

This **Schematic Diagram** compares segmented with cascaded thermoelectric generator. The cascading ratio is defined as the ratio between the numbers of unicouples in the two stages.

material that may vary with the temperature. The equation for s is

$$s \equiv \frac{\sqrt{1 + ZT} - 1}{\alpha T}$$

where Z is the traditional thermoelectric figure of merit, defined as $Z = \alpha^2 / \rho\kappa$; α is the Seebeck coefficient; ρ is the electrical resistivity; and κ is the thermal conductivity.

For maximum efficiency, u should be equal to s , both within a single material, and throughout a segmented thermoelectric-generator leg as a whole. It is in this sense that s serves as a basis for assessing both compatibility among segments and compatibility within a segment (self-compatibility). Given that u remains relatively constant throughout the thermoelectric element, the degree

to which s varies with temperature along a given segment or differs among adjacent segments thus serves as a measure of incompatibility that one strives to minimize.

The compatibility factor can further be used as a quantitative guide for deciding whether a thermoelectric material is better suited for segmentation or cascading. Cascading enables the use of a material that may be suitable for a given temperature stage but is incompatible for segmentation with one or more other materials in the same temperature stage. The simplest option that may be available in a given case is to choose the numbers of unicouples in both temperature stages such that each stage is operating at its optimal u value. Such a choice is em-

$$\frac{g'}{g} = \frac{u'}{u}$$

bodied in the following expression for the cascading ratio:

where g is the number of unicouples per stage and the prime mark distinguishes one stage from the other.

This work was done by G. Jeffrey Snyder and Tristan Ursell of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-30798

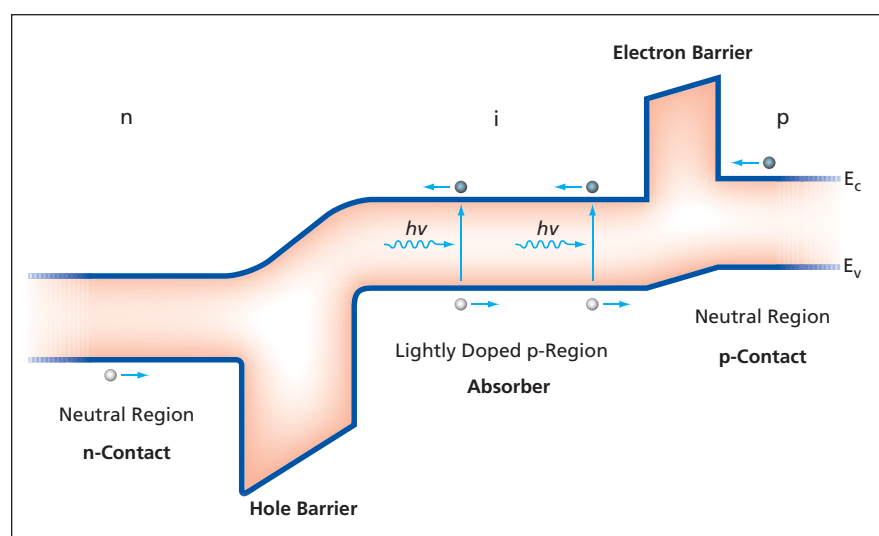
Complementary Barrier Infrared Detector

These detectors can be used in infrared imaging cameras in manufacturing process monitoring, environmental monitoring, and medical imaging.

NASA's Jet Propulsion Laboratory, Pasadena, California

The complementary barrier infrared detector (CBIRD) is designed to eliminate the major dark current sources in the superlattice infrared detector. The concept can also be applied to bulk semiconductor-based infrared detectors. CBIRD uses two different types of specially designed barriers: an electron barrier that blocks electrons but not holes, and a hole barrier that blocks holes but not electrons. The CBIRD structure consists of an n-contact, a hole barrier, an absorber, an electron barrier, and a p-contact.

The barriers are placed at the contact-absorber junctions where, in a conventional p-i-n detector structure, there normally are depletion regions that produce generation-recombination (G-R) dark currents due to Shockley-Read-Hall (SRH) processes. The wider-



This schematic energy band diagram illustrates the **Complementary Barrier Infrared Detector (CBIRD)** concept.

bandgap complementary barriers suppress G-R dark current. The barriers also block diffusion dark currents generated in the diffusion wings in the neutral regions. In addition, the wider gap barriers serve to reduce tunneling dark currents. In the case of a superlattice-based absorber, the superlattice itself can be designed to suppress dark currents due to Auger processes. At the same time, the barriers actually help to enhance the collection of photo-generated carriers by deflecting the photo-carriers that are diffusing in the "wrong" direction (i.e., away from collectors) and redirecting them toward the collecting contacts. The contact layers are made from materials with narrower bandgaps than the barriers. This allows good ohmic contacts to be made, resulting in lower contact resistances.

Previously, THALES Research and Technology (France) demonstrated de-

tectors with bulk InAsSb (specifically InAs_{0.91}Sb_{0.09}) absorber lattice-matched to GaSb substrates. The absorber is surrounded by two wider bandgap layers designed to minimize impedance to photocurrent flow. The wide bandgap materials also serve as contacts. The cutoff wavelength of the InAsSb absorber is fixed. CBIRD may be considered as a modified version of the THALES double heterostructure (DH) p-i-n device, but with even wider bandgap barriers inserted at the contact layer/absorber layer interfaces. It is designed to work with either bulk semiconductors or superlattices as the absorber material. The superlattice bandgap can be adjusted to match the desired absorption cutoff wavelength.

This infrared detector has the potential of high-sensitivity operation at higher operating temperatures. This would reduce cooling require-

ments, thereby reducing the power, mass, and volume of the equipment and allowing an increased mission science return.

This work was done by David Z. Ting, Sumith V. Bandara, Cory J. Hill, and Sarath D. Gunapala 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

E-mail: iaoffice@jpl.nasa.gov

Refer to NPO-46207, volume and number of this NASA Tech Briefs issue, and the page number.

JPL Greenland Moulin Exploration Probe

NASA's Jet Propulsion Laboratory, Pasadena, California

A probe was designed to investigate the moulins (melt water drainage channels on an ice cap) and ice-hydrology interaction in the Greenland Ice Cap. By using commercially available components, the strong and reliable system has been developed that has a high-definition video recording element, is lightweight, and has buoyancy that is easily adjustable for neutrality or to be slightly positive in the water, enabling

different deployment scenarios.

The system is in a small (20×20×20-cm), watertight Lexan box that can follow the water into the ice, but then be retrieved by tether. The system is rated for a water depth of 100 meters. The purpose of this system is to gain understanding about the interaction between the ice and the melt water and how this interaction may be accelerating the melting of glaciers and, in general, an

overall better understanding of global warming.

This work was done by Alberto Behar and Victor Zlotnicki of Caltech; Huan Wang of Stanford; Henrik Karlsson of the International Space University; Jonas Jonsson of Angstrom Space Laboratory; and Konrad Steffen and Russell Huff of the University of Colorado, Boulder, for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-45464