Simultaneous Spectral Temporal Adaptive Raman Spectrometer — SSTARS

NASA's Jet Propulsion Laboratory, Pasadena, California

Raman spectroscopy is a prime candidate for the next generation of planetary instruments, as it addresses the primary goal of mineralogical analysis, which is structure and composition. However, large fluorescence return from many mineral samples under visible light excitation can render Raman spectra unattainable. Using the described approach, Raman and fluorescence, which occur on different time scales, can be simultaneously obtained from mineral samples using a compact instrument in a planetary environment. This new approach is taken based on the use of time-resolved spectroscopy for removing the fluorescence background from Raman spectra in the laboratory.

In the SSTARS instrument, a visible excitation source (a green, pulsed laser) is used to generate Raman and fluorescence signals in a mineral sample. A spectral notch filter eliminates the directly reflected beam. A grating then disperses the signal spectrally, and a streak camera provides temporal resolution. The output of the streak camera is imaged on the CCD (charge-coupled device), and the data are read out electronically. By adjusting the sweep speed of the streak camera, anywhere from picoseconds to milliseconds, it is possible to resolve Raman spectra from numerous fluorescence spectra in the same sample. The key features of SSTARS include a compact streak tube capable of picosecond time resolution for collection of simultaneous spectral and temporal information, adaptive streak tube electronics that can rapidly change from one sweep rate to another over ranges of picoseconds to milliseconds, enabling collection of both Raman and fluorescence signatures versus time and wavelength, and Synchroscan integration that allows for a compact, low-power laser without compromising ultimate sensitivity.

This work was done by Jordana Blacksberg of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-46752

Improved Speed and Functionality of a 580-GHz Imaging Radar

This room-temperature, all-solid-state active submillimeter imager can be used to detect concealed weapons through clothing.

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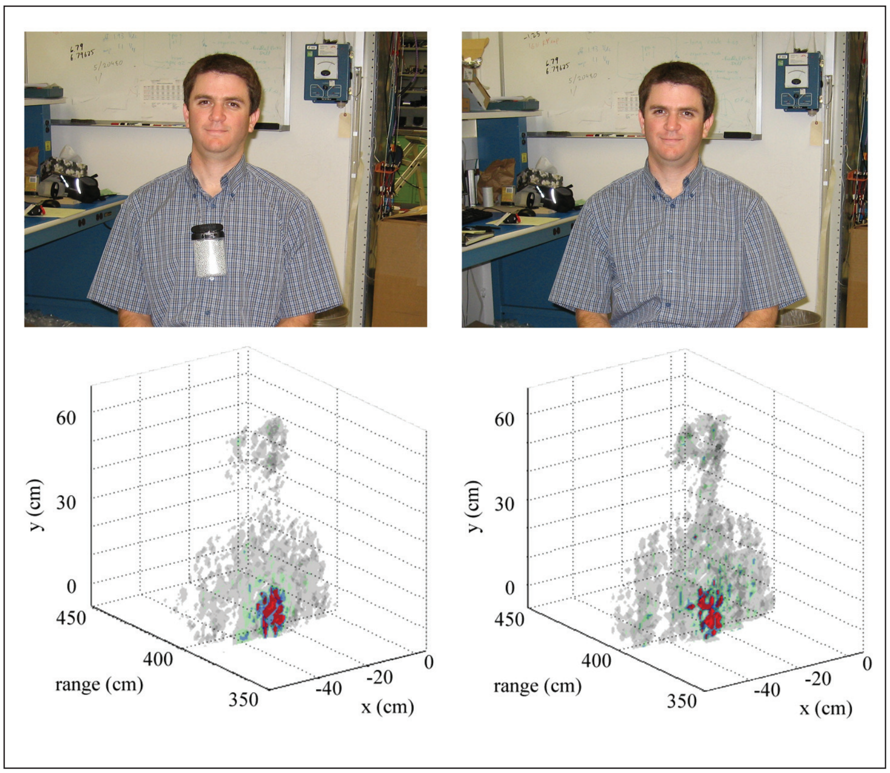
With this high-resolution imaging radar system, coherent illumination in the 576-to-589-GHz range and phase-sensitive detection are implemented in an all-solid-state design based on Schottky diode sensors and sources. By employing the frequency-modulated, continuous-wave (FMCW) radar technique, centimeter-scale range resolution has been achieved while using fractional bandwidths of less than 3 percent. The high operating frequencies also permit centimeter-scale cross-range resolution at several-meter standoff distances without large apertures. Scanning of a single-pixel transceiver enables targets to be rapidly mapped in three dimensions, so that the technology can be applied to the detection of concealed objects on persons.

The system evolved from a tunable, continuous-wave (CW) 600-GHz vector imager system. The radar's key components, custom-built for a different application at JPL, are the Schottky-diode multipliers generating transmit powers of 0.3 to 0.4 mW over 576 to 595 GHz and a balanced fundamental mixer exhibiting a double-sideband noise temperature of ≈4,000 K over the same range. Also no-



Photographs (top) and **3D THz Radar Imager Reconstructions** (bottom) of a person. On the left, the subject is wearing an exposed plastic container filled with ball bearings. On the right, the same container is concealed under his shirt.

table in the design is that residual phase-wander between the locked radio frequency (RF) and local oscillator (LO) K-band source synthesizers is canceled at an intermediate 450 MHz IF stage before final conversion to baseband through an IQ mixer.

