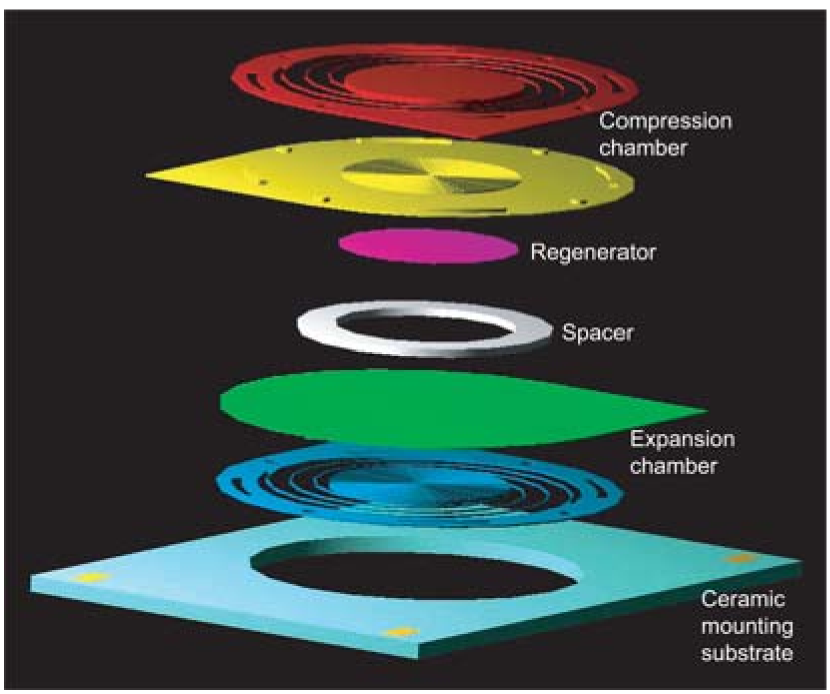
Microsystem Cooler Concept Developed and Being Fabricated

A patented microsystem cooler concept has been developed by the NASA Glenn Research Center. It incorporates diaphragm actuators to produce the Stirling refrigeration cycle within a planar configuration compatible with the thermal management of electronics, sensors, optical and radiofrequency systems, microarrays, and other microsystems. The microsystem cooler is most suited to volume-limited applications that require cooling below the ambient or sink temperature. Johns Hopkins University Applied Physics Laboratory is conducting development testing and fabrication of a prototype under a grant from Glenn.

Primary components of the planar device include two diaphragm actuators that replace the pistons found in traditional-scale Stirling machines, and a microregenerator that stores and releases thermal energy to the working gas during the Stirling cycle. The use of diaphragms eliminates the frictional losses and bypass leakage associated with pistons while permitting reversal of the hot and cold sides of the device during operation to allow precise temperature control. The concept has evolved into a design incorporating deep-reactive ion-etching fabrication to produce electrostatically driven comb-drive diaphragms with a spiral spring mounting for maximum deflection. A prototype device based on this design (see the following illustration) is being fabricated.



Prototype microsystem cooler design.

The regenerator part of the microsystem cooler is critical to the feasibility and performance of the device. A piezoelectric-actuated test apparatus was constructed to characterize this critical component, and several regenerator candidates were fabricated and tested. Johns Hopkins custom fabricated two of the regenerators of porous ceramic, and Polar Thermal Technologies constructed one regenerator of multiple layers of nickel and photoresist in an offset grating pattern. An additional regenerator composed of random stainless-steel fiber matrix commonly used in existing traditional-scale Stirling machines was prepared for comparison to the custom-fabricated regenerators.

Test results indicate that each regenerator exhibits a unique system resonant frequency where the greatest membrane deflection occurs, and hence the greatest swept volume (see the table). These data will be used to select the regenerator with the best combination of high resonant frequency and maximum membrane deflection for the prototype device.

SUMMARY OF PASSIVE MEMBRANE DISPLACEMENT FOR EACH REGENERATOR AT 400-V INPUT

Regenerator	**Resonant frequency, Hz**	**Displacement at resonance, µm**	**Displacement at 1000 Hz, µm**
Layered nickel-photoresist	500±100	98	55
Large-grain porous ceramic	800±100	104	36
Small-grain porous ceramic	800±100	108	31
Random stainless-steel fiber	1500±100	50	50

Bibliography

Moran, Matthew E.: Microsystem Cooler Development. NASA/TM--2004-213307 (AIAA-2004-5611), 2004. http://gltrs.grc.nasa.gov/cgi-bin/GLTRS/browse.pl?2004/TM-2004-213307.html

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