Environmental Qualification of a Single-Crystal Silicon Mirror for Spaceflight Use

Goddard Space Flight Center, Greenbelt, Maryland

This innovation is the environmental qualification of a single-crystal silicon mirror for spaceflight use. The single-crystal silicon mirror technology is a previous innovation, but until now, a mirror of this type has not been qualified for spaceflight use. The qualification steps included mounting, gravity change measurements, vibration testing, vibration-induced change measurements, thermal cycling, and testing at the cold operational temperature of 225 K.

Typical mirrors used for cold applications for spaceflight instruments include aluminum, beryllium, glasses, and glass-like ceramics. These materials show less than ideal behavior after cool-down. Single-crystal silicon has been demonstrated to have the smallest change due to temperature change, but has not been spaceflight-qualified for use. The advantage of using a silicon substrate is with temperature stability, since it is formed from a stress-free single crystal. This has been shown in previous testing. Mounting and environmental qualification have not been shown until this testing.

This work was done by John Hagopian, John Chambers, Scott Rohrbach, Vincent Bly, Armando Morell, and Jason Budinoff of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-16473-1

Planar Superconducting Millimeter-Wave/Terahertz Channelizing Filter

The design enables multiple-octave operation with no spurious harmonic response.

Goddard Space Flight Center, Greenbelt, Maryland

This innovation is a compact, superconducting, channelizing bandpass filter on a single-crystal (0.45 µm thick) silicon substrate, which operates from 300 to 600 GHz. This device consists of four channels with center frequencies of 310, 380, 460, and 550 GHz, with approximately 50-GHz bandwidth per channel. The filter concept is inspired by the mammalian cochlea, which is a channelizing filter that covers three decades of bandwidth and 3,000 channels in a very small physical space. By using a simplified physical cochlear model, and its electrical analog of a channelizing filter covering multiple octaves bandwidth, a large number of output channels with high inter-channel isolation and high-order upper stopband response can be designed.

A channelizing filter is a critical component used in spectrometer instruments that measure the intensity of light at various frequencies. This embodiment was designed for MicroSpec in order to increase the resolution of the instrument (with four channels, the resolution will be increased by a factor of four). MicroSpec is a revolutionary wafer-scale spectrometer that is intended for the SPICA (Space Infrared Telescope for Cosmology and Astrophysics) Mission. In addition to being a vital component of MicroSpec, the channelizing filter itself is a low-resolution spectrometer when integrated with only an antenna at its input, and a detector at each channel’s output.

During the design process for this filter, the available characteristic impedances, possible lumped element ranges, and fabrication tolerances were identified for design on a very thin silicon substrate. Iterations between full-wave and lumped-element circuit simulations were performed. Each channel’s circuit was designed based on the availability of characteristic impedances and lumped element ranges.

This design was based on a tabular type bandpass filter with no spurious har-