



## Physical Sciences

### **Direct Coupling From WGM Resonator Disks to Photodetectors**

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

Output coupling of light from a whispering-gallery-mode (WGM) optical resonator directly to a photodetector has recently been demonstrated. By "directly" is meant that the coupling is effected without use of intervening optical components. Heretofore, coupling of light into and out of WGM resonators has been a complex affair involving the use of such optical components as diamond or glass prisms, optical fibers, coated collimators, and/or fiber tapers. Alignment of these components is time-consuming and expensive.

To effect direct coupling, one simply mounts a photodetector in direct me-

chanical contact with a spacer that is, in turn, in direct mechanical contact with a WGM resonator disk. The spacer must have a specified thickness (typically of the order of a wavelength) and an index of refraction lower, by an adequate margin, than the indices of refraction of the photodetector and the WGM resonator disk. This mechanically simple approach makes it possible to obtain an optimum compromise between maximizing optical coupling and maximizing the resonance quality factor ( $Q$ ).

*This work was done by Anatoliy Savchenkov, Lute Maleki, Makan Mohageg, and Thanh Le*

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### **Using Digital Radiography To Image Liquid Nitrogen in Voids**

**X-ray motion pictures show draining and filling caused by cryopumping.**

*Marshall Space Flight Center, Alabama*

Digital radiography by use of (1) a field-portable x-ray tube that emits low-energy x rays and (2) an electronic imaging x-ray detector has been found to be an effective technique for detecting liquid nitrogen inside voids in thermal-insulation panels. The technique was conceived as a means of investigating cryopumping (including cryoingestion) as a potential cause of loss of thermal insulation foam from space-shuttle external fuel tanks. The technique could just as well be used to investigate cryopumping and cryoingestion in other settings.

In images formed by use of low-energy x-rays, one can clearly distinguish between voids filled with liquid nitrogen and those filled with gaseous nitrogen or other gases. Conventional film radiography is of some value, but yields only non-real-time still images that do not show time dependences of levels of liquids in voids. In contrast, the present digital radiographic technique yields a succession of images in real time at a rate of about 10 frames per second. The digitized images can be

saved for subsequent analysis to extract data on time dependencies of levels of liquids and, hence, of flow paths and rates of filling and draining. The succession of images also amounts to a real-time motion picture that can be used as a guide to adjustment of test conditions.

*This work was done by Dwight Cox and Elana Blevins of Lockheed Martin Corp. for Marshall Space Flight Center. Further information is contained in a TSP (see page 1). MFS-32443-1*

### **Multiple-Parameter, Low-False-Alarm Fire-Detection Systems**

**Compact, low-power systems detect fires reliably.**

*John H. Glenn Research Center, Cleveland, Ohio*

Fire-detection systems incorporating multiple sensors that measure multiple parameters are being developed for use in storage depots, cargo bays of ships and aircraft, and other locations not amenable to frequent, direct visual inspection. These systems are intended to

improve upon conventional smoke detectors, now used in such locations, that reliably detect fires but also frequently generate false alarms: for example, conventional smoke detectors based on the blockage of light by smoke particles are also affected by dust particles and water

droplets and, thus, are often susceptible to false alarms. In contrast, by utilizing multiple parameters associated with fires, i.e. not only obscuration by smoke particles but also concentrations of multiple chemical species that are commonly generated in combustion, false