layer to serve as a template for epitaxial growth. The third was a 3-μm-thick GaN epilayer containing electron-donor (n) doping at a density of 4.8×10^{18} cm^{-3}. The fourth was a 0.75-μm-thick GaN epilayer n-doped at a density of $\approx 10^{16}$ cm^{-3}.

Four masks were used to define features of devices having Schottky contact areas ranging up to the aforementioned maximum of 1 cm square. Mesas (one for each device) were first defined by use of conventional photolithography and chlorine-bromine reactive-ion etching for complete removal of the n epilayer. Metal patterns, each consisting of a 10-nm-thick layer of Ti followed by a 10-nm-thick layer of Ni followed by a 150-nm-thick layer of Al, were defined at the bottoms of the mesas by means of a lift-off procedure and electron-beam evaporation. These metal patterns were annealed at a temperature of 500 °C for 10 minutes in flowing nitrogen to form ohmic contacts.

Next, semitransparent Pt Schottky contacts having a thickness of 10 nm were defined on the tops of the mesas by means of a lift-off procedure. Contact rings, each consisting of a 30-nm-thick layer of Pt followed by a 150-nm-thick layer of Au, were formed on the peripheries of the semitransparent Pt Schottky areas by electron-beam evaporation and lift-off.

In preliminary tests of the electrical characteristics of these devices, forward and reverse current-vs.-voltage characteristics were measured in a dark enclosure. The measurements confirmed that as desired, these devices are characterized by low levels of dark current at low reverse bias voltage: For example, one device having an active area of 0.25 cm^2 exhibited a leakage current density of only 14 pA/cm^2 at a reverse bias of 0.5 V (see figure).

This work was done by Shahid Aslam and David Franz of Raytheon Co. for Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-14777-1

Fiber Bragg Grating Sensor System for Monitoring Smart Composite Aerospace Structures

Dryden Flight Research Center, Edwards, California

Lightweight, electromagnetic interference (EMI) immune, fiber-optic, sensor-based structural health monitoring (SHM) will play an increasing role in aerospace structures ranging from aircraft wings to jet engine vanes. Fiber Bragg Grating (FBG) sensors for SHM include advanced signal processing, system and damage identification, and location and quantification algorithms. Potentially, the solution could be developed into an autonomous onboard system to inspect and perform non-destructive evaluation and SHM.

A novel method has been developed to massively multiplex FBG sensors, supported by a parallel processing interrogator, which enables high sampling rates combined with highly distributed sensing (up to 96 sensors per system). The interrogation system comprises several subsystems. A broadband optical source subsystem (BOSS) and routing and interface module (RIM) send light from the interrogation system to a composite embedded FBG sensor matrix, which returns measurand-dependent wavelengths back to the interrogation system for measurement with subpicometer resolution. In particular, the returned wavelengths are channeled by the RIM to a photonic signal processing subsystem based on powerful optical chips, then passed through an optoelectronic interface to an analog post-detection electronics subsystem, digital post-detection electronics subsystem, and finally via a data interface to a computer.

A range of composite structures has been fabricated with FBGs embedded. Stress tensile, bending, and dynamic strain tests were performed. The experimental work proved that the FBG sensors have a good level of accuracy in measuring the static response of the tested composite coupons (down to submicrostrain levels), the capability to detect and monitor dynamic loads, and the ability to detect defects in composites by a variety of methods including monitoring the decay time under different dynamic loading conditions.

In addition to quasi-static and dynamic load monitoring, the system can capture acoustic emission events that can be a prelude to structural failure, as well as piezoactuator-induced ultrasonic Lamb-waves-based techniques as a basis for damage detection.

This work was done by Behzad Moslehi and Richard J. Black of Intelligent Fiber Optic Systems Corp. and Yasser Gowayed of Auburn University for Dryden Flight Research Center. Further information is contained in a TSP (see page 1). DRC-011-004

Health-Enabled Smart Sensor Fusion Technology

Stennis Space Center, Mississippi

A process was designed to fuse data from multiple sensors in order to make a more accurate estimation of the environment and overall health in an intelligent rocket test facility (IRTF), to provide reliable, high-confidence measurements for a variety of propulsion test articles.

The object of the technology is to provide sensor fusion based on a distributed architecture. Specifically, the fusion technology is intended to succeed in providing health condition monitoring capability at the intelligent transceiver, such as RF signal strength, battery reading, computing resource monitoring, and sensor data reading. The technology also provides analytic and diagnostic intelligence at the intelligent transceiver, enhancing the IEEE 1451.x-based standard for sensor data management and distributions, as well as providing appropriate communications protocols to enable complex interactions to support timely and high-quality flow of information among the system elements.

Troubleshooting is simplified through sensor fusion that allows users to interface and verify all sensors via Web-based interfaces. Confidence is improved in decisions due to the use of fusion algorithms. Performance is improved in adverse environmental conditions. Costs for setup and teardown are reduced. Recalibration when replacing sensors is not required as the data acquisition system can autonomously recalibrate itself. The costs for installation, maintenance, and upgrades for measurement and control systems are also reduced.

This work was done by Ray Wang of Mobitrum Corporation for Stennis Space Center. For more information, contact Ray Wang, Mobitrum Corporation, (301) 585-4040. Refer to SSC-00361.

Extended-Range Passive RFID and Sensor Tags

SAW devices and retroreflective antenna arrays are combined.

