Nanoconverters for Powering Nanodevices

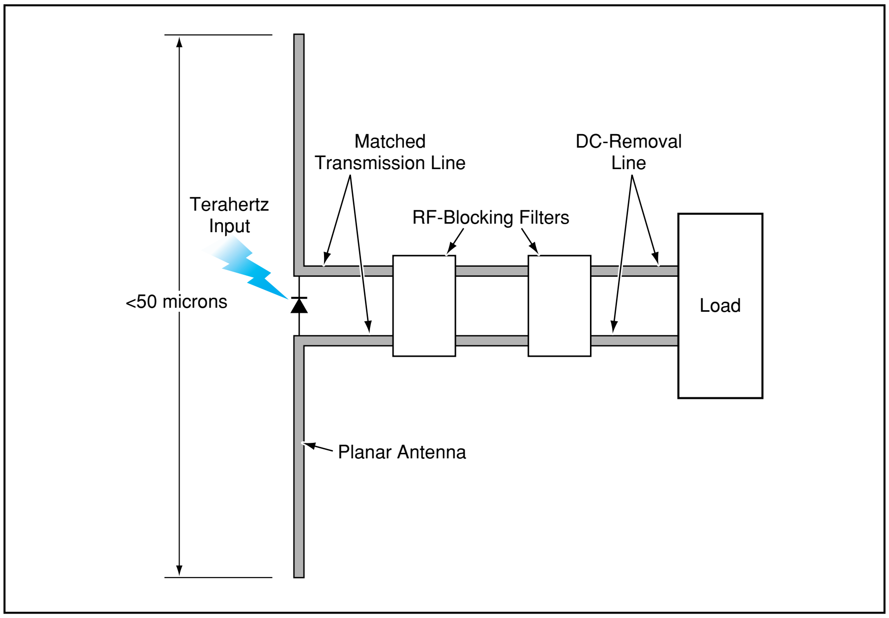
Power would be beamed at terahertz frequencies, using microscopic transmitting and receiving antennas.

NASA's Jet Propulsion Laboratory, Pasadena, California

Proposed integrated-circuit modules called "nanoconverters" would derive DC power from impinging electromagnetic beams having frequencies in the terahertz range. Nanoconverters are composed of microscopic antennas and diodes (see Figure 1) resembling rectennas that have been developed to perform the same function at frequencies in the gigahertz range. The submillimeter wavelength nanoconverters would make it possible to incorporate the antenna elements and diodes on structures much smaller than those of prior rectennas, thereby opening up opportunities for noncontact transmission of power to a variety of microelectronic devices, including surgically implanted medical devices and untethered microscopic robots.

The basic concept of radio beaming of electric power through space without the use of wires was explored before World War II and has been used at microwave frequencies. Novel aspects of the terahertz nanoconverter include:

1. Fully integrated monolithic rectennas at submillimeter dimensions,
2. Direct integration auto microrobots and devices,
3. Fairly high radio frequency (RF) to DC conversion efficiency with focusing optics,
4. Greater penetration in biomaterials and many plastics than infrared (IR) or visible wavelengths,
5. Negligible tissue damage due to nonresonant frequencies and low beam density, and
6. Fully integrated packages for direct RF in DC out.



An **Antenna-and-Diode Combination** (a rectenna) would convert power from an impinging terahertz radio beam to DC. The transmission line and RF filter confine the terahertz signal to the diode and allow DC to be removed.

Techniques, processes, and equipment needed for manufacturing circuitry with dimensions comparable to those of nanoconverters have already been developed for manufacturing GaAs-based sensors and sources at the frequencies. The nanoconverters could be used to remotely transmit power to microdevices in hostile environments or through smoke and dust.

This work was done by Peter Siegel of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP [see page 1].*
NPO-21229

MOS Circuitry Would Detect Low-Energy Charged Particles

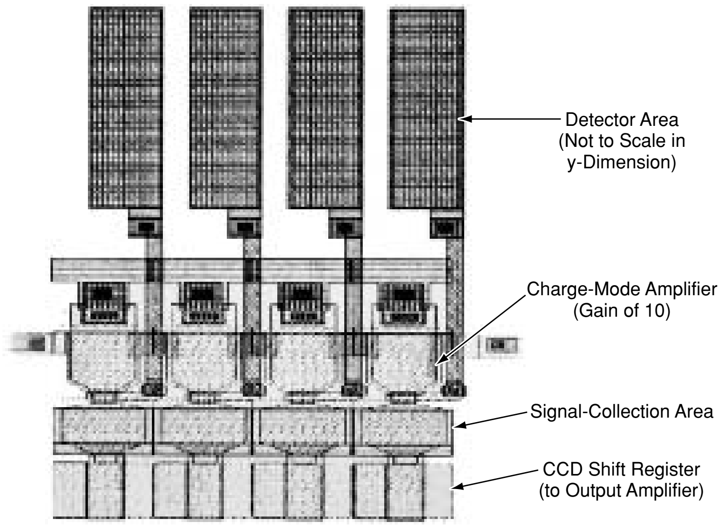
Conversion from ions to electrons, and photons, would not be necessary.

