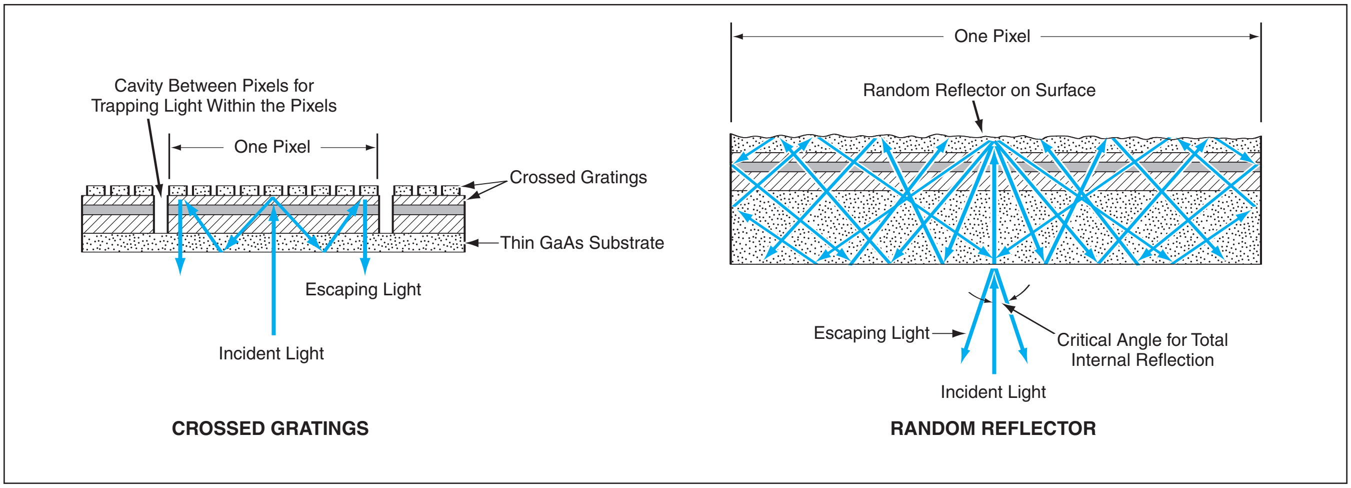

Crossed Diffraction Gratings or a Random Reflector would be fabricated on the back (here, the top) face of a PIN photodiode in each pixel of an imaging array of such photodiodes.

the focal plane and, hence, can excite charge carriers.

- A pair of crossed gratings or a random reflector on a PIN photodiode would also scatter light into directions away from the perpendicular to the focal plane. However, in this case, the reason for redirecting light away from the perpendicular is to increase the length of the optical path through the detector to increase the probability of absorption of photons and thereby increase the resulting excitation of charge carriers.

A pair of crossed gratings or a random reflector according to the proposal would be fabricated as an integral part of photodetector structure on the face opposite the focal plane (see figure). In the presence of crossed gratings, light would make four passes through the device before departing. In the presence of a random reflector, a significant portion of the light would make more than four passes: After each bounce, light would be scattered at a different random angle, and would have a chance to escape only when it was reflected, relative to the normal, at an angle less than the critical angle for total internal reflection. Given the indices of refraction of the photodiode materials, this angle would be about 17°. This amounts to a very narrow cone for escape of trapped light.

This work was done by Sarath Gunapala, Sumith Bandara, John Liu, and David Ting 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-30509, volume and number of this NASA Tech Briefs *issue, and the page number.*

Optically Transparent Split-Ring Antennas for 1 to 10 GHz

Advantages include ultra-wide-band operation, miniaturization, and excellent impedance matching.

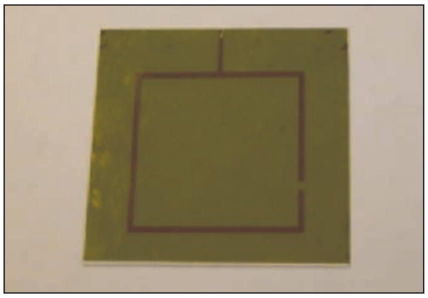
John H. Glenn Research Center, Cleveland, Ohio

Split-ring antennas made from optically transparent, electrically conductive films have been invented for applications in which there are requirements for compact antennas capable of operation over much or all of the frequency band from 1 to 10 GHz. Primary examples of such applications include wireless local-area networks and industrial, scientific, and medical (ISM) applications. These antennas can be conveniently located on such surfaces as those of automobile windows and display screens of diverse hand-held electronic units. They are fabricated by conventional printed-circuit techniques and can easily be integrated with solid-state amplifier circuits to enhance gain.

The structure of an antenna of this type includes an antenna/feed layer supported on the top or outer face of a dielectric (e.g., glass) and, optionally, a ground layer on the bottom or inner face of the substrate. The ring can be in the form of either a conductive strip or a slot in the antenna/feed layer. The ring can be of rectangular, square, circular, elliptical, or other suitable shape and can be excited by means of a microstrip, slot line, or coplanar waveguide. For example, the antenna shown in the figure features a square conductive-strip split ring with a microstrip feed.

