

copper (one at each end), and two stainless-steel collars surrounding the access holes are joined to the copper. After brazing, an outer stainless-steel containment tube is welded to the weldment rings. At this point, the salt pill is hermetically sealed except for the collared openings, which are to be welded shut after the salt is grown.

The size and spacing of the copper fingers are set to provide very high thermal conductance to the salt while minimizing complications caused by surface-tension forces on the salt solution during growth of the salt. The salt is grown by use of a continuous-counterflow technique in which saturated solution is pumped into,

and depleted solution is withdrawn from, the salt pill in such a way that crystallites are first nucleated at the bottom, and then salt crystals grow from the bottom upward in a controlled manner until the entire container is filled with salt. The salt solution is circulated by a dual peristaltic pump, using tubes of different sizes for supply and return so that the flow capability for return exceeds that for supply: This is key to ensuring that the saturated solution occupies only a thin layer above the growing salt, ensuring that salt grows only by extending itself rather than by nucleation at random locations throughout the salt pill. Growing the salt in this way ensures that regard-

less of the configuration and thermal conductance of the thermal bus, there is no premature formation of salt in the upper volume of the salt pill. If allowed to occur, such premature formation could trap pockets of solution.

This salt-growth process can yield a high fill fraction (>98 percent). The process can be automated at a high growth rate. The fabrication and salt-growth processes are suitable for mass production of salt pills for ADRs.

*This work was done by Peter J. Shirron, Michael J. DiPirro, and Edgar R. Canavan of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-14873-1*

## Monolithic Flexure Pre-Stressed Ultrasonic Horns

**Flexures are used rather than stress bolts, allowing one to apply pre-load to the piezoelectric material.**

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

High-power ultrasonic actuators are generally assembled with a horn, backing, stress bolt, piezoelectric rings, and electrodes. The manufacturing process is complex, expensive, difficult, and time-consuming. The internal stress bolt needs to be insulated and presents a potential internal discharge point, which can decrease actuator life. Also, the introduction of a center hole for the bolt causes many failures, reducing the throughput of the manufactured actuators.

A new design has been developed for producing ultrasonic horn actuators. This design consists of using flexures rather than stress bolts, allowing one to apply pre-load to the piezoelectric material. It also allows one to manufacture them from a single material/plate, rapid prototype them, or make an array in a plate or 3D structure. The actuator is easily assembled, and application of pre-stress greater than 25 MPa was demonstrated.

The horn consists of external flexures that eliminate the need for the conventional stress bolt internal to the

piezoelectric, and reduces the related complexity. The stress bolts are required in existing horns to provide pre-stress on piezoelectric stacks when driven at high power levels. In addition, the manufacturing process benefits from the amenability to produce horn structures with internal cavities. The removal of the pre-stress bolt removes a potential internal electric discharge point in the actuator. In addition, it significantly reduces the chances of mechanical failure in the piezoelectric stacks that result from the hole surface in conventional piezoelectric actuators. The novel features of this disclosure are:

1. A design that can be manufactured from a single piece of metal using EDM, precision machining, or rapid prototyping.
2. Increased electromechanical coupling of the horn actuator.
3. Higher energy density.
4. A monolithic structure of a horn that consists of an external flexure or flex-

ures that can be used to pre-stress a solid piezoelectric structure rather than a bolt, which requires a through hole in the piezoelectric material.

5. A flexure system with low stiffness that accommodates mechanical creep with minor reduction in pre-stress.

*This work was done by Stewart Sherrit, Xiaohu Bao, Mircea Badescu, and Yoseph Bar-Cohen of Caltech, and Phillip Grant Allen of Cal Poly Pomona for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).*

*In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:*

*Innovative Technology Assets Management  
JPL  
Mail Stop 202-233  
4800 Oak Grove Drive  
Pasadena, CA 91109-8099  
E-mail: iaoffice@jpl.nasa.gov  
Refer to NPO-47610, volume and number of this NASA Tech Briefs issue, and the page number.*