

program files to be generated, saving both time and expense.

The film module includes a material supply and feed system, a material preheating system for the tackifying of incoming and substrate materials, and a film-cutting system. The preheating system utilizes an infrared quartz-halogen lamp with a focused parabolic reflector to provide radiant heating of the substrate and incoming materials at the point of application. All prototype device actuators are pneumatic; however, digital

servo/stepper motors may be employed for additional control and accuracy.

The prototype device was designed to supply material of width identical to that of the composite material typically processed by the machine that was used as the test-bed during the course of module development. By thus setting the width of the film, use may be made of the same placement files as written for the composite. The device is designed to be portable and easily removed from the host machine. A simple switch allows

for the disabling of the device when placement of composites alone is being performed.

*This work was done by A. Bruce Hulcher of Marshall Space Flight Center. For further information on this technology, contact A. Bruce Hulcher at (256) 544-5124.*

*This invention is owned by NASA, and a patent application has been filed. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at [sammy.a.nabors@nasa.gov](mailto:sammy.a.nabors@nasa.gov). Refer to MFS-32008-1.*

## Fabrication of Submillimeter Axisymmetric Optical Components

**Surfaces of components can be arbitrarily shaped to optimize spectral responses.**

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It is now possible to fashion transparent crystalline materials into axisymmetric optical components having diameters ranging from hundreds down to tens of micrometers, whereas previously, the smallest attainable diameter was 500  $\mu\text{m}$ . A major step in the fabrication process that makes this possible can be characterized as diamond turning or computer numerically controlled machining on an ultrahigh-precision lathe. This process affords the flexibility to make arbitrary axisymmetric shapes that have various degrees of complexity: examples include a flat disk or a torus supported by a cylinder (see figure), or multiple closely axially spaced disks or tori supported by a cylinder. Such optical components are intended mainly for use as whispering-gallery-mode optical resonators in diverse actual and potential applications, including wavelength filtering, modulation,

photonic generation and detection of microwaves, and research in quantum electrodynamics and quantum optics.

The first step in the fabrication process is to use a brass tube bore with a 30- $\mu\text{m}$  diamond suspension to cut a small cylindrical workpiece from a plate or block of the selected crystalline material. In a demonstration of the process, the cylindrical workpiece was 1.8 mm in diameter and 5 mm long; in general, different dimensions would be chosen to suit a specific application.

The workpiece is then glued to a metal cap that, in turn, is attached to the rotor of an aerostatic spindle. During the rotation of the spindle, a diamond tool is used to cut the workpiece. A computer program is used to control stepping motors that move the diamond tool, thereby controlling the shape cut by the tool. Because the shape can be

controlled via software, it is possible to choose a shape designed to optimize a resonator spectrum.

*This work was done by Ivan Grudin, Anatoliy Savchenkov, and Dmitry Strelkov of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).*

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