Manufacturing & Prototyping

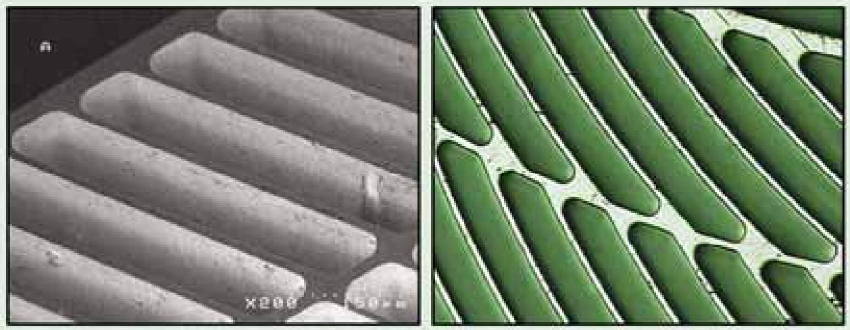
Microfabricated Segmented-Involute-Foil Regenerator for Stirling Engines

Tests show significantly improved performance.

John H. Glenn Research Center, Cleveland, Ohio

An involute-foil regenerator was designed, microfabricated, and tested in an oscillating-flow test rig. The concept consists of stacked involute-foil nickel disks (see figure) microfabricated via a lithographic process. Test results yielded a performance of about twice that of the 90-percent random-fiber currently used in small Stirling converters.

The segmented nature of the involute-foil in both the axial and radial directions increases the strength of the structure relative to wrapped foils. In addition, relative to random-fiber regenerators, the involute-foil has a reduced pressure drop, and is expected to be less susceptible to the release of metal fragments into the working space, thus increasing reliability. The prototype nickel involute-foil regenerator was adequate for testing in an engine with a 650 ºC hot-end temperature. This is lower than that required by larger engines, and high-temperature alloys are not suited for the lithographic microfabrication approach.



(a) (b)

Micrographs of Regenerator Disks are shown during the final steps of fabrication: (a) micrograph of features with remaining PMMA removed and (b) picture of nickel ribs after removal from substrate.

This work was done by Mounir Ibrahim and Daniel Danila of Cleveland State University; Terrence Simon, Susan Mantell, and Liyong Sun of the University of Minnesota; David Gedeon of Gedeon Associates; Songgang Qiu of Infinia Corp.; Gary Wood of Sunpower Inc.; and Kevin Kelly and Jeffrey McLean of International Mezzo Technologies for Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18431-1.

Reducing Seal Adhesion in Low Impact Docking Systems

Atomic oxygen is used to treat mating silica surfaces to reduce unwanted adhesion during docking/undocking operations.

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Silicone elastomers, used in seals for airlocks or other sealing surfaces in space, are sticky in their as-received condition. Because of the sticking, a greater force may be needed to separate the mating surfaces. If the adhesion is sufficiently high, a sudden unpredicted movement of the spacecraft during undocking, vibration, or uneven release could pull off the seal, resulting in a damage that would have to be repaired before another docking. The damaged seal can result in significant gas leakage and possibly in a catastrophic mishap impacting the safety of the crew. It is also possible that a compromised seal could result in a delayed but sudden gas leak that could put the crew at unexpected risk. This is especially of concern for androgynous seals, which have identical mating surfaces on both sides for interchangeability and redundancy. Such seals typically have elastomer-on-elastomer sealing surfaces. To reduce sticking, one could use release agents such as powders and lubricants, but these can be easily removed and transferred to other surfaces, causing uneven sealing and contamination. Modification of the elastomer surface to make a more slippery and less sticky surface that is integral with the bulk elastomer would be more desirable.

The analysis of materials retrieved from early space shuttle missions such as the Long Duration Exposure Facility indicated that silicone surfaces were converted to SiO_2 silica glass as a result of the low Earth orbital atomic oxygen exposure. With a controlled atomic oxygen exposure, the converted silica