

## Fabrication of Spherical Reflectors in Outer Space

**Process takes advantage of vacuum.**

*NASA's Jet Propulsion Laboratory, Pasadena, California*

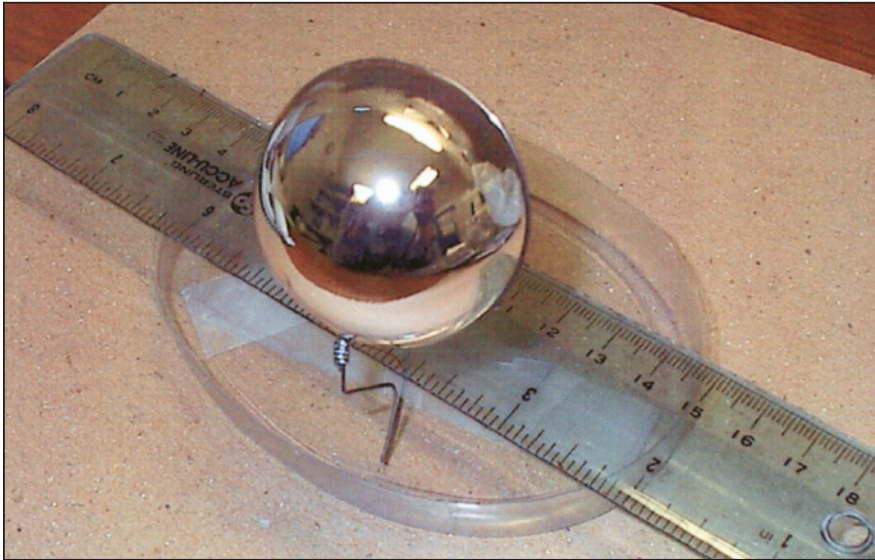
A process is proposed for fabrication of lightweight spherical reflectors in outer space for telescopes, radio antennas, and light collectors that would be operated there. The process would obviate the relatively massive substrates and frames

needed to support such reflectors in normal Earth gravitation. According to the proposal, fabrication of a reflector would begin with blowing of a bubble to the specified reflector radius. Taking advantage of the outer-space vacuum as a suit-

able environment for evaporative deposition of metal, a metal-evaporation source would be turned on and moved around the bubble to deposit a reflective metal film over the specified reflector area to a thickness of several microns. Then the source would be moved and aimed to deposit more metal around the edge of the reflector area, increasing the thickness there to  $\approx 100 \mu\text{m}$  to form a frame. Then the bubble would be deflated and peeled off the metal, leaving a thin-film spherical mirror having an integral frame. The mirror would then be mounted for use.

The feasibility of this technology has been proved by fabricating a prototype at JPL. As shown in the figure, a 2-in. ( $\approx 5\text{-cm}$ ) diameter hemispherical prototype reflector was made from a polymer bubble coated with silver, forming a very smooth surface.

*This work was done by Yu Wang, Jennifer Dooley, and Mark Dragovan of Caltech and Wally Serivens of the University of South Carolina for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-30649*



A **Prototype Reflector** was successfully produced, showing that the proposed fabrication is practicable.

## Automated Rapid Prototyping of 3D Ceramic Parts

**Unlike in prior rapid-prototyping processes, there is no manual stacking of sheets.**

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An automated system of manufacturing equipment produces three-dimensional (3D) ceramic parts specified by computational models of the parts. The system implements an advanced, automated version of a generic rapid-prototyping process in which the fabrication of an object having a possibly complex 3D shape includes stacking of thin sheets, the outlines of which closely approximate the horizontal cross sections of the object at their respective heights. In this process, the thin sheets are made of a ceramic precursor material, and the stack is subsequently heated to transform it into a unitary ceramic object.

In addition to the computer used to generate the computational model of

the part to be fabricated, the equipment used in this process includes:

- A commercially available laminated-object-manufacturing machine that was originally designed for building woodlike 3D objects from paper and was modified to accept sheets of ceramic precursor material, and
- A machine designed specifically to feed single sheets of ceramic precursor material to the laminated-object-manufacturing machine.

Like other rapid-prototyping processes that utilize stacking of thin sheets, this process begins with generation of the computational model of the part to be fabricated, followed by computational sectioning of the part into lay-

ers of predetermined thickness that collectively define the shape of the part. Information about each layer is transmitted to rapid-prototyping equipment, where the part is built layer by layer.

What distinguishes this process from other rapid-prototyping processes that utilize stacking of thin sheets are the details of the machines and the actions that they perform. In this process, flexible sheets of ceramic precursor material (called "green" ceramic sheets) suitable for lamination are produced by tape casting. The binder used in the tape casting is specially formulated to enable lamination of layers with little or no applied heat or pressure. The tape is cut into individual sheets, which are stacked in the