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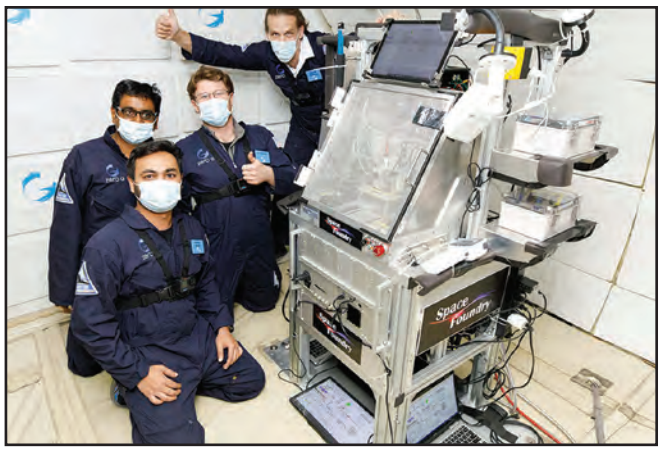
Beyond the Board: 3D Plasma Jet Printing in Space

By Michael Skinner, Editor

PHOENIXVILLE, PA — Today there are roughly 6,500 satellites orbiting the Earth, growing in number at a rate of around 1,000 per year. Several companies, such as Amazon, Starlink, OneWeb, and Telesat, have made ambitious plans to deliver tens of thousands of satellites into orbit over the next decade. These companies are in furious competition to create the largest, fastest, highest-bandwidth wireless network, available anywhere in the world, and in space.



Space Foundry's Ram Prasad Gandhiraman and senior engineers test plasma 3D printing during parabolic flight.

Maximizing each launch and payload delivery mission is key to success or failure. But, without physical access to the satellites after launch, there are few options available for maintenance, repair, or for building auxiliary equipment in orbit.

Now, a new method of printing electronic components developed by startup Space Foundry, promises to simplify the construction of electronics both on Earth and in space.

3D Plasma Jet Printing

With help from NASA, Space Foundry has designed a plasma-based 3D printing process for electronics that has a number of advantages over other techniques. For one, it's a single-step approach that doesn't require heat or ultraviolet curing, as other methods do.

Eliminating the curing step, especially in space, "is huge logistically because you have to plan everything around astronaut up time," says Ian Small, an electrical engineer at NASA's Marshall Space Flight Center in Huntsville, Alabama.

Post-print curing can also be a challenge on Earth, where, in addition to the added infrastructure needed for curing, some of the printed materials oxidize quickly in the atmosphere. Copper, for example, which is useful in electronics because it's highly conductive, is a challenge to cure and difficult to print on temperature-sensitive platforms.

Space Foundry has developed the hardware,

Continued on page 6

"Opto-Ionic" Effect May Improve Batteries

MUNICH, GERMANY — Lithium-ion batteries, fuel cells and many other devices depend on the high mobility of ions in order to work properly. But there are a large number of obstacles to such mobility. A research team led by Jennifer L. M. Rupp of the Technical University of Munich (TUM) and Harry L. Tuller of the Massachusetts Institute of Technology (MIT) have now shown for the first time that light can be used to increase the mobility of ions and improve the performance of such devices.

A charge can be transported by a material in a number of different ways. The most familiar is the electrical conductivity of metals, where the charge is borne by electrons. However, ceramics are currently being investigated as solid electrolytes for transporting oxygen ions.

Ions on the Go

In their current publication Tuller and his colleague Jennifer L. M. Rupp, Professor for solid-state electrolyte chemistry at the Technical University of Munich, shows how light can be used to reduce the barriers encountered by ions at ceramic grain boundaries.

Many devices based on ion conductivity, such as solid-oxide fuel cells, have to operate at very high temperatures in order for the ions to be able to overcome

Continued on page 8

Microchips for Quantum Secure Encryption

ST. LOUIS, MO — It's fairly reasonable to assume that an encrypted email can't be seen by prying eyes. That's because in order to break through most of the encryption systems we use on a day-to-day basis, unless you are the intended recipient, you'd need the answer to a mathematical problem that's nearly impossible for a computer to solve in a reasonable amount of time.

Nearly impossible for modern-day computers, at least.

"If quantum computing becomes a reality, however, some of those problems are not hard any-

Continued on page 8

NASA Launches mmWave Systems to New Heights

By Greg Rankin

For both space and terrestrial mmWave applications, new hybrid designs enable maximum use of bandwidth while maintaining high isolation. However, the lack of high-performance components in higher mmWave bands (50 to 500 GHz) is limiting the ability to take full advantage of these frequencies.

