



Low-Loss Waveguides for Terahertz Frequencies

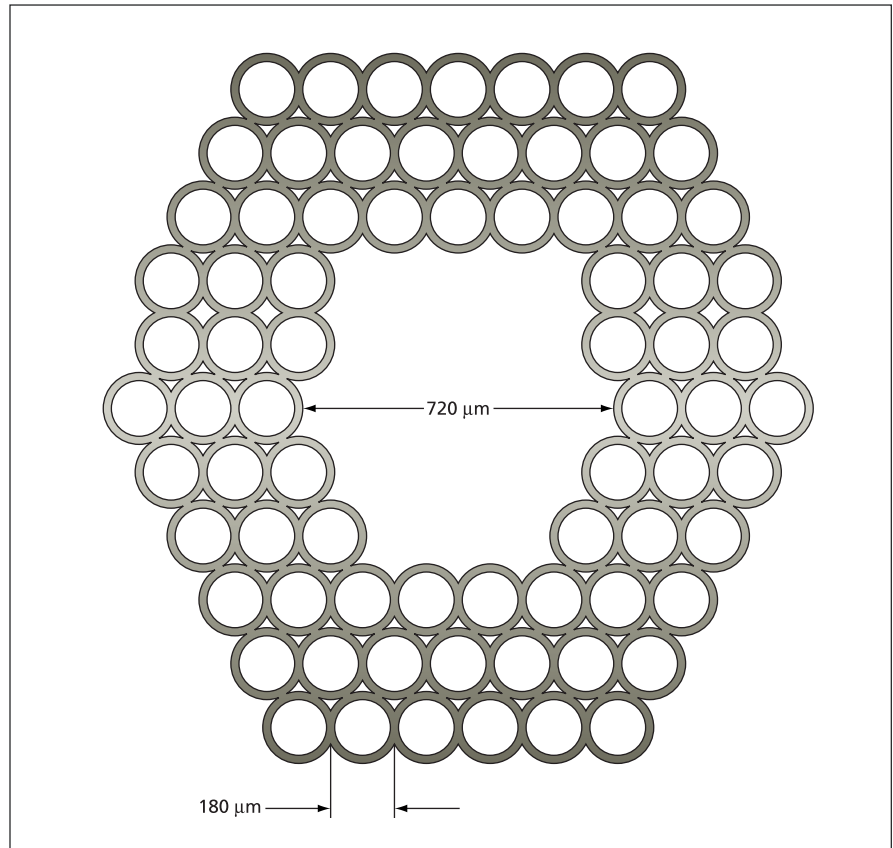
Low-loss, flexible conduits of terahertz power would be developed.

NASA's Jet Propulsion Laboratory, Pasadena, California

Hollow-core, periodic bandgap (HC-PBG) flexible waveguides have been proposed as a means of low-loss transmission of electromagnetic signals in the frequency range from about 300 GHz to 30 THz. This frequency range has been called the "terahertz gap" because it has been little utilized: Heretofore, there has been no way of low-loss guiding of terahertz beams other than by use of fixed-path optical beam guides with lenses and mirrors or multimode waveguides that cannot maintain mode purity around bends or modest discontinuities.

The terahertz HC-PBG waveguide concept utilizes a periodic bandgap structure surrounding a hollow single-mode core to transfer energy with low loss even around bends. The waveguide was developed to enable *in-vivo* applications for THz imaging and sensing at wavelengths from 10 microns to 1 mm, using flexible endoscopes and fiberscopes. Other potential applications include distribution of terahertz power and coupling of signals in general terahertz instrumentation. PBG structures have been developed for a wide range of traveling-wave applications in the microwave and optical regions of the electromagnetic spectrum.

The terahertz HC-PBG waveguide concept involves the same basic physical principles used to optimize infrared PBG structures, but at significantly increased length scales (corresponding to the greater terahertz wavelengths), and with somewhat different geometric arrangements and different materials appropriate to the intended applications. A representative proposed terahertz HC-PBG flexible waveguide (see figure) would comprise a hollow overmoded air or vacuum waveguide core surrounded by a flexible PBG honeycomb structure made of low-loss polyethylene, Teflon, quartz, or high-resistivity silicon tubing. The honeycomb structure would be designed to exhibit bandpass/band-stop behavior for electromagnetic fields of the guided wave penetrating into that structure, resulting



This **Cross Section** of a proposed HC-PBG flexible waveguide shows shapes and sizes optimized for propagation of electromagnetic waves in narrow frequency bands centered around 2.5 THz and 650 GHz — frequencies known to be useful for imaging applications and for which test equipment is available.

in the confinement of the wave within the core for frequencies within one or more desired propagation band(s). Because the core would be hollow and the periodic structure would be of a honeycomb nature, most of the electromagnetic power would propagate in air; therefore, propagation losses would be much lower than that of prior dielectric or metal waveguides.

A major advantage of the proposed structure is flexibility for bending or twisting the waveguide without appreciably distorting the internal electromagnetic fields. In designing this or a similar structure of the same type, the width of the hollow core could be chosen to accommodate insertion of a pyramidal or conical waveguide horn for

exciting the propagating field or coupling the field out to a detector or load.

This work was done by Peter Siegel, Cavour Yeh, Fred Shimabukuro, and Scott Fraser 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:

*Innovative Technology Assets Management
JPL*

*Mail Stop 202-233
4800 Oak Grove Drive
Pasadena, CA 91109-8099
(818) 354-2240*

*E-mail: iaoffice@jpl.nasa.gov
Refer to NPO-41299, volume and number of this NASA Tech Briefs issue, and the page number.*