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OPTICS

ELECTROFORMING PROCESS REDUCES COST AND IMPROVES QUALITY OF MIRRORS

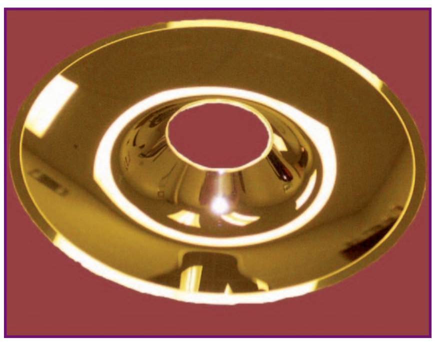
Single-point diamond turning (SPDT)—the standard for machining high-quality aspheric mirrors—is expensive and inconsistent. But now there's a new process being developed that reliably fabricates high-quality mirrors for one-quarter the cost of SPDT.

Multigenerational electroforming is a viable alternative to SPDT for making aspherical and spherical mirrors, according to Advanced Optical Systems, Inc. (AOS; Huntsville, AL). AOS developed the new process with Phase II SBIR funding from MDA. While the technology can be used to make more affordable optics for MDA missile seekers, it also has applications in mirror manufacturing for telescopes and commercial cameras.

SPDT is a subtractive process that uses a diamond turning machine to hollow out a flat substrate, known as a blank, into a mirror. Alternatively, the AOS technology is an additive process that deposits materials, such as nickel, onto a mandrel (the negative of the desired shape of the product). The proposed material is then removed from the mandrel to create a mirror, which is the very precise inverse replica of the mandrel.

Typically, a mandrel will degrade after approximately 20 uses. Mandrel degradation leads to poor quality mirrors, but to replace the mandrel after only 20 uses is very expensive. The AOS multigenerational process reduces cost by producing a quantity of "daughter" mirrors from the mandrel. Then, rather than using the daughters as mirrors, they are instead employed as mandrels to produce a similar quantity of "granddaughter" mirrors. As long as sufficient optical quality is maintained from one generation to the next, a very large number of spherical and aspherical mirrors can descend from a single mandrel.

An additional benefit to consistent high quality is the reduced weight of the resulting mirror. The conventional SPDT process may stress the substrate so there is a limit to how thin the mirror can be made. Typically, diamond-turned optics require a diameter-to-thickness ratio of 8:1 to hold their shape. In the AOS process, as soon as the mirror is thick enough to support its own weight without deforming, it can be removed from the mandrel. The company has achieved aspect ratios as high as 50:1. The process is producing mirrors as thin as 0.02-inch and may be capable of reaching 0.005 inches. The rigidity of the material and its shape help reduce deformations due to gravity.



Eye spy. *Pictured above is the first of several prototype primary mirrors AOS fabricated. Its unusual aspheric shape allows for a very wide field-of-view while still maintaining a central area of high resolution.*

In one of its first defense applications, AOS created a 4-inch, wildly aspheric mirror for the MDA Foveated Panoramic Seeker mock-up. This system is designed to mimic the human eye, which has a very high-resolution area in the center surrounded by a very low-resolution area on the edges. Combined with a secondary adaptive optical component, the mirror will provide the seeker with a wider field-of-view and real-time adjustable areas of high resolution.

Camera and telescope manufacturers also may benefit using the AOS process. When producing large quantities of mirrors, the AOS process is much more cost-effective than SPDT. For example, if a single mirror costs $2,000 using a SPDT process, the cost of manufacturing 1,000 will be $2 million. Using its process to make multiple mirrors from a single generation of mandrels, AOS can produce 1,000 mirrors for about $500,000. As the quantity increases, so does the cost savings.

Currently, AOS is capable of producing infrared-quality mirrors for imaging cameras using the electroforming process. However, the process requires further development to reliably fabricate high-quality mirrors in the visible. AOS welcomes inquiries about potential mirror applications and further development of this technology.

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