In general, an antenna fed at its external boundary in the manner of this invention presents very high impedance, thereby creating an impedance-matching problem. Splitting the ring — that is, cutting a notch through the ring — offers a solution to the problem in that the notch fixes the location of maximum electric field, which location is directly related to the impedance. Thus, an excellent impedance match can be achieved through proper choice of the location of the notch.

In geometric layout, such a ring antenna structure is typically between ¼ and ⅓ the size of a patch antenna capable of operating in the same frequency range. This miniaturization of the antenna is desirable, not only because it contributes to overall miniaturization of equipment, but



This **Square Split-Ring Antenna** operates with a voltage standing-wave ratio of 2 or less over the entire ISM frequency band.

also because minimization of the extent of the optically transparent, electrically conductive film helps to minimize the electrical loss associated with the surface resistance (≈5 ohms per square) of the transparent, electrically conductive film material.

Incidentally, even at ≈5 ohms per square, this surface resistance is significantly less than that of indium tin oxide film (typically > 25 ohms per square), which, heretofore has been the transparent, electrically conductive film material of choice. At the time of writing this article, information on the composition of the lower-resistance film used in the antennas of this invention was not available.

This work was done by Richard Q. Lee and Rainee N. Simons of **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-17925-1.

Ice-Penetrating Robot for Scientific Exploration

A compact probe contains advanced power, instrumentation, navigation, control, and communication systems.

NASA's Jet Propulsion Laboratory, Pasadena, California

The cryo-hydro integrated robotic penetrator system (CHIRPS) is a partially developed instrumentation system that includes a probe designed to deeply penetrate the Europan ice sheet in a search for signs of life. The CHIRPS could also be used on Earth for similar exploration of the polar ice caps — especially at Lake Vostok in Antarctica. The CHIRPS probe advances downward by a combination of simple melting of ice (typically for upper, non-compacted layers of an ice sheet) or by a combination of melting of ice and pumping of meltwater (typically, for deeper, compacted layers). The heat and electric power for melting, pumping, and operating all of the onboard instrumentation and electronic circuitry are supplied by radioisotope power sources (RPSs) and thermoelectric converters energized by the RPSs. The instrumentation and electronic circuitry includes miniature guidance and control sensors and an advanced autonomous control system that has fault-management capabilities.

The CHIRPS probe is about 1 m long and 15 cm in diameter. The RPSs generate a total thermal power of 1.8 kW. Initially, as this power melts the surrounding ice, a meltwater jacket about 1 mm thick forms around the probe. The center of gravity of the probe is well forward (down), so that the probe is vertically stabilized like a pendulum. Heat is circulated to the nose by means of miniature pumps and heat pipes.

The probe melts ice to advance in a step-wise manner: Heat is applied to the nose to open up a melt void, then heat is applied to the side to allow the probe to slip down into the melt void. The melt void behind the probe is allowed to re-freeze. Four quadrant heaters on the nose and another four quadrant heaters on the rear (upper) surface of the probe are individually controllable for steering: Turning on two adjacent nose heaters on the nose and two adjacent heaters on the opposite side at the rear causes melt voids to form on opposing sides, such that the probe descends at an angle from vertical. This steering capability can be used to avoid debris trapped in the ice or to maneuver closer to a trapped object of scientific interest.

The probe contains a system that ingests meltwater, heats the water, and pumps the heated water to form a jet out of a central orifice on the nose. The jet removes debris and contributes to the melting of ice in front of the probe. The external pressure of the ice is utilized to drive some of the meltwater into a channel on the outside of the probe shell, across a membrane, into miniature pumps, which supply water samples to the onboard scientific instruments.

The guidance and control sensors include a three-axis inclinometer, a forward-looking acoustic imager, and sensors for measuring temperature, pressure, flow rate, and pump-motor current. There is also a tether-payout encoder and a tether-actuator/brake current sensor for use in the event that the probe is connected to surface instrumentation via a tether cable (typically, for a shallow penetration). The electronic circuitry includes a power conditioner, telemetry driver, master controller, digital-to-analog and analog-to-digital converters, instrument drivers, and memory circuits, including data buffers.

At the rear (upper end) of the fully developed probe, for radio communication with the surface instrumentation in the event that a tether cable was not used (typically, during a deep penetration), there would be a primary radio transceiver and its antenna. Behind this antenna there would be 13 radio relay units, denoted ice transceivers, each between 2 and 3 cm thick and about 10 cm in diameter. The transceivers would be released, one at a time, into the rear slush and allowed to become frozen in place for relaying signals between the probe and the surface. The release depths would be chosen on the basis of signal strength and of the temperature and electrical conductivity of the ice.

In the event of an ice sheet over a body of liquid water (as in Lake Vostok), as the probe approached the ice/liquid interface, the acoustic imager would sense the interface. At this point, the front portion of the probe carrying the heat source and instruments would separate from the rear portion of the probe. The ice would refreeze around the aft body, which would thereafter serve as an anchor and a communication relay. The front portion would descend through the water on a tether, sampling the water for signs of life.

This work was done by Wayne Zimmerman, Frank Carsey, and Lloyd French of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-40747