Lyndon B. Johnson Space Center, Houston, Texas

Extended-range passive radio-frequency identification (RFID) tags and related sensor tags are undergoing development. A tag of this type incorporates a retroreflective antenna array, so that it reflects significantly more signal power back toward an interrogating radio transceiver than does a comparable passive RFID tag of prior design, which does not incorporate a retroreflective antenna array. Therefore, for a given amount of power radiated by the transmitter in the interrogating transceiver, a tag of this type can be interrogated at a distance greater than that of the comparable passive RFID or sensor tag of prior design.

The retroreflective antenna array is, more specifically, a Van Atta array, named after its inventor and first published in a patent issued in 1959. In its simplest form, a Van Atta array comprises two antenna elements connected by a transmission line so that the signal received by each antenna element is reradiated by the other antenna element (see Figure 1). The phase relationships among the received and reradiated signals are such as to produce constructive interference of the reradiated signals; that is, to concentrate the reradiated signal power in a direction back toward the source. Hence, an RFID tag equipped with a Van Atta antenna array automatically tracks the interrogating transceiver. The effective gain of a Van Atta array is the same as that of a traditional phased antenna array having the same number of antenna elements. Additional pairs of antenna elements connected by equal-length transmission lines can be incorporated into a Van Atta array to increase its directionality.

Like some RFID tags heretofore commercially available, an RFID or sensor tag of the present developmental type includes one-port surface-acoustic-wave (SAW) devices. In simplified terms, the mode of operation of a basic one-port

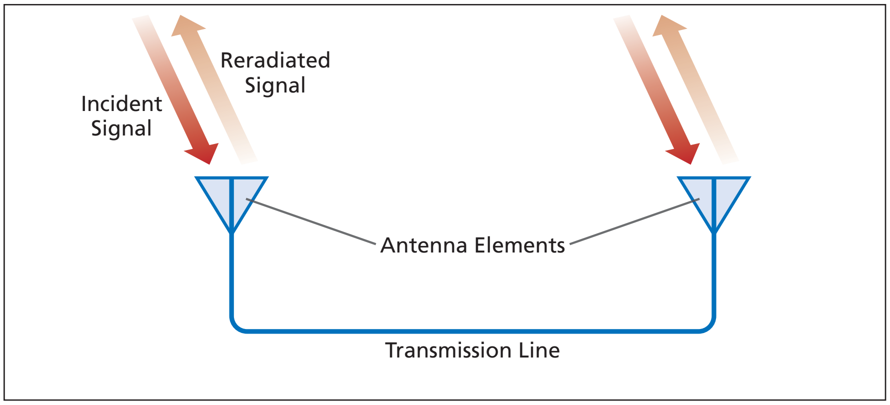

Figure 1. A **Van Atta Array** in its simplest form, comprising two antenna elements connected via a transmission line, exhibits partial retroreflection of an incident radio signal. If more pairs of antennas connected by equal-length transmission lines are added, the array becomes more nearly completely retroreflective.

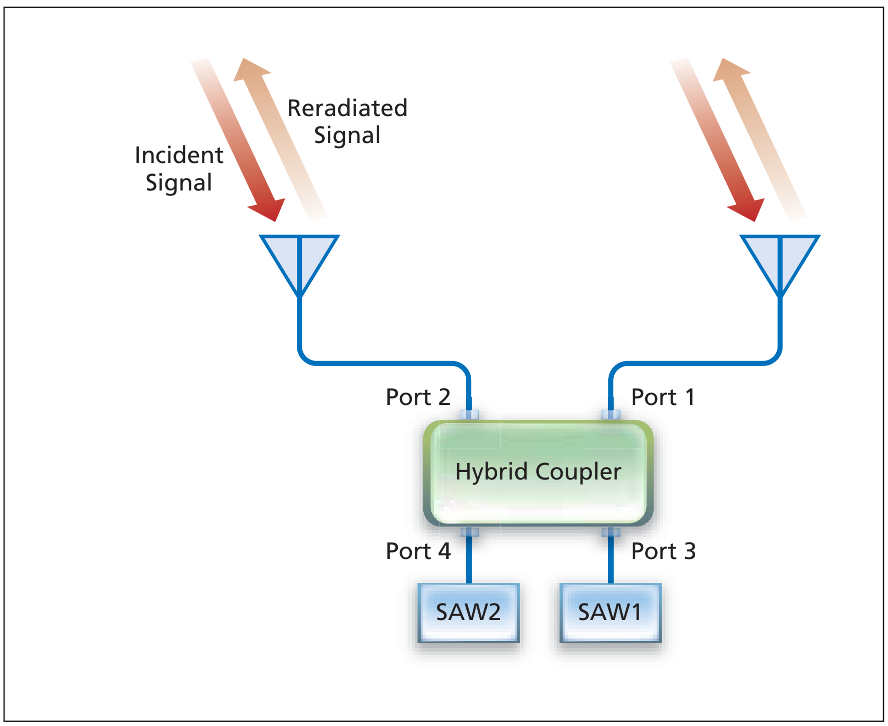

Figure 2. An **Extended-Range Passive RFID or Sensor Tag** in its simplest form includes two antenna elements and two SAW devices incorporated into a Van Atta array by use of a hybrid 90° coupler. A more highly directional (and, hence, longer-range) tag would incorporate additional subunits, each incorporating a similar pair of SAW devices and a similar pair of antenna elements connected via a hybrid 90° coupler.