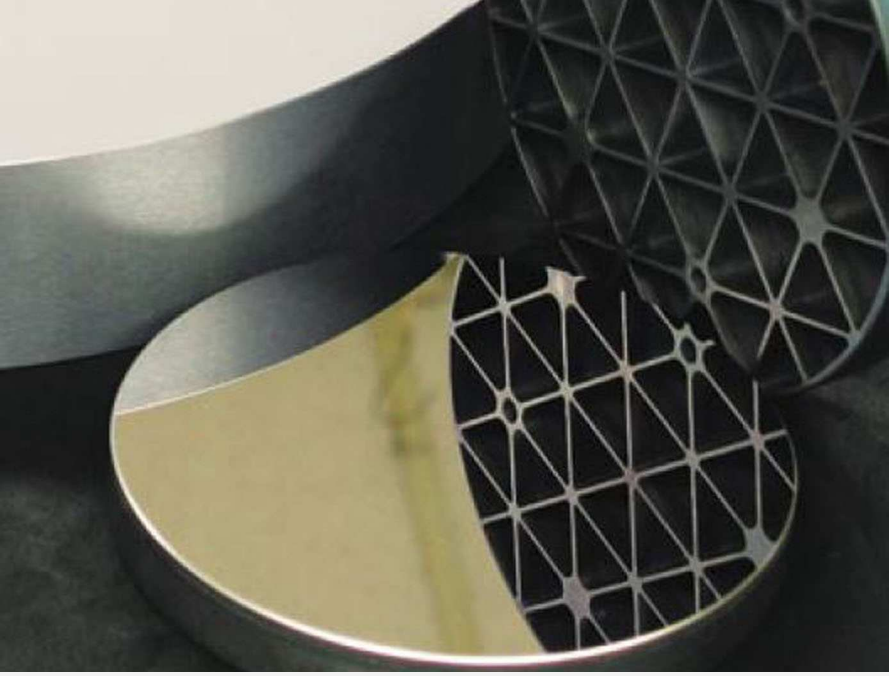

National Aeronautics and Space Administration

Optics

A Process for Producing High-Quality Lightweight Mirrors

A process using single-crystal silicon

NASA Goddard Space Flight Center invites companies to license its innovative process that helps significantly reduce the risk, time, and costs associated with producing lightweight mirrors for demanding instrument applications. The method employs a solid disc of single-crystal silicon (SCS) and calls for most of the polishing to be completed before lightweighting. Due to the extraordinary homogeneity of SCS, the distortion caused by traditional lightweighting processes is significantly reduced.

BENEFITS

- Robust: In Goddards process, the SCS disc is polished before any lightweighting is done, eliminating the possibility of print-through
- Thin: The face sheet of the optic can be very thin because it does not need to withstand mechanical polishing after the optic has been lightweighted
- Cryogenic-tolerant: SCS mirrors exhibit very little or no distortion when cooled to cryogenic temperatures
- High-quality: SCS hardness and homogeneity allows mirrors of exceptional optical quality to be made using conventional polishing techniques
- Cost-effective: Silicon can be polished directly for visible and ultraviolet applications. This eliminates the need for a cladding layer, simplifying fabrication and reducing costs

technology solution

THE TECHNOLOGY

Each mirror is a monolithic structure consisting of a face sheet with a highly polished front optical surface. In Goddards process for making these mirrors, the optical surface is formed in a solid SCS blank either by conventional grinding and polishing or by diamond turning. The blank is then lightweighted using Computer Numerical Control (CNC) grinding. For critical applications, post-lightweighting polishing can be performed to further improve the optical surface. Due to the very small amount of material removed during this step, it produces no quilting or print-through of the lightweight support structure. At several points during the process, the mirror is heated to near its melting point to remove small crystalline defects caused by the fabrication process.

Each resulting SCS mirror features a homogeneous composition free of internal stress. These parameters inhibit distortion when cooling the mirror to cryogenic temperatures. Under such conditions, the mirrors maintain their optical figure to 1/50th wave root mean square (RMS) or better. At room temperature, SCS has a thermal conductivity about the same as aluminum and a thermal coefficient of expansion about equal to Pyrex glass. So SCS mirrors are extremely resistant to thermal shock and ideal for applications where high heat dissipation is required.

Virtually all conventional lightweight mirrors are made by optically grinding and polishing an already lightweighted blank. Mirrors made this way always risk print-through to the optical surface. In some cases this can be removed by a zero-pressure process, such as ion-beam polishing, although these processes tend to be slow and costly. Lightweighting after optical polishing is not an option for conventional materials as their inhomogeneous qualities and internal stresses cause the lightweighting to distort the optical surface. By contrast, in Goddards process for SCS mirrors, optical grinding and polishing is done before lightweighting, eliminating the possibility of print-through. This is due to the extreme homogeneity and absence of stress possible in a monolithic structure from a single crystal. This results in a simple and cost-effective process that is capable of producing mirrors of exceptional quality.

APPLICATIONS

The technology has several potential applications:

- Goddards technology is ideal for use in environments in which cryogenic operation or high heat dissipation is required. SCS lightweight mirrors typically weigh about one-fourth that of a solid quartz blank of the same size, making them useful for a variety of instruments where weight is a concern
- The SCS technology provides a cost effective solution for applications including space-based imaging systems, military reconnaissance, satellite and unmanned aerial vehicles (UAVs), and fast-scanning or -steering mirrors

PUBLICATIONS

Patent No: 9075188

More Information

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