Manufacturing & Prototyping

Single-Layer, All-Metal Patch Antenna Element With Wide Bandwidth

This design is suitable for military and commercial environments with high ESD susceptibility.

NASA's Jet Propulsion Laboratory, Pasadena, California

It is known that the impedance at the center of a patch antenna element is a short circuit, implying that a wire or post can be connected from the patch to the groundplane at this point without impacting radiation performance. In principle, this central post can be used to support the patch element, thus eliminating the need for dielectric. In spaceborne applications, this approach is problematic because a patch element supported by a single, thin post is highly susceptible to acoustic loads during launch.

The technology reported here uses a large-diameter center post as its supporting structure. The supporting structure allows for the fabrication of a sufficiently rigid antenna element that can survive launch loads. The post may be either hollow or solid, depending on fabrication approach and/or mass constraints. The patch antenna element and support post are envisioned as being fabricated (milled) from a single piece of aluminum or other metal. Alternately, the patch plate and support column can be fabricated separately and then joined using fasteners, adhesive, or welding. Casting and electroforming are also viable techniques for manufacturing the metal patch part(s). The patch structure is then either bonded or fastened to the supporting groundplane. Arrays of patch elements can be fabricated by attaching several structures to a common groundplane/support structure.

Patch antennas can be fed in a number of different ways; the current design is envisioned as being fed from a coaxial probe, the connector of which is attached to the backside of a supporting groundplane. The probe can be either soldered to the patch or attached by means of a slip-fit connector assembly in the patch. The latter approach provides stress relief for the probe attachment during launch. The thickness of the patch material, interconnect technique, and attachment technique will depend on individual mass and launch load requirements. Alternatively, techniques such as aperture coupling or proximity coupling could be used to feed the patch.

The all-metal design eliminates the use of dielectric in patch substrate, making it suitable to environments with high electrostatic discharge (ESD) susceptibility. Elimination of dielectric also makes the tuning of the element largely independent of material properties (principally permittivity) and eliminates dielectric losses, which become appreciable at high frequencies. This simplifies the design and modeling of the antenna element. Concurrence between measurements and modeling is thus driven by the fidelity of the modeling software and fabrication tolerances (as opposed to material properties). Additionally, the large central support column has been shown to increase the bandwidth of the element to 20% without significantly affecting the radiation pattern performance. Typically, a stacked patch design is used to obtain an impedance bandwidth of 20% or more. While the new technology was conceived for the purpose of eliminating dielectric from the patch-radiating element, a large-diameter ground post could be added to dielectric-based patch designs to increase bandwidth without having to add extra radiating layers. The new design has good cross-polarization suppression (better than 50 dB) because of the symmetry of the design.

This work was done by Neil F. Chamberlain, Richard E. Hodges, and Mark S. Zawadzki of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Management Office–JPL. Refer to NPO-46843.

Scanning Laser Infrared Molecular Spectrometer (SLIMS)

This instrument can be used in any application requiring chemical sensing.

NASA's Jet Propulsion Laboratory, Pasadena, California

This prototype innovation is a novel design that achieves very long, effective laser path lengths that are able to yield ppb (parts per billion) and sub-ppb measurements of trace gases. SLIMS can also accommodate multiple laser channels covering a wide range of wavelengths, resulting in detection of more chemicals of interest. The mechanical design of the mirror cell allows for the large effective path length within a small footprint. The same design provides a robust structure that lends itself to being immune to some of the alignment challenges that similar cells face.

By taking a hollow cylinder and by cutting an elliptically or spherically curved surface into its inner wall, the basic geometry of a reflecting ring is created. If the curved, inner surface is diamond-turned and highly polished, a surface that is very highly reflective can be formed. The surface finish can be further improved by adding a thin chrome or gold film over the surface. This creates a high-quality, curved, mirrored surface. A laser beam, which can be injected from a small bore hole in the wall of the cylinder, will be able to make many low-loss bounces around the ring, creating a large optical path length.

The reflecting ring operates on the same principle as the Herriott cell. The difference exists in the mirror that doesn't have to be optically aligned, and which has a relatively large, internal surface area that lends itself to either open air or evacuated spectroscopic measurements. This solid, spherical ring mirror removes the possibility of mirror misalignment caused by thermal expansion or vibrations, because there is only a single, solid reflecting surface. Benefits of the reflecting ring come into play when size constraints reduce the size of the system, especially for space missions in which mass is at a premium.

This work was done by David C. Scott, Kelly Rickey, Alexander Ksendzov, Warren P. George, and Abdullah S. Aljabri of Caltech; and Joel M. Steinkraus of Cal Poly for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

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
E-mail: iaoffice@jpl.nasa.gov

Refer to NPO-47512, volume and number of this NASA Tech Briefs *issue, and the page number.*

Next-Generation Microshutter Arrays for Large-Format Imaging and Spectroscopy

Goddard Space Flight Center, Greenbelt, Maryland

A next-generation microshutter array, LArge Microshutter Array (LAMA), was developed as a multi-object field selector. LAMA consists of small-scaled microshutter arrays that can be combined to form large-scale microshutter array mosaics. Microshutter actuation is accomplished via electrostatic attraction between the shutter and a counter electrode, and 2D addressing can be accomplished by applying an electrostatic potential between a row of shutters and a column, orthogonal to the row, of counter electrodes. Microelectromechanical system (MEMS) technology is used to fabricate the microshutter arrays.

The main feature of the microshutter device is to use a set of standard surface micromachining processes for device fabrication. Electrostatic actuation is used to eliminate the need for macromechanical magnet actuating components. A simplified electrostatic actuation with no macro components (e.g. moving magnets) required for actuation and latching of the shutters will make the microshutter arrays robust and less prone to mechanical failure. Smaller-size individual arrays will help to increase the yield and thus reduce the cost and improve robustness of the fabrication process. Reducing the size of the individual shutter array to about one square inch and building the large-scale mosaics by tiling these smaller-size arrays would further help to reduce the cost of the device due to the higher yield of smaller devices.

The LAMA development is based on prior experience acquired while developing microshutter arrays for the James Webb Space Telescope (JWST), but it will have different features. The LAMA modular design permits large-format mosaicking to cover a field of view at least 50 times larger than JWST MSA. The LAMA electrostatic, instead of magnetic, actuation enables operation cycles at least 100 times faster and a mass significantly smaller compared to JWST MSA. Also, standard surface micromachining technology will simplify the fabrication process, increasing yield and reducing cost.

This work was done by Samuel Moseley, Alexander Kutyrev, Ari Brown, and Mary Li of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-16000-1