



## Electronics/Computers

### Highly Efficient Multilayer Thermoelectric Devices

Temperature differences as great as 50 K can be produced at or near room temperature.

*Goddard Space Flight Center, Greenbelt, Maryland*

Multilayer thermoelectric devices now at the prototype stage of development exhibit a combination of desirable characteristics, including high figures of merit and high performance/cost ratios. These devices are capable of producing temperature differences of the order of 50 K in operation at or near room temperature. A solvent-free batch process for mass production of these state-of-the-art thermoelectric devices has also been developed.

Like prior thermoelectric devices, the present ones have commercial potential mainly by virtue of their utility as means of controlled cooling (and/or, in some cases, heating) of sensors, integrated circuits, and temperature-critical components of scientific instruments. The advantages of thermoelectric devices for such uses include no

need for circulating working fluids through or within the devices, generation of little if any noise, and high reliability. The disadvantages of prior thermoelectric devices include high power consumption and relatively low coefficients of performance.

The present development program was undertaken in the hope of reducing the magnitudes of the aforementioned disadvantages and, especially, obtaining higher figures of merit for operation at and near room temperature. Accomplishments of the program thus far include development of an algorithm to estimate the heat extracted by, and the maximum temperature drop produced by, a thermoelectric device; solution of the problem of exchange of heat between a thermoelectric cooler and a water-cooled copper block; retrofitting of a

vacuum chamber for depositing materials by sputtering; design of masks; and fabrication of multilayer thermoelectric devices of two different designs, denoted I and II.

For both the I and II designs, the thicknesses of layers are of the order of nanometers. In devices of design I, non-consecutive semiconductor layers are electrically connected in series. Devices of design II contain superlattices comprising alternating electron-acceptor (p)-doped and electron-donor (n)-doped, nanometer-thick semiconductor layers.

*This work was done by Ali Boufelfel of Sigma Technologies International, Inc. for Goddard Space Flight Center. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810. GSC-14786-1*

### Very High-Speed Digital Video Capability for In-Flight Use

Flight-qualified video system provides very-high-speed color digital-video imaging up to 10,000 pictures per second at flight speeds up to Mach 2.

*Dryden Flight Research Center, Edwards, California*

A digital video camera system has been qualified for use in flight on the NASA supersonic F-15B Research Testbed aircraft. This system is capable of very-high-speed color digital imaging at flight speeds up to Mach 2. The components of this system have been ruggedized and shock-mounted in the aircraft to survive the severe pressure, temperature, and vibration of the flight environment. The system includes two synchronized camera subsystems installed in fuselage-mounted camera pods (see Figure 1).

Each camera subsystem comprises a camera controller/recorder unit and a camera head. The two camera subsystems are synchronized by use of an M-Hub™ synchronization unit. Each camera subsystem is capable of recording at a rate up to 10,000 pictures per second (pps). A state-of-the-art complementary metal oxide/semiconductor (CMOS)

sensor in the camera head has a maximum resolution of 1,280×1,024 pixels at 1,000 pps. Exposure times of the electronic shutter of the camera from

1/200,000 of a second to full open. The recorded images are captured in a dynamic random-access memory (DRAM) and can be downloaded directly to a per-



Figure 1. Two Very-High-Speed Digital Video Cameras are mounted in forward and aft camera pods, respectively, on the F-15B Research Testbed aircraft. The cameras are positioned to obtain photogrammetric data of simulated space-shuttle external-tank thermal-insulation foam debris released from a fixture under the centerline of the aircraft at flight speed up to Mach 2.

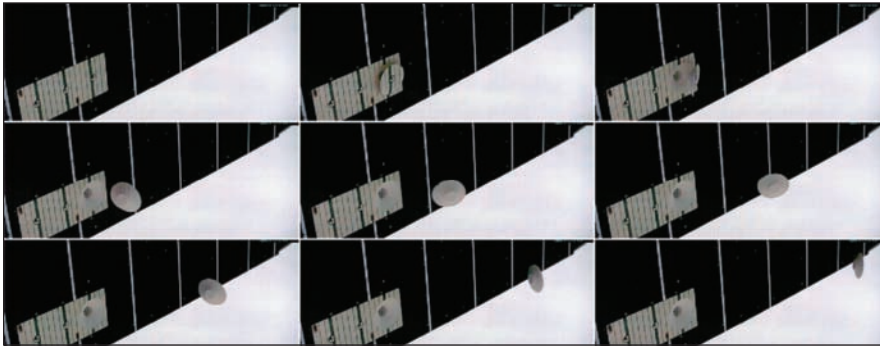


Figure 2. **Frame Captures of High-Speed Digital Video** are showing ejection of "divot" debris from F-15B Aerodynamic Flight Test Fixture underneath the aircraft centerline. Flight conditions for the divot ejection are Mach 2 at 48,250 ft (14.7 km) altitude. Video frame rate is 2,000 pictures per second, exposure rate is 50 microseconds, and resolution is 1280x512 pixels. (Sequence starts at upper left frame and proceeds from left to right.)

sonal computer or saved on a compact flash memory card. In addition to the high-rate recording of images, the system can display images in real time at 30 pps. Inter Range Instrumentation Group (IRIG) time code can be inserted into

the individual camera controllers or into the M-Hub unit. The video data could also be used to obtain quantitative, three-dimensional trajectory information.

The first use of this system was in support of the Space Shuttle Return to

Flight effort. Data were needed to help in understanding how thermally insulating foam is shed from a space-shuttle external fuel tank during launch. The cameras captured images of simulated external tank debris ejected from a fixture mounted under the centerline of the F-15B aircraft. Digital video was obtained at subsonic and supersonic flight conditions, including speeds up to Mach 2 and altitudes up to 50,000 ft (15.24 km). The digital video was used to determine the structural survivability of the debris in a real flight environment and quantify the aerodynamic trajectories of the debris.

*This work was done by Stephen Corda, Ting Tseng, Matthew Reaves, Kendall Mauldin, and Donald Whiteman of Dryden Flight Research Center. Further information is contained in a TSP (see page 1). DRC-05-16*

## MMIC DHBT Common-Base Amplifier for 172 GHz

**This single-transistor circuit performs comparably to a prior four-transistor circuit.**

*NASA's Jet Propulsion Laboratory, Pasadena, California*

Figure 1 shows a single-stage monolithic microwave integrated circuit (MMIC) power amplifier in which the gain element is a double-heterojunction bipolar transistor (DHBT) connected in common-base configuration. This amplifier, which has been demonstrated to function well at a frequency of 172 GHz, is part of a continuing effort to develop compact, efficient amplifiers for scientific instrumentation, wide-band communication systems, and radar systems that will operate at frequencies up to and beyond 180 GHz.

The transistor is fabricated from a layered structure formed by molecular-beam epitaxy in the InP/InGaAs material system. A highly doped InGaAs base layer and a collector layer are fabricated from the layered structure in a triple mesa process. The transistor includes two separate emitter fingers, each having dimensions of 0.8 by 12  $\mu\text{m}$ . The common-base configuration was chosen for its high maximum stable gain in the frequency band of interest. The input-matching network is designed for high bandwidth. The output of the transistor is matched to a load line for maximum saturated output power under large-signal conditions, rather than being matched for maximum gain under small-signal conditions.

