



## Manufacturing & Prototyping

### High-Reliability Waveguide Vacuum/Pressure Window

**This design is suitable for commercial, military, and space applications requiring a helium-leak-tight vacuum pressure window.**

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

The NASA Deep Space Network (DSN) uses commercial waveguide windows on the output waveguide of Ka-band (32 GHz) low-noise amplifiers. Mechanical failure of these windows resulted in an unacceptable loss in tracking time.

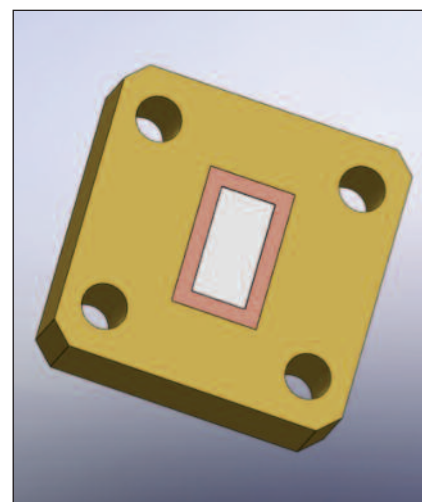
To address this issue, a new Ka-band WR-28 waveguide window has been designed, fabricated, and tested. The window uses a slab of low-loss, low-dielectric constant foam that is bonded into a  $\frac{1}{2}$ -wave-thick waveguide/flange. The foam is a commercially available, rigid, closed-cell polymethacrylimide. It has excellent electrical properties with a dielectric constant of 1.04, and a loss tangent of 0.01. It is relatively strong with a tensile strength of 1 MPa. The material is virtually impermeable to helium. The finished window exhibits a leak rate of less than  $3 \times 10^{-3}$  cm<sup>3</sup>/s with helium. The material is also chemically resistant and can be cleaned with acetone.

The window is constructed by fabricating a window body by brazing a short length of WR-28 copper waveguide into a standard rectangular flange, and machining the resulting part to a thickness of 4.6 mm. The foam is machined to a

rectangular shape with a dimension of 7.06×3.53 mm. The foam is bonded into the body with a two-part epoxy. After curing, the excess glue and foam are knife-trimmed by hand. The finished window has a loss of less than 0.08 dB (2%) and a return loss of greater than 25 dB at 32 GHz. This meets the requirements for the DSN application. The window is usable for most applications over the entire 26-to-40-GHz waveguide band. The window return loss can be tuned to a required frequency by varying the thickness of the window slightly.

Most standard waveguide windows use a thin membrane of material bonded into a recess in a waveguide flange, or sandwiched between two flanges with a polymer seal. Designs using the recessed window are prone to mechanical failure over time due to constraints on the dimensions of the recess that allow the bond to fail. Designs using the sandwich method are often permeable to helium, which prohibits the use of helium leak detection.

At the time of this reporting, 40 windows have been produced. Twelve are in operation with a combined operating time of over 30,000 hours without a failure.



A solid model of the completed Waveguide Window assembly.

*This work was done by Michael J. Britcliffe, Theodore R. Hanson, Ezra M. Long, and Steven Montanez of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48372*

### Methods of Fabricating Scintillators With Radioisotopes for Beta Battery Applications

**Applications for these power sources are implantable medical devices, power supplies for remote monitoring, and "trickle chargers" for consumer applications.**

*John H. Glenn Research Center, Cleveland, Ohio*

Technology has been developed for a class of self-contained, long-duration power sources called beta batteries, which harvest the energy contained in the radioactive emissions from beta decay isotopes. The new battery is a significant improvement over the conventional phosphor/solar cell concept for converting this energy in three ways. First, the thin phosphor is replaced with a thick scintillator that is transparent to

its own emissions. By using a scintillator sufficiently thick to completely stop all the beta particles, efficiency is greatly improved. Second, since the energy of the beta particles is absorbed in the scintillator, the semiconductor photodetector is shielded from radiation damage that presently limits the performance and lifetime of traditional phosphor converters. Finally, instead of a thin film of beta-emitting material, the isotopes

