of polymer binder (polyvinyl pyrolidone or PVP) added. Systematic experiments will be conducted by adjusting the amount of each of these components of our system, with rheology measurements made on each system.

<u>HSAP Student</u>: We envision the high school apprentice being involved with the URAP student by evaluating his/her platelet alumina suspensions for 3D printing. The important research question the HSAP student will address is the following, “How does the flow characteristics of the platelet alumina suspensions affect the alignment of the final 3d printed sample?” We envision using our new Hyrel 3D printer (system 30M) to form 50 mm by 50 mm square billets, using the syringe writer to extrude our platelet alumina loaded suspensions in parallel lines, building up the thickness to approximately 4 mm. Assessments of alignment will be made using XRD, and scanning electron microscopy. The HSAP student will work closely with the URAP student to coordinate research activities. Both the URAP and HSAP students will work with two graduate students (Willy Costakis and Andrew Schlup) in the lab.

<u>Application</u>: Students must have a GPA above a 3.0 and one letter of recommendation, which will be weighted heavily in the decision making process. A video conference with the applicants will also be part of the decision making process. Send your resume and have your letter writer send a recommendation to rtrice@purdue.edu by March 30th. Decisions will be made in early April. The stipend for the HSAP is $3000 paid over 11 weeks, and $4500 (plus $600 housing allowance) for the URAP student paid over 11 weeks. It is expected that the research will be conducted from mid-May through early August, but this is somewhat flexible.