A design has been proposed for a photodetector that would exhibit a high quantum efficiency (as much as 90 percent) over a wide wavelength band, which would typically be centered at a wavelength of 1.55 μm. This and similar photodetectors would afford a capability for detecting single photons — a capability that is needed for research in quantum optics as well as for the practical development of secure optical communication systems for distribution of quantum cryptographic keys.

The proposed photodetector would be of the hot-electron, phonon-cooled, thin-film superconductor type. The superconducting film in this device would be a meandering strip of niobium nitride. In the proposed photodetector, the quantum efficiency would be increased through incorporation of opti-

**Wide-Band, High-Quantum-Efficiency Photodetector**

*This device could detect single photons.*

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

A design has been proposed for a photodetector that would exhibit a high quantum efficiency (as much as 90 percent) over a wide wavelength band, which would typically be centered at a wavelength of 1.55 μm. This and similar photodetectors would afford a capability for detecting single photons — a capability that is needed for research in quantum optics as well as for the practical development of secure optical communication systems for distribution of quantum cryptographic keys.

The proposed photodetector would be of the hot-electron, phonon-cooled, thin-film superconductor type. The superconducting film in this device would be a meandering strip of niobium nitride. In the proposed photodetector, the quantum efficiency would be increased through incorporation of opti-
cal components, described below, that would increase the electromagnetic coupling between the input optical field and the meandering superconducting film.

The meandering niobium nitride strip would be fabricated on top of a dielectric (e.g., silicon) optical waveguide on a silicon dioxide substrate (see figure). The input end face of the waveguide would be cut, polished, and antireflection-coated to maximize in-coupling efficiency. The thickness of the waveguide would be chosen so that at the design wavelength, there would be a single through-the-thickness electromagnetic mode, the evanescent tail of which would overlap with the niobium nitride strip. Because the waveguide would exhibit little optical loss over the length of the strip, there would be a high probability of absorption of photons by the strip. The width of the waveguide would be chosen to accommodate multiple widthwise electromagnetic modes, thereby increasing the interaction of light with the niobium nitride strip.

Light would be brought to the photodetector via an optical fiber. A point-to-line-focusing diffractive optical element would couple the light from the output end of the optical fiber into the waveguide. The diffractive optical element would be specially designed and fabricated to collimate as well as possible in the width dimension and to focus as well as possible in the thickness dimension in order to maximize the coupling into the desired waveguide electromagnetic mode.

**Input Light Would Be Focused Into a Waveguide**, where it would propagate along, and interact with, a meandering superconducting strip made of niobium nitride.

This work was done by Deborah Jackson, Daniel Wilson, and Jeffrey Stern 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: iaooffice@jpl.nasa.gov

Refer to NPO-40163, volume and number of this NASA Tech Briefs issue, and the page number.