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

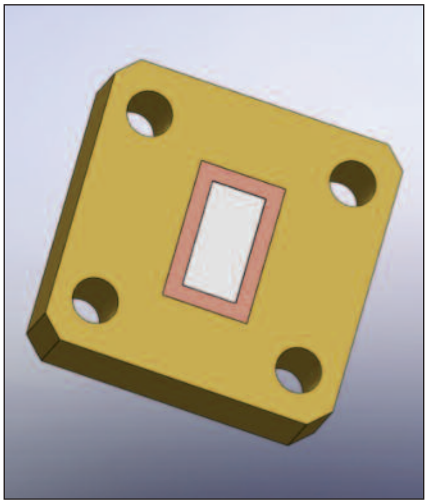
The NASA Deep Space Network (DSN) uses commercial waveguide windows on the output waveguide of Ka-band (32 GHz) low-noise amplifiers. Mechanical failure of these windows resulted in an unacceptable loss in tracking time.

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 ½-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 3×10^{-3} cm^3/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.

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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-