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A High-Performance Optical Challenger

Rad-hard silicon-carbide mirrors offer alternative to toxic beryllium.

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A small Hawaii-based company wants to give the beryllium optics market a run for its money with innovative, high-performance silicon-carbide mirrors originally designed for MDA.

Trex Advanced Materials (Lihue, HI), a division of Trex Enterprises Corporation, manufactures silicon-carbide mirrors using chemically grown materials that have higher optical performance and thermal stability than beryllium. These silicon-carbide mirrors, in contrast to beryllium, meet the military's radiation-hardened requirements for space-based surveillance optics, and they are manufactured in a nontoxic environment. Beyond missile defense, Trex's mirrors could find a home in products used in chemical-corrosive environments, cryo-applications, and the high-energy laser market.

MDA funded Trex through three SBIR Phase II contracts to design lightweight, thermally stable, rad-hard mirrors that could be used as seeker optics on space-based, missile-interceptor weaponry. After successfully completing the contracts, MDA further awarded Trex an IDIQ (indefinite delivery/indefinite quantity) contract for silicon-carbide mirrors. Most recently, the agency awarded Trex a new SBIR Phase I contract to focus its silicon-carbide material on divert and attitude control system components, given the material's demonstrated performance in high-temperature environments.

Trex manufactures the mirrors using a patented material known as CVC SiC™, or Chemical Vapor Composite Silicon Carbide. To make CVC SiC, Trex engineers insert silicon-carbide seed particles into a gas stream as the optical material is chemically grown. The seeds act as stress relievers for the highly pure silicon-carbide optical material. Without the silicon-carbide stress relief, an excessively stressed columnar grain structure would form during chemical growth, making the material difficult to handle, manufacture, and polish. The silicon-carbide seeds enable the formation of an equiaxial grain structure in which the optical material can be grown five times faster than without the additive.

The chemically grown structure of the material also provides strength benefits, with silicon carbide providing a specific stiffness—defined as material strength per unit of weight—that rivals beryllium. Due to the inherent strength of the product, CVC SiC mirrors are lightweight, requiring only one-sixth the amount of material that would be needed when using competing glass optical materials.

▲ Workers display a silicon-carbide "face sheet" used in the production of large, industrial mirrors made by Trex Advanced Materials.

The material can be grown into complex geometries, at thicknesses from 0.02 inches to 2 inches. And the size of the mirrors can be scaled to demand, from 0.5 inches to 50 inches in diameter.

Another advantage silicon-carbide mirrors provide is radiation hardness. Successfully tested to be radiation-resistant, the optics meet the rad-hard requirements for space-based military equipment such as kill vehicles, something beryllium cannot do.

Silicon carbide also has a high thermal tolerance that makes these optical materials useful in the commercial high-energy laser market. Beyond these markets, Trex plans to look at the possibility of selling its mirrors to manufacturers that need such optics for cryo-applications and for products used in chemical-corrosive environments.

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Manufacturing silicon-carbide mirrors also has an environmental and health advantage over the beryllium competition: The product is not toxic. Beryllium particles are a known inhalation hazard, and rigid environmental controls must be put in place for the safety of employees working around the material. "With silicon carbide, you don't have that issue at all," said Dave Kane, Trex Advanced Materials vice president. "You can just walk though a silicon-carbide machine shop or polishing house and not even put a mask over your nose. It's an inert material."

Despite Trex's successful development of lightweight, silicon-carbide mirrors, the company still faces a few challenges, namely supply-chain management and cost increases due to a highly energy-consumptive process. The company is now in the process of transforming itself from what was an R&D company to a full-fledged production company.

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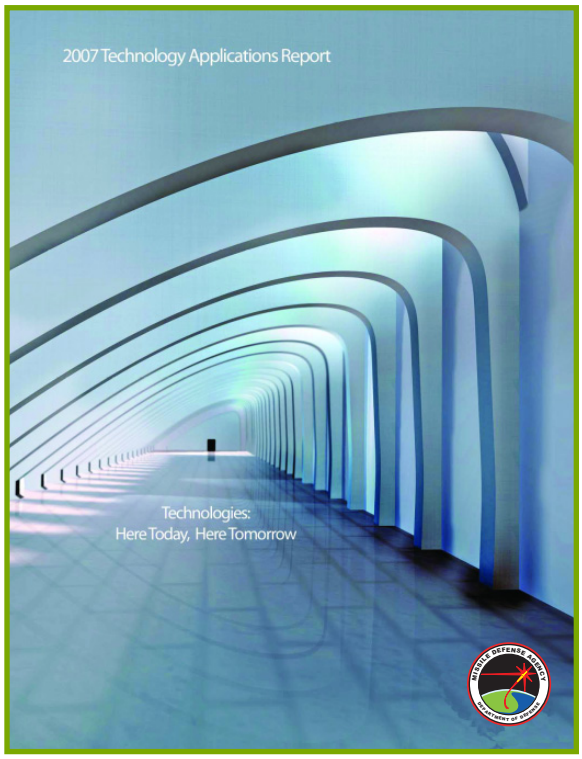

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