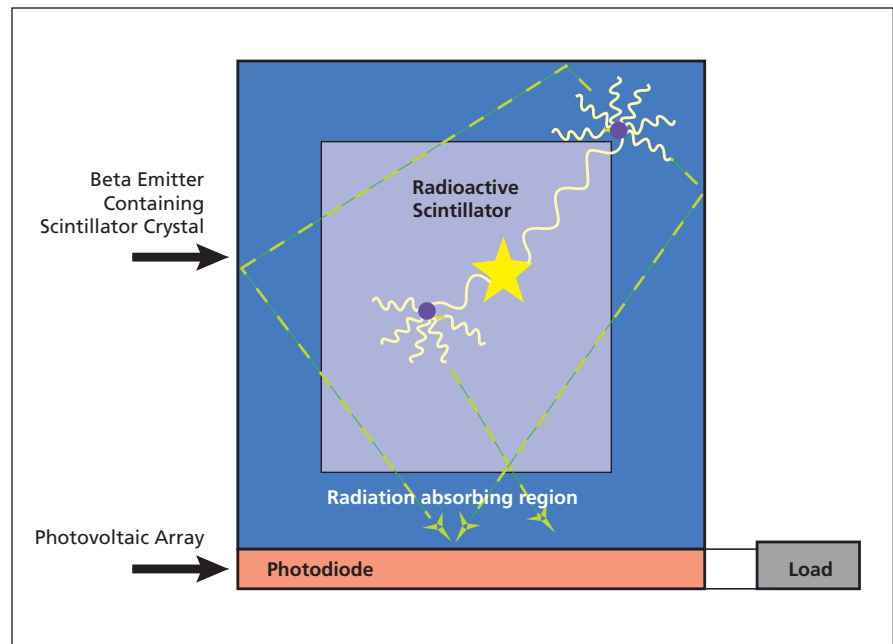
are incorporated into the entire volume of the thick scintillator crystal allowing more activity to be included in the converter without self-absorption.

There is no chemical difference between radioactive and stable strontium beta emitters such as Sr-90, so the beta emitter can be uniformly distributed throughout a strontium based scintillator crystal. When beta emitter material is applied as a foil or thin film to the sur-

face of a solar cell or even to the surface of a scintillator, much of the radiation escapes due to the geometry, and some is absorbed within the layer itself, leading to inefficient harvesting of the energy. In contrast, if the emitting atoms are incorporated within the scintillator, the geometry allows for the capture and efficient conversion of the energy of particles emitted in any direction. Any gamma rays associated with secondary decays or Bremsstrahlung photons may also be absorbed within the scintillator, and converted to lower energy photons, which will in turn be captured by the photocell or photodiode.

Some energy will be lost in this two-stage conversion process (high-energy particle to low-energy photons to electric current). The geometric advantage partially offsets this as well, since the absorption depth of high-energy beta radiation is much larger than the depth of a p-n junction. Thus, in a p-n junction device, much of the radiation is absorbed far away from the junction, and the electron-hole pairs are not all effectively collected. In contrast, with a transparent scintillator the radiation can be converted to light in a larger volume, and all of the light can be collected in the active region of the photodiode.

Finally, the new device is more practical because it can be used at much higher power levels without unduly shortening its lifetime. While the crystal structure of scintillators is also subject to radiation



The **Scintillator-Based Beta Battery**: Isotope containing scintillator and surrounding scintillator captures virtually all of the energy emitted by the beta emitter.

damage, their performance is far more tolerant of defects than that of semiconductor junctions. This allows the scintillator-based approach to use both higher energy isotopes and larger quantities of the isotopes. It is projected that this technology has the potential to produce a radioisotope battery with up to twice the efficiency of presently used systems.

*This work was done by Noa M. Rensing, Michael R. Squillante, Timothy C. Tiernan,*

*William Higgins, and Urmila Shirwadkar of Radiation Monitoring Devices, Inc. for Glenn Research Center. Further information is contained in a TSP (see page 1). LEW-18871-1*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18871-1.*

## Magnetic Shield for Adiabatic Demagnetization Refrigerators (ADR)

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

A new method was developed for creating a less expensive shield for ADRs using 1018 carbon steel. This shield has been designed to have similar performance to the expensive vanadium permen-

dur shields, but the cost is 30 to 50% less. Also, these shields can be stocked in a variety of sizes, eliminating the need for special forgings, which also greatly reduces cost.

*This work was done by Talso C. Chui and Nicolas E. Haddad of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-48732*