I/UCRC Executive Summary - Project Synopsis	**Date**: **June 21, 2017**

Center/Site: Center for Freeform Optics (**CeFO**) / UNC Charlotte & UofR
Title: Fundamentals of material removal in silicon carbide for freeform optics

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Project Leader(s): Matt Davies (UNC Charlotte)
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Type: Completed – Year 3 of 3

Proposed Budget/YR3: **$63,429**
3-year budget estimate: $191,197

Project Description: This three-year project, a collaboration between UNC Charlotte and University of Rochester, will develop the fundamental knowledge within CeFO to enable grinding of silicon carbide freeform optics. This is a fundamental study that dovetails with other CeFO projects aimed at producing freeform imager designs and optical devices (CeFO-1, CeFO-12, ENH) using metal optics; *this project is the fundamental cornerstone enabling the translation of these designs to SiC.* The literature on silicon carbide grinding is vast but comparative studies that examine the response of different grades of SiC to different types of grinding tools are lacking. SiC freeform optics with high surface integrity will likely be produced by grinding the freeform shape into the base material, coating with CVD SiC, and finish grinding and polishing to final form. However, the grain size of the silicon carbide grade, the type of grinding wheel, the diamond grit size in the grinding wheel and machining parameters affect the surface/subsurface integrity of the final optical surface. This project focuses on commercial grades of SiC of variable crystal size including: (1) direct sintered SiC (3 μm to 10 μm crystal size); (2) reaction bonded SiC (12 μm crystal size); (3) CVD SiC (5 μm crystal size) and (4) CVC SiC. Resin bonded and metal bonded diamond wheels with variable grain size are being investigated. Machining parameters were varied across a wide range. Surface finish is being measured using scanning white light interferometery. MRF dimples are being polished onto the ground surface and surface roughness at the base of the dimples as a function of depth were correlated with SSD. In year 1, of this project, UNC Charlotte conducted grinding tests in these materials while studying grinding mechanics in an SEM. Surface finish and SSD were correlated with the measured grinding mechanics, the material grade, the wheel type and grain size. In year 2, optimal parameters are being be used to machine spherical test optics and measurements of surface and subsurface integrity and form metrology will be made. Finally, in year 3, work will culminate in the production of a SiC freeform demonstrator optic for an imaging application in concert with other CeFO projects (ENH).

Experimental plan: (1) Identify and obtain materials and tools; characterize microstructure; (2) choose parameters; (3) conduct machining experiments and measure and analyze forces; (4) conduct measurements of surface and subsurface integrity; (5) cut test spheres and measure; (6) test freeform.

Related work elsewhere: The work on SiC grinding is vast. Most relevant to this work are Shafrir et al. (2007); Xie et al. (2015); Tohme (2007); Zhong (1994) and Rausch (2014).

How this project is different: This project studies the effect of SiC crystal size/grade on machining performance, surface finish and SSD. It is targeted at large SiC freeform optics.

Milestones for the planned year: (1) Parameter/material/tool identification for test spheres; (2) Machining of test spheres; (3) Measurement of surface finish and SSD in test spheres; (4) Correlation of parameters and tool configuration to surface and subsurface damage.

Deliverables for the planned year: (1) Ground SiC test spheres; (2) Parameter development and linkage of parameters and tool configurations to surface/sub-surface integrity; (3) Publication.

How the project may be transformative and/or benefit society: SiC freeform optics are important for space based surveillance and telescopes. The size and weight of a SiC imager may be an order of magnitude less than a conventional spherical system.

Research areas of expertise needed for project success: (1) Manufacturing/metrology (Evans/A Davies/Ellis/Fienup); (2) Mechanics & materials science (Lambropoulos); (3) Design (Rolland/Suleski).

Potential Member Company Benefits: This project provides expertise in SiC grinding relevant to miniaturized, high-strength, low-weight imaging systems.

Start Date: January 1, 2016	**Estimated Knowledge Transfer Date**: continuously through the CeFO website and webinars, and semiannual CeFO meetings.