



Manufacturing & Prototyping

Discrete Fourier Transform Analysis in a Complex Vector Space

Goddard Space Flight Center, Greenbelt, Maryland

Alternative computational strategies for the Discrete Fourier Transform (DFT) have been developed using analysis of geometric manifolds. This approach provides a general framework for performing DFT calculations, and suggests a more efficient implementation of the DFT for applications using iterative transform methods, particularly phase retrieval. The DFT can thus be implemented using fewer operations when compared to the usual DFT counterpart.

The software decreases the run time of the DFT in certain applications such as phase retrieval that iteratively call the DFT function. The algorithm exploits a special computational approach based on analysis of the DFT as a transformation in a complex vector space. As such, this approach has the potential to realize a DFT computation that approaches N operations versus $\log(N)$ operations for the equivalent Fast Fourier Transform (FFT) calculation.

This work was done by Bruce H. Dean of Goddard Space Flight Center. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center, (301) 286-7351. Refer to GSC-15684-1.

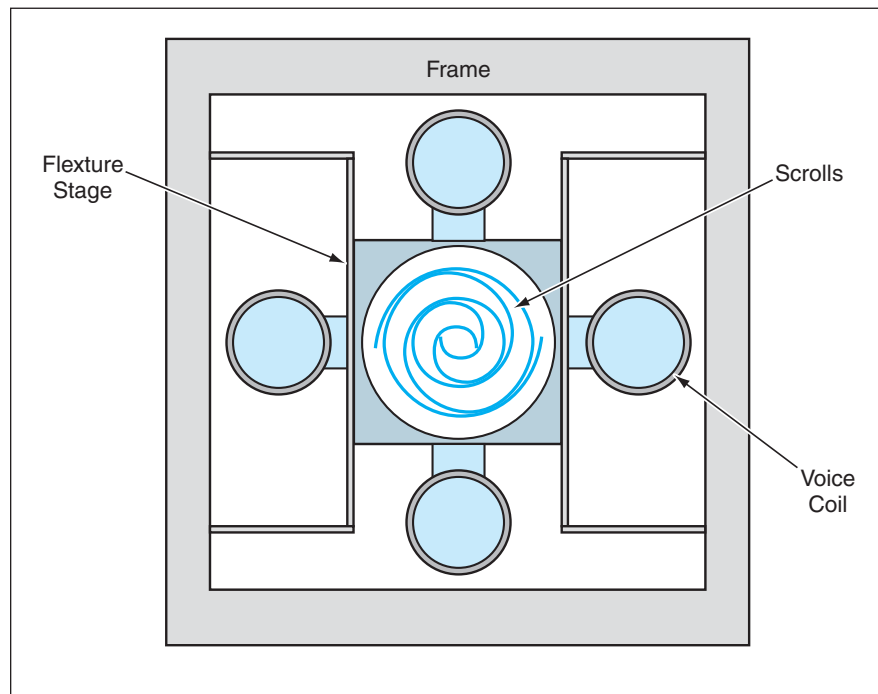
Miniature Scroll Pumps Fabricated by LIGA

These would serve as roughing pumps for vacuum systems of miniature instruments.

NASA's Jet Propulsion Laboratory, Pasadena, California

Miniature scroll pumps have been proposed as roughing pumps (low-vacuum pumps) for miniature scientific instruments (e.g., portable mass spectrometers and gas analyzers) that depend on vacuum. The larger scroll pumps used as roughing pumps in some older vacuum systems are fabricated by conventional machining. Typically, such an older scroll pump includes (1) an electric motor with an eccentric shaft to generate orbital motion of a scroll and (2) conventional bearings to restrict the orbital motion to a circle.

The proposed miniature scroll pumps would differ from the prior, larger ones in both design and fabrication. A miniature scroll pump would include two scrolls: one mounted on a stationary baseplate and one on a flexure stage (see figure). An electromagnetic actuator in the form of two pairs of voice coils in a push-pull configuration would make the flexure stage move in the desired circular orbit. The capacitance between the scrolls would be monitored to provide position (gap) feedback to a control system that would adjust the drive signals applied to the voice coils to maintain the circular orbit as needed for precise sealing of the scrolls. To minimize



A **Miniature Scroll Pump** includes a scroll mounted on a flexure stage and a scroll mounted on a stationary baseplate. The voice coils drive the flexure stage in a circular orbit to effect pumping.

power consumption and maximize precision of control, the flexure stage would be driven at the frequency of its mechanical resonance.

The miniaturization of these pumps would entail both operational and manufacturing tolerances of $<1 \mu\text{m}$. Such tight tolerances cannot be achieved eas-

ily by conventional machining of high-aspect-ratio structures like those of scroll-pump components. In addition, the vibrations of conventional motors and ball bearings exceed these tight tolerances by an order of magnitude. Therefore, the proposed pumps would be fabricated by the microfabrication method known by the German acronym LIGA (“lithographie, galvanofornung, abfornung,” which means lithography,

electroforming, molding) because LIGA has been shown to be capable of providing the required tolerances at large aspect ratios.

This work was done by Dean Wiberg, Kirill Shcheglov, Victor White, and Sam Bae of Caltech 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:

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Refer to NPO-21161, volume and number of this NASA Tech Briefs issue, and the page number.

Self-Assembling, Flexible, Pre-Ceramic Composite Preforms

Pliable, unfired preforms deploy *in-situ* to save fuel and weight costs.

John H. Glenn Research Center, Cleveland, Ohio

In this innovation, light weight, high temperature, compact aerospace structures with increased design options are made possible by using self-assembling, flexible, pre-ceramic composite materials. These materials are comprised of either ceramic or carbon fiber preforms, which are infiltrated with polymer precursors that convert to ceramics upon thermal exposure. The preform architecture can vary from chopped fibers formed into blankets or felt, to continuous fibers formed into a variety of 2D or 3D weaves or braids. The matrix material can also vary considerably. For demonstration purposes, a 2D carbon weave was infiltrated with a SiC polymer precursor. The green or unfired material is fabricated into its final shape while it is still pliable. It is then folded or rolled into a much more compact shape, which will occupy a smaller space. With this approach, the part remains as one continuous piece, rather than being fabricated as multiple sections, which would require numerous seals for eventual component use. The infiltrated pre-

form can then be deployed *in-situ*. The component can be assembled into its final shape by taking advantage of the elasticity of the material, which permits the structure to unfold and spring into its final form under its own stored energy. The pre-ceramic composites are converted to ceramics and rigidized immediately after deployment.

The final ceramic composite yields a high-temperature, high-strength material suitable for a variety of aerospace structures. The flexibility of the material, combined with its high-temperature structural capacity after rigidization, leads to a less complex component design with an increased temperature range. The collapsibility of these structures allows for larger components to be designed and used, and also offers the potential for increased vehicle performance. For the case of collapsible nozzle extensions, a larger nozzle, and thus a larger nozzle exit plane, is possible because interference with surrounding structures can be avoided in the collapsed state. The larger exit plane leads

to an increase in expansion area ratio, which has the potential to increase thrust and overall rocket performance. In general, the use of advanced ceramic materials can lead to improved engine and vehicle performance. The ceramics can run hotter, so less cooling is required. Fuel to coolant ratios can be balanced more readily to reduce weight. Engine efficiency can also be increased with hotter combustion and exhaust temperatures. In addition, the ceramic composites themselves can reduce the component weight by as much as 50 percent, which can translate into greater payload for the vehicle.

This work was done by Martha H. Jaskowiak and Andrew J. Eckel of Glenn Research Center and Daniel Gorican of Arctic Slope Regional Corp. 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-18421-1.