

An example of Air Force supported SBIR/STTR technology that has been transitioned into an Air Force or other DoD system or subsystem or used by Air Force test ranges and facilities or maintenance depots.

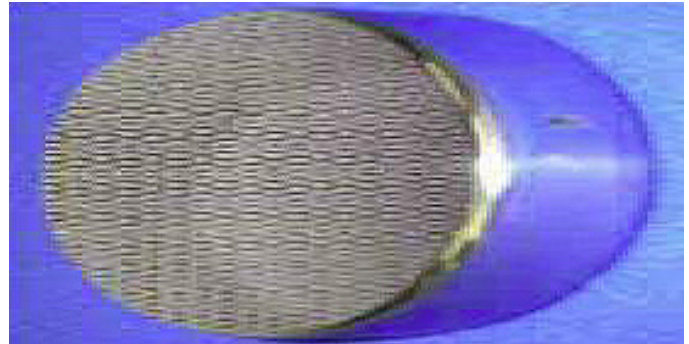
**SBIR Topic Number:**  
AF04-008

**SBIR Title:**  
Lightweight Optics  
for High Energy  
Applications

**Contract Number:**  
FA9451-05-C-0018

**SBIR Company Name:**  
Schafer Corporation  
Chelmsford, MA

**Technical Project Office:**  
AFRL Directed Energy  
Directorate, Kirtland  
AFB, NM



Left: Silicon Lightweight Mirror Systems (SLMS™) Primary Mirror.

Right: Silicon Carbide SiC-SLMS™ High Energy Laser Fast Steering Mirror.

## Lightweight Optics for High Energy Applications

- The Air Force needs high stiffness, lightweight, and low cost technologies for beam control of tactical airborne and relay mirror high-energy laser systems
- In this SBIR project, Schafer Corporation used its proven Silicon Lightweight Mirror Systems (SLMS™) technology to design and manufacture a prototype mirror in the configuration and form factor of a beam director primary mirror (PM)
- Later, in Phase II, a SBIR enhancement modification was added to the baseline contract to apply the silicon carbide SiC-SLMS™ technology toward developing a fast steering mirror (FSM) instrument funded by the DoD Office of Force Transformation
- A coated FSM mirror set that met program requirements was delivered, and this technology could have future applications in a number of space-based and high-altitude relay mirror systems and terrestrial high-energy laser systems

Commercialization Pilot  
Program Series

RD08-747

**A**

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## Air Force Requirement

Conventional lightweight optics have not demonstrated performance under high laser-fluence levels. The Air Force needs high stiffness, lightweight, and low cost technologies for beam control of tactical airborne and relay mirror high-energy laser systems.

## SBIR Technology

The initial objective of this SBIR program was for the Schafer Corporation to use its proven Silicon Lightweight Mirror Systems (SLMS™) technology to design and manufacture a prototype mirror in the configuration and form factor of a beam director primary mirror (PM). The baseline material of construction of the PM for the target application was Zerodur® low expansion glass-ceramic. A Cestic® mirror-mount/manifold assembly with a coefficient of thermal expansion (CTE) matched to the SLMS™ was successfully produced. The mount/manifold allowed relevant environmental testing to simulate low-, high-altitude, or even vacuum environments. The SLMS™/Cestic® assembly weighs nearly half the weight of the Zerodur® classical double-arch design PM, and has a first fundamental frequency almost 10-times higher than the Zerodur® design. Schafer successfully produced a 50 cm clear aperture, F/1.0 parabolic SLMS™ mirror substrate, not once, but twice.

The dramatic improvement in weight and stiffness of the SLMS™ PM led the AFRL Directed Energy Directorate to the conclusion that SLMS™ technology could be useful in other parts of a high-energy laser beam control system, particularly for fast steering mirror (FSM) instruments, and especially if Schafer's silicon carbide SiC-SLMS™ foam core mirror technology were used. Consequently, a SBIR enhancement modification was added to the baseline contract and addressed applying the SiC-SLMS™ technology as the mirror in a FSM instrument that is being developed by AFRL under funding from the Department of Defense (DoD) Office of Force Transformation. A coated FSM mirror set that met program requirements was delivered in less than six months.

## Transition Impact

The SLMS™ technology demonstrated in this project is directly applicable to many current needs of the Air Force, including beam expanders for tactical airborne applications, telescopes which have an athermal requirement at geosynchronous orbit (GEO), for telescopes which have an athermal requirement at cryogenic temperatures, for the beam walk mirrors and fast

steering mirrors of space-based and high-altitude relay mirror systems and terrestrial high-energy laser systems, and for Light Detection and Ranging (LIDAR) and Laser Detection and Ranging (LADAR) telescopes for remote sensing applications. Such systems include, but are not limited to, the Tactical Relay Mirror System (TRMS), Aerospace Relay Mirror System (ARMS), Airborne Laser (ABL), Advanced Tactical Laser (ATL), and High Energy Laser Technology Demonstrator (HELTD).

The FSM mirror is a substantially more difficult and refined application of SLMS™ technology for at least two reasons.

- The diameter of the FSM is only 5 inches. Thus, the incident laser intensity that the mirror is exposed to is more than an order-of-magnitude greater than is seen on a beam director primary mirror.
- The mirror is operated at a bandwidth up to 1000 Hz and must be perfectly balanced about the center of gravity to avoid any resonances that would preclude beam cleanup over the prescribed closed-loop bandwidth. Thus, there are superposed thermal and dynamic loads that can dramatically impact the wavefront error of the instrument.

## Company Impact

This SBIR project enabled Schafer Corporation to develop a further application of its proven SLMS™ technology line. SLMS™ technology will significantly impact and benefit a very broad set of future missions for DoD (e.g., directed energy, communications, imaging) and has applications for other government and commercial industry customers as well.

Schafer Corporation, formed in 1972, is a leading-edge technology company providing high quality products and professional services to government and industry. Schafer provides research, development, test and evaluation, modeling and analysis of 21st Century technology applications in the growing markets of laboratory analytical services, biotechnology, energy, environment, defense, space, and wireless services through consulting contracts.



# SBIR/STTR

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