To implement the FMCW chirp, a 2–4 GHz low-phase-noise commercial YIG synthesizer is used with a tuning bandwidth of 5 kHz, typically ramping over 350 MHz (subsequently multiplied by 36 to 12.6 GHz) in 50 ms. The chirp signal is up-converted onto the CW synthesizers' signals before multiplication. De-ramping of the FMCW waveform occurs at the 600 GHz receiver mixer. While high multiplication factors should be generally avoided in FMCW radar systems to minimize the impact of phase noise in the transmitted signal, in this case, the short standoff ranges produce a phase noise floor that lies below the thermal noise except for the brightest, mirrorlike specular targets.

The submillimeter power is transmitted first through a silicon wafer beam splitter and then a plano-convex Teflon lens with a diameter of 20 cm. This lens focuses the THz beam to a spot size of ≈2 cm at a standoff range of 4 m. To achieve scanned images, a flat mirror on a two-axis rotational stage deflects the beam in the desired direction

This innovation is an improvement over an earlier submillimeter high-resolution radar. First, a faster frequency-sweeping method consisting of a wideband YIG oscillator has been implemented. Second, the data acquisition and signal processing software has been updated in order to deal with the faster radar pulse repetition rate.

The improvements mean that the 580-GHz imaging radar can now acquire three-dimensional images of people in about five minutes. It is also feasible to detect objects concealed by clothing. This capability is possible because of the improved speed and functionality of the imaging radar's hardware and software.

This work was done by Robert Dengler, Ken Cooper, Goutam Chattopadhyay, Peter Siegel, Erich Schlecht, Imran Mehdi, Anders Skalare, and John Gill of Caltech for NASA's Jet Propulsion Laboratory.

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-45156, volume and number of this NASA Tech Briefs *issue, and the page number.*

Bolometric Device Based on Fluxoid Quantization

This device offers extremely high sensitivity for radiometric applications.

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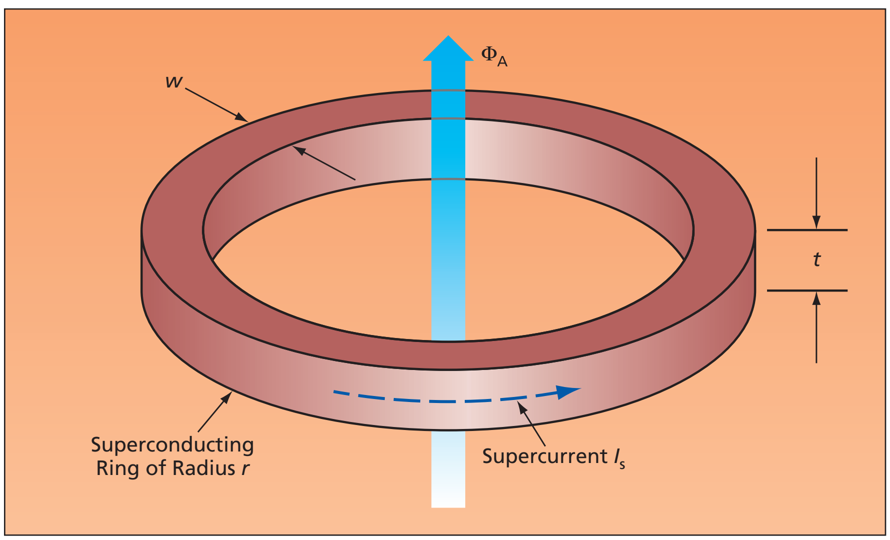
The temperature dependence of fluxoid quantization in a superconducting loop. The sensitivity of the device is expected to surpass that of other superconducting-based bolometric devices, such as superconducting transition-edge sensors and superconducting nanowire devices. Just as important, the proposed device has advantages in sample fabrication. Two challenges of transition edge sensor fabrication are the reproducibility of the superconducting transition temperature, T_c , and the sharpness of the transition. In the proposed device, unlike in other devices, the sample would remain in the superconducting state at all times during operation. That is to say it would be maintained at an absolute temperature, T, below its superconducting T_c. Thus, the sharpness of the transition does not directly come into play. Also, the device can operate over a relatively wide temperature span of about 0.70 T_c to 0.95 T_c. Therefore, reproducibility of T_c is not important from sample to sample. These two advantages eliminate major challenges in device fabrication.

The proposal is based on the theory of fluxoid quantization in a superconducting loop (see figure) with a track width (w) less than the temperature-dependent characteristic depth of supercurrent penetration (λ) of the material. The theory has been shown to lead to the following equation:



A **Superconducting Ring** would support a temperature-dependent supercurrent I_s in the presence of an applied magnetic flux Φ_A.

$$I_s(T) = \frac{wt(n\Phi_0 - \Phi_A)}{2\pi r \mu_0 \lambda_0^2}[1-(T/T_c)^4]$$

where I_s is the temperature-dependent supercurrent, t is the thickness of the superconducting ring, Φ_0 is the magnetic-flux quantum, n is an integer denoting the number of fluxoid quanta, Φ_A is the magnetic flux applied to the ring, r is the radius of the ring, and λ_0 is the characteristic depth of penetration of supercurrent at absolute zero temperature.

The applied magnetic flux (Φ_A) would serve as a bias that could be adjusted to select the mode of operation.