

HCl, and HF during thermal ISRU processing with hydrogen or other reducing gases. Removal of contaminant gases is required during ISRU processing to prevent hardware corrosion, electrolyzer damage, and catalyst poisoning. The use of Earth-supplied, single-use consumables to entirely remove contaminants at the levels existing in lunar soils would make many ISRU processes unattractive due to the large mass of consumables relative to the mass of oxygen produced. The LSCS concept of using a primary sorbent prepared from lunar soil was identified as a method by which the ma-

majority of contaminants could be removed from process gas streams, thereby substantially reducing the required mass of Earth-supplied consumables.

The LSCS takes advantage of minerals containing iron and calcium compounds that are present in lunar soil to trap sulfur and halide gases in a fixed-bed reactor downstream of an in-ISRU process such as hydrogen reduction. The lunar-soil-sorbent trap is held at a temperature significantly lower than the operating temperature of the hydrogen reduction or other ISRU process in order to maximize capture of

contaminants, but is held at a high enough temperature to allow moisture to pass through without condensing. The lunar soil benefits from physical beneficiation to remove ultrafine particles (to reduce pressure drop through a fixed bed reactor) and to upgrade concentrations of iron and/or calcium compounds (to improve reactivity with gaseous contaminants).

*This work was done by Mark Berggren, Robert Zubrin, and Emily Bostwick-White of Pioneer Astronautics for Kennedy Space Center. Further information is contained in a TSP (see page 1). KSC-13233/615*

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## 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 sin-

gle 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 Rohrback, 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*

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## 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  $\mu\text{m}$  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 out-

put channels with high inter-channel isolation and high-order upper stop-band 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 chan-

nelizing 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-