is also a fourth fiber, which is used for monitoring power.)

- Two of the fiber optical paths include delay lines containing electro-optical modulators.
- In operation, the modulators are used to create phase shifts that alter the interference fringes in ways that aid the extraction of the desired information.
- Images of the phase-shifted interference fringes are captured, digitized, and then analyzed by use of a very robust fringe-tracking and phase-unwrapping algorithm developed specifically for this gauge.
- The final product of the analysis is a map, accurate to 1 nm or less, of the deviation from flatness of the component under test.

The third gauge is denoted the split-fiber-beam, single-fiber interferometer. This gauge utilizes a reference optical flat that has been calibrated by use of the three-fiber gauge for measuring the optical-corner/siderostat-mirror-surface distance. A single laser beam is delivered by an optical fiber, and is split in half and collimated by two off-axis paraboloidal reflectors. The collimated first half beam is aimed at the siderostat/retroreflector assembly. The light reflected from the assembly is sent back toward the fiber by the same paraboloid that collimated it. This light is then reflected from the tip of the optical fiber and interferes with the second half beam coming out of the fiber. The resulting two divergent beams are intercepted and collimated by the second paraboloidal reflector, then focused by a third paraboloidal reflector onto an image detector for analysis of interference fringes. For the purpose of shifting phases in order to shift interference fringes to aid the extraction of the required information, the siderostat/retroreflector assembly is mounted on a closed-loop, three-axis piezoelectric transducer that moves the assembly in controlled steps that can be resolved to 1 nm.

This work was done by Yekta Gursel of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-30804

Improved Electrolytic Hydrogen Peroxide Generator

Energy efficiency exceeds that of a prior electrolytic H_2O_2 generator.

Lyndon B. Johnson Space Center, Houston, Texas

An improved apparatus for the electrolytic generation of hydrogen peroxide dissolved in water has been developed. The apparatus is a prototype of H_2O_2 generators for the safe and effective sterilization of water, sterilization of equipment in contact with water, and other applications in which there is need for hydrogen peroxide at low concentration as an oxidant. Potential applications for electrolytic H_2O_2 generators include purification of water for drinking and for use in industrial processes, sanitation for hospitals and biotechnological industries, inhibition and removal of biofouling in heat exchangers, cooling towers, filtration units, and the treatment of wastewater by use of advanced oxidation processes that are promoted by H_2O_2.

The apparatus is an electrochemical cell in which the electrodes are located on opposite sides of a commercially available polymeric membrane, which separates the electrolytes of the two electrolytic half-reactions. One of the half-cells produces the biocidal aqueous H_2O_2 product; the product of the other half-cell restores the biocidal solution to potability. The apparatus is designed to process water that is neutral (in the sense of neither acidic nor alkaline) or nearly neutral, to consume minimal energy, and to operate without need to supply nonregenerable material(s) other than the small proportion of water that is electrolyzed.

The energy efficiency of the cell is increased through improved microscopic mixing of the electrolytes near the electrodes without need for large bulk electrolyte flow rates: this is accomplished by rotating the electrodes relative to the rest of the cell (in contradistinction to forcing electrolyte flow over stationary electrodes). Even though the design of this prototype cell is unoptimized, the total energy consumption per unit of product was found to be 60 percent less than that of a common planar H_2O_2-generating cell in operation at similar Faradaic and production rates.

This work was done by Patrick I. James of Eltron Research, Inc., for **Johnson Space Center**. *For further information, contact the Johnson Innovative Partnerships Office at (281) 483-3809.*
MSC-23093

High-Power Fiber Lasers Using Photonic Band Gap Materials

PBG materials would be exploited to increase power levels and efficiencies.

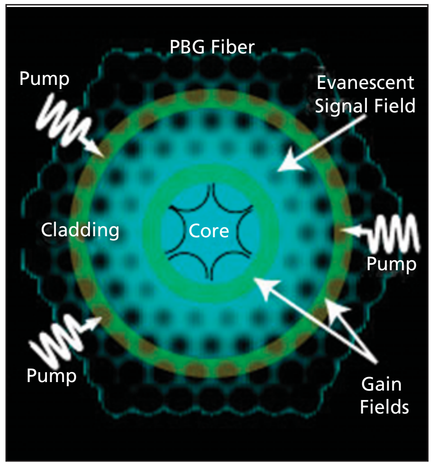
NASA's Jet Propulsion Laboratory, Pasadena, California

High-power fiber lasers (HPFLs) would be made from photonic band gap (PBG) materials, according to the proposal. Such lasers would be scalable in the sense that a large number of fiber lasers could be arranged in an array or bundle and then operated in phase-locked condition to generate a superposition and highly directed high-power laser beam. It has been estimated that an average power level as high as 1,000 W per fiber could be achieved in such an array.

Examples of potential applications for the proposed single-fiber lasers include welding and laser surgery. Additionally, the bundled fibers have applications in beaming power through free space for autonomous vehicles, laser weapons, free-space communications, and inducing photochemical reactions in large-scale industrial processes.

The proposal has been inspired in part by recent improvements in the capabilities of single-mode fiber amplifiers and lasers to produce continuous high-power radiation. In particular, it has been found that the average output power of a single strand of a fiber laser can be increased by suitably changing the doping profile of active ions in its gain medium to optimize the spatial overlap of the electromagnetic field with the distribution of active ions. Such optimization minimizes pump power losses and increases the gain in the fiber laser system. The proposal would expand the basic concept of this type of optimization to incorporate exploitation of the properties (including, in some cases, nonlinearities) of PBG materials to obtain power levels and efficiencies higher than are now possible. Another element of the proposal is to enable pumping by concentrated sunlight.

Somewhat more specifically, the proposal calls for exploitation of the properties of PBG materials to overcome a number of stubborn adverse phenomena that have impeded prior efforts to perfect HPFLs. The most relevant of those phenomena is amplified spontaneous emission (ASE), which causes saturation of gain and power at undesirably low levels, and scattering of light from dopants. In designing a given fiber laser for reduced ASE, care must be taken to maintain a correct fiber structure for eventual scaling to an array of many such lasers such that the interactions among all the members of the array would cause them to operate in phase lock. Hence, the problems associated with improving a single-fiber laser are not entirely separate from the bundling problem, and some designs for individual fiber lasers may be better than others if the fibers are to be incorporated into bundles.



In this **Image Generated in a Simulation** of a PBG fiber laser, the intensity of a single-mode signal decaying away from the waveguide core is represented by the intensity of the bright field against the dark fiber holes. Also shown here are different gain regions, which would be exposed to different evanescent fields by virtue of a band-gap shift, which would depend on the intensity of radiation in the core. The band-gap shift would be exploited as a feedback control mechanism.

Extensive calculations, expected to take about a year, must be performed in order to determine design parameters before construction of prototype individual and fiber lasers can begin. The design effort can be expected to include calculations to optimize overlaps between the electromagnetic modes and the gain media and calculations of responses of PBG materials to electromagnetic fields. Design alternatives and physical responses that may be considered include simple PBG fibers with no intensity-dependent responses, PBG fibers with intensity-dependent band-gap shifting (see figure), and broad-band pumping made possible by use of candidate broad-band pumping media in place of the air or vacuum gaps used in prior PBG fibers.

This work was done by Leo DiDomenico and Jonathan Dowling 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:

Innovative Technology Assets Management
JPL
Mail Stop 202-233
4800 Oak Grove Drive
Pasadena, CA 91109-8099
(818) 354-2240
E-mail: iaoffice@jpl.nasa.gov

Refer to NPO-40552, volume and number of this NASA Tech Briefs *issue, and the page number.*