Air Force SBIR/STTR

Innovation

Air Force SBIR/STTR Innovation Story

SBIR Topic Number:
AF06-216

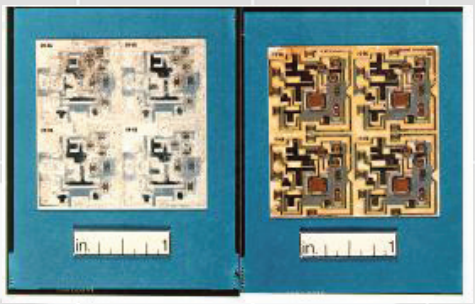
SBIR Title:
Coatings for Millimeter Wave (MMW) Electronics

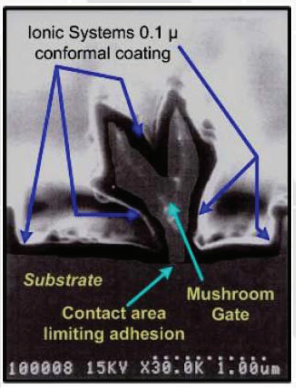
Contract Number:
FA8650-08-C-1305

SBIR Company Name:
Ionic Systems, Inc., San Jose, CA

Technical Project Office:
AFRL Sensors Directorate, Wright-Patterson AFB, OH

This Air Force SBIR/STTR Innovation Story is an example of Air Force supported SBIR/STTR technology that met topic requirements and has outstanding potential for Air Force and DoD.





Left: Ford pressure sensors after life test. Device on right coated with Ionic Relseal (Photo courtesy of Hughes Radar Systems Group, El Segundo, California). Right: Mushroom Gate on gallium arsenide (GaAs) (Photo courtesy of Power Spectra, Sunnyvale, California)

Reliability Without Hermeticity for Millimeter Wave Devices

- The Air Force needs alternative packaging approaches for future, high frequency (GHz/THz) electronics, especially for large area, flexible Millimeter Wave (MMW) assemblies where arrays of electronic chips will be assembled without packaging; a material with an ultra-low dielectric constant is needed that can provide military robustness to monolithic microwave integrated circuit (MMIC) devices without a need for hermetic packaging
- This technology approach has the potential to reduce cost and size of high frequency electronics in major programs while providing equal or better reliability and performance
- Under this SBIR project, a nanocomposite with an ultra low dielectric constant was developed and applied to MMIC devices, and it was independently confirmed that no measurable loading was exhibited from application of the coating
- The technology has been used by the National Aeronautics and Space Administration (NASA) and discussions are underway with several defense contractors concerning continued development opportunities for Department of Defense applications

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Air Force Requirement

The Air Force needs alternative packaging approaches for future, high frequency (GHz/THz) electronics, especially for large area, flexible Millimeter Wave (MMW) assemblies where arrays of electronic chips will be assembled without packaging. These coatings must be low cost, lightweight, conformal to the surface topography, and with minimal loading effects (requiring ultra low dielectric) at MMW operational frequencies.

Specifically, a material with an ultra low dielectric constant is needed that can provide military robustness to monolithic microwave integrated circuit (MMIC) devices without a need for hermetic packaging.

SBIR Technology

During this SBIR project, a nanocomposite with an ultra low dielectric constant was developed by Ionic Systems, Inc., and applied to MMIC devices. It was independently confirmed that no measurable loading on MMIC devices was exhibited from application of the coating. Verification that the dielectric material provided reliable hermetic protection to the circuits was accomplished through a series of accelerated life tests. In Phase II, 1000 hours of life testing demonstrated that the nanocomposite provided hermetic-like protection on assembled MMIC devices.

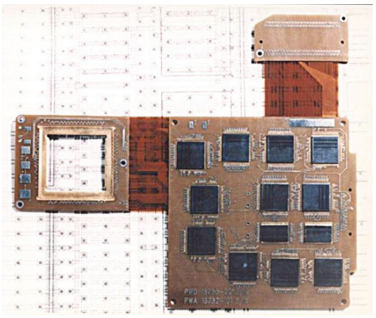
Ionic Systems designed a low-temperature plasma enhanced chemical vapor deposition (PECVD) reactor capable of creating nanocomposite films. The nanocomposite films are mesoscale semiconductor atomic clusters, self assembled in a binding matrix. The PECVD technique is used to self assemble a nanocomposite and engineer its material properties on a molecular level leading to advanced bulk properties.

Potential Application

The hermetic low dielectric barrier film offers a lower cost alternative to ceramic packaging for high frequency devices. Instead of ceramic conventional packaging, devices as well as bare die and large-scale mixed chip-on-board (COB) assemblies may now be hermetically protected with the nanocomposite barrier film and low cost, lightweight plastic packages alone.

This approach has the potential to reduce the cost and size of high frequency electronics in major programs while providing equal or better reliability and performance. The dielectric constant of the developed barrier material provides a path to low cost protection of both current MMIC devices and for generations of future devices/systems.

The National Aeronautics and Space Administration (NASA) used an early variation of this barrier coating technology on all of the Source/Loss Cone Energetic Particle Spectrometer (SEPS) instruments. A Lockheed large-scale hybrid assembly with flexible connectors and detectors was assembled with only an Ionic Systems barrier film (RelSeal) for hermetic protection. Twelve instrument packages made up the flight hardware. The NASA-Goddard Space Flight Center approved the use of the thin film alternative environmental protection technology. The board is on NASA's Polar satellite operating continuously in low earth orbit since launch in 1996. This early material was only a hermetic barrier film and not an ultra low dielectric constant material.



Mockup of Lockheed SEPS spectrometer without detector. Flight hardware flown on Polar Satellite. (Photo courtesy of Lockheed Palo Alto Research Laboratory)

Discussions are underway with several defense contractors for continued development and incorporation into Department of Defense (DoD) systems which will produce savings on future programs.

Company Impact

Dr. R.M. Kubacki, President, Ionic Systems, Inc., states, "The SBIR program has given Ionic Systems the opportunity to demonstrate our advanced molecular engineering technology. This program has demonstrated that, after years of development by Ionic Systems, design rules are now available to engineer material properties on a custom basis determined by the application. Within the SBIR timeframe, a material with both an ultra-low dielectric constant and superior barrier properties was designed, produced and demonstrated. Defense contractors who have expressed interest in our technology are being contacted for further collaboration and commercialization dialogue. This SBIR program for the Air Force not only achieved the lowest reported dielectric constant for a complementary metal-oxide semiconductor (CMOS) compatible material but also has permitted us to discuss additional commercial opportunities for custom material development with potential adopters."

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