NASA's Jet Propulsion Laboratory, Pasadena, California

Metal oxide semiconductor (MOS) circuits for measuring spatially varying intensities of beams of low-energy charged particles have been developed. These circuits are intended especially for use in measuring fluxes of ions with spatial resolution along the focal planes of mass spectrometers. Unlike prior mass-spectrometer focal-plane detectors, these MOS circuits would not be based on ion-induced generation of electrons, and photons; instead, they would be based on direct detection of the electric charges of the ions. Hence, there would be no need for microchannel plates (for ion-to-electron conversion), phosphors (for electron-to-photon conversion), and photodetectors (for final detection) — components that degrade spatial resolution and contribute to complexity and size.

The developmental circuits are based on linear arrays of charge-coupled devices (CCDs) with associated readout circuitry (see figure). They resemble linear CCD photodetector arrays, except that instead of a photodetector, each pixel contains a capacitive charge sensor. The capacitor in each sensor comprises two electrodes (typically made of aluminum) separated by a layer of insulating material. The exposed electrode captures ions and accumulates their electric charges during signal-integration periods.

The CCD array is of a standard three-phase type. The array circuitry includes a shift register and a charge-mode input structure denoted a "fill-and-spill" structure. This structure provides the coupling through which the charge accumulated in each capacitive sensor gives rise to a packet of signal charge in the shift register. The fill-and-spill structure has previously been shown to keep the nonlinear component of response below –100 dB, with negligible offset. An ancillary benefit of the fill-and-spill design is elimination of a noise component proportional to kTC (where k is Boltzmann's constant, T is absolute temperature, and C is capacitance) that would be present if the charge-storage wells in the array were to be



A **Linear CCD Array** contains capacitive charge sensors (instead of photodetectors) in the detector areas. Four representative pixels of the array are shown here. The detector array has many pixels (e.g., 1,024 pixels for 25-mm long array).

filled via diode sources. By appropriate design, the fill-and-spill structure can be made to provide gain in the charge domain. The design under consideration at the time of reporting the information for this article is expected to provide a gain of 10.

The signal charges are clocked through the shift register in basically the same manner as that of a CCD photodetector array. After clocking through the array, the signal charge is presented to a charge-to-voltage-conversion output amplifier. Unlike in some CMOS photodetector circuits, there is only one such amplifier. This feature minimizes variations of signal gain and signal offset among pixels.

This work was done by Mahadeva Sinha and Mark Wadsworth 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

Intellectual Property group
JPL
Mail Stop 202-233
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2240

Refer to NPO-21168, volume and number of this NASA Tech Briefs *issue, and the page number.*

Contactless Rotary Electrical Couplings

Efficient inductive couplings are used in place of slip rings.

Ames Research Center, Moffett Field, California

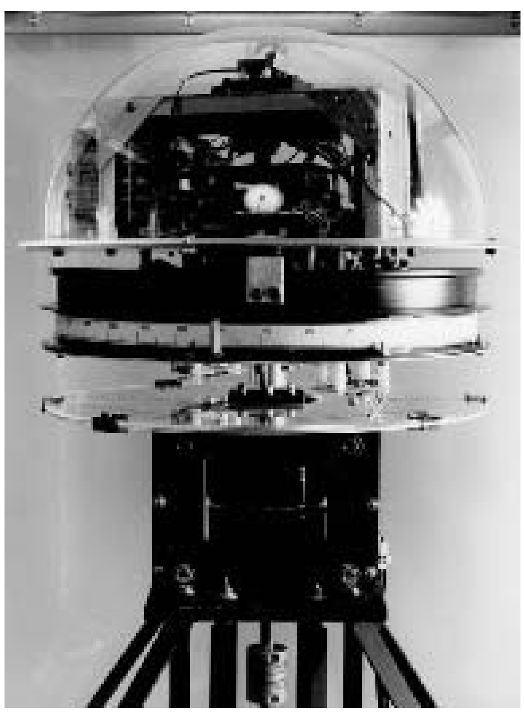


Figure 1. **Transformers, Instead of Slip Rings and Brush Contacts,** are used to couple ac power and data signals between stationary and rotating circuits.

Rotary electrical couplings based on induction (transformer action) rather than conduction between rotating and stationary circuitry have been invented. These couplings provide an alternative to slip rings and contact brushes.

Mechanical imperfections of slip-ring and brush contact surfaces and/or dust particles trapped between these surfaces tend to cause momentary interruptions in electrical contact and thereby give rise to electrical noise. This source of noise can be eliminated in the inductive rotary couplings because no direct contact is necessary for transformer action.

Figure 1 shows an example of the use of a rotary inductive coupling. In this application, it supplies power to a rotating digital data acquisition/transmission system test bed. The rotating data system is shown under the transparent dome and the data is transmitted via free-space optical data transmission through the dome. The rotary inductive coupling is shown in the lower half of the photograph. As in the case of conventional stationary transformers, the levels of power that can be transferred via inductive rotary couplings are limited only by con-