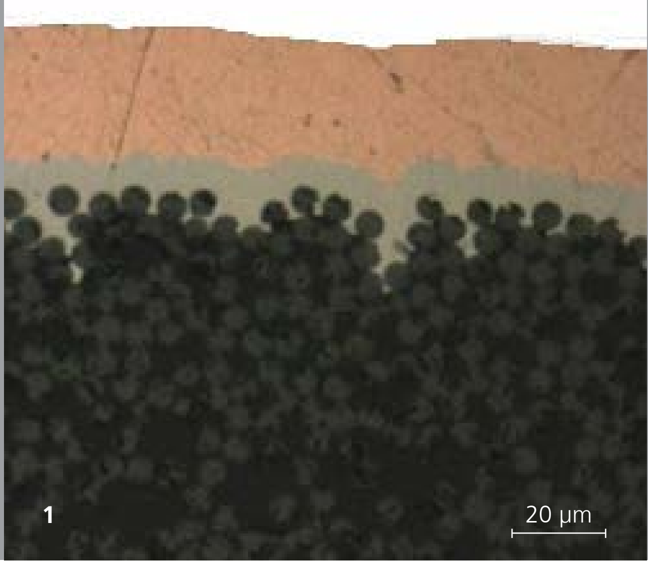

METALLIZED CFRP MIRRORS FOR OUTER SPACE

Optical mirrors for space applications must have extraordinary stability due to the constantly changing thermal stresses in outer space, but also due to the high mechanical stresses at lift-off of a rocket. For this reason, as rule optical mirrors are manufactured of metals, ceramics, or glasses. These materials have a high specific weight and are the cause of tremendous costs at start. Consequently, at the Fraunhofer IST work is underway on a significantly lighter alternative: Mirrors of carbon fiber reinforced plastic.

CFRP – a lightweight

Carbon fiber reinforced plastic (CFRP) is a real champion among lightweight materials. With a specific weight of 1.6 g/cm^3 it is even lighter than aluminum, magnesium or titanium, and in addition it has significantly better mechanical characteristics. For this reason it is used wherever weight reduction is essential. What is new however is the use of CFRP material as mirrors for space applications. A comparison makes this clear: A mirror segment of beryllium that is used in the James Webb Space Telescope has a mass of approximately 20 kg. A comparable metallized mirror of CFRP has a mass of approximately 3.5 kg.

The manufacturing of the metallized mirror

In the project “OCULUS” (Optical Coatings for Ultra Light-weight Robust Spacecraft Structures) funded by the German Aerospace Center (DLR) the Fraunhofer IST develops a folding mirror of CFRP in collaboration with the Technical University of Braunschweig and the company INVENT GmbH. This mirror will be metallized and surface-treated in a subsequent step. In a process developed at Fraunhofer IPT, so-called ultra precision turning, the initially quite rough and irregular surface is processed to a mirror finish.

The metallization of CFRP was developed at the Fraunhofer IST where the process has been successfully used for approximately 10 years. Well-known application examples include the CFRP antennas that are used in space flight. However, in the specific case of the CFRP mirror, additional requirements are imposed on the base material: It must not deform, even under the changing temperatures in outer space conditions, and in addition it must meet the optical requirements. To do this, the base material is modified. A modified layer of nickel approximately 200 µm thick that must be absolutely free of pores is used as the coating. This layer is then again turned to a minimal layer thickness in a downstream process. In this process the unevenness is leveled and a roughness of approximately 5 nm r_a is achieved.

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1 *Micrograph of the metallized CFRP sample.*

2 *Machine for ultra-precise turning of surfaces.*

3 *Coated and ultra-precise turned CFRP mirror.*

Outlook
Due to the significant weight savings, metallized CFRP surfaces with optical application offer significant potential. Further developments must improve the reliability of the metal deposition. Moreover, modifications of the CFRP material are also necessary in order to stabilize the material even under changing temperature conditions. In addition to space travel, implementations in other business sectors are also conceivable, e. g. in the machine tool industry and in the automotive industry.

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