MATERIALS ENGINEERING

SEMINAR

"Developing Mechanically Robust Transparent Alumina for Infrared Windows"

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ABSTRACT

Aluminium oxide, or alumina, has the potential to replace sapphire (single-crystal alumina) for its uses in optoelectronic and thermal applications for its improved flexural strength and corrosion resistance. However, substantial limiting factors of alumina include porosity and birefringent scattering, inherent to its polycrystalline nature. The goal of this research has been to reduce the grain size to minimize the effects of birefringence as well as improve mechanical strength. Early testing of Purdue's Ronaflair™ alumina powder included washing in 15 Ω-cm high-purity de-ionized water, ball-milling for up to 12 hours, centrifuging and decanting and sieving large batches of powder for testing. Purdue also explored several sintering profiles optimized over multiple years (with landmark contributions by Dr. Andrew Schlup), as well as developed novel sintering profiles in order to determine the effects on microstructure. These sintering profiles include a control (or "Standard") sintering run of an isothermal hold of 5 hours at 1800˚C, With a ramp rate from room temperature at 25˚C/min. Newly developed profiles include a "Long" and "Two-Step" profile, that hold instead for 10 hours at 1700˚C, with the Two-Step having an initial hold for 15 minutes at 1800˚C. Preliminary grain size results indicated that sintering at lower temperatures for longer isothermal holds had a significant effect on the microstructure, in that average grain sizes were reduced from an average of 28 µm for a "Standard" profile to 15 µm for a "Long" profile. Earlier this year, Purdue made novel discoveries as to the thermal shock behavior of its polycrystalline alumina samples, which appeared to withstand a high degree of thermal stress during ablation testing, as opposed to commercially available equiaxed alumina. Through testing, Purdue has concluded its in-house "Long" alumina exhibits the most favorable ablation profile with minimal post-ablation transparency lost but will continue testing. Purdue has successfully made and reproduced large 55 mm samples using a pre-existing larger graphite die. Purdue has recently completed mechanical testing of alumina bend bars, following the 1161a standard, showcasing a promising Weibull modulus while achieving high theoretical density and small grain sizes. Purdue additionally plans to further test its high-quality alumina samples on the impact of grain size on mechanical strength.

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