NASA, for one, has invested a lot of energy in trying to solve the issue. One focus has been on developing a new generation of mmWave circulators suitable for use in spacecraft instrumentation.

Circulators are primarily used in transmit-receive systems such as point-to-point radio and radar. They allow a transmitter and receiver to share a common antenna while simultaneously isolating the transmitter and receiver from each other. Thus, a high-power signal from a transmitter does not damage a sensitive receiver. The greater the isolation, the better.

New hybrid circulators are able to transmit greater amounts of data for space applications.

However, at the higher mmWave frequencies, the state-of-the-art Y-junction circulator is effective only within a very narrow bandwidth. Using a Y-junction circulator can place a severe bandwidth limitation on the entire system.

A new type of circulator, dubbed the "hybrid circulator," can theoretically cover entire waveguide bands with relatively low insertion loss and more than 20 dB of isolation. The hybrid circulator will enable designers to push greater volumes of data through systems operating in the upper regions of the mmWave spectrum.

Stretching the limits

The hybrid circulator is being developed by Micro Harmonics Corporation of Fincastle, Virginia. Their initial prototypes were designed to cover the 150-190 GHz band in WR-5 and were assembled and tested in early 2021.

The measured insertion loss was less than 2.2 dB and the isolation was greater than 20 dB across the entire 150 to 190 GHz band.

For comparison, a state-of-the-art Y-junction circulator operating at 160 GHz has a 20 dB bandwidth near 3 GHz and a slightly higher insertion loss than the hybrid. The bandwidth of the hybrid circulator is thus an order of magnitude greater than that of the Y-junction.

The new hybrid circulator gives microwave engineers the option of specifying one component that can operate over multiple bands, making instrument architecture much easier. The hybrid circulators are quickly finding application. NASA's Cloud Radar System group — based at the Jet Propulsion Laboratory (JPL) in California — is currently exploring their use in weather radars.

JPL utilizes circulators in

Continued on next page

NASA Launches mmWave Systems to New Heights

Continued from previous page

their high-altitude aircraft and high-throughput satellite communication systems for measuring cloud properties and upper atmospheric constituents. Some of these systems operate in the G-band (167 to 175 GHz) with development also planned at frequencies near 240 GHz and beyond. Y-junction circulators are not manufactured at these frequencies due to the extreme sensitivity of the center frequency to small variations in the dimensions of the ferrite core. But the hybrid circulator can easily reach the WR-2.8 band 260 to 400 GHz and possibly beyond.

The Y-junction has been the dominant circulator technology for more than 50 years. The Y-junction circulator comprises a magnetically biased ferrite core located at the convergence of three waveguides. But the hybrid circulator achieves the circulator function in an entirely different way which overcomes the inherent bandwidth limitations in the Y-junction.

Micro Harmonics' patent-pending design combines an orthomode transducer (OMT) with a Faraday rotator. Both the OMT and Faraday rotator are inherently broadband devices. When properly configured, these components interact to create the circulator function over full rectangular waveguide bandwidths.

While opening up mmWave bands for terrestrial applications, hybrid circulators also possess characteristics that qualify them for deep space. Improvements in amplifier technology are allowing higher and higher transmit power levels.

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Transient Voltage Suppressors Offer ESD Protection for Advanced Electronics

Continued from page 57

channel array package; therefore array package TVS can be easily used for some applications like USB, HDMI or DisplayPort. In addition, TVS is manufactured by semiconductor process, so there is no aging issue of it.

Nowadays, because IC is manufactured by advanced semiconductor processes and embedded more transistors in it, IC is more susceptible to the disturbance from the surroundings than before.

High voltage transient events may induce system unpredictable reactions and it may result in temporary software faults or permanently hardware damage.

Besides, more companies regard "pin injection" as an ESD qualification method. This is a rigorous ESD contact discharge method used to simulate customers' operation like cable or portable device plugging.

TVS is the best solution for protecting the system from ESD events because of its low trigger voltage and low clamping voltage. Low trigger voltage of a TVS makes it trigger immediately once there is a transient high voltage.

After TVS is triggered, it will clamp the voltage at suitable level to keep the system working normally or prevent it from damage. Then TVS will turn off, and wait for another transient event.

The scaling trend of the semiconductor industry leads to a reduction in IC component-level ESD robustness. The phenomenon that system-level protection devices change varistors to TVS shows that external protection is now more important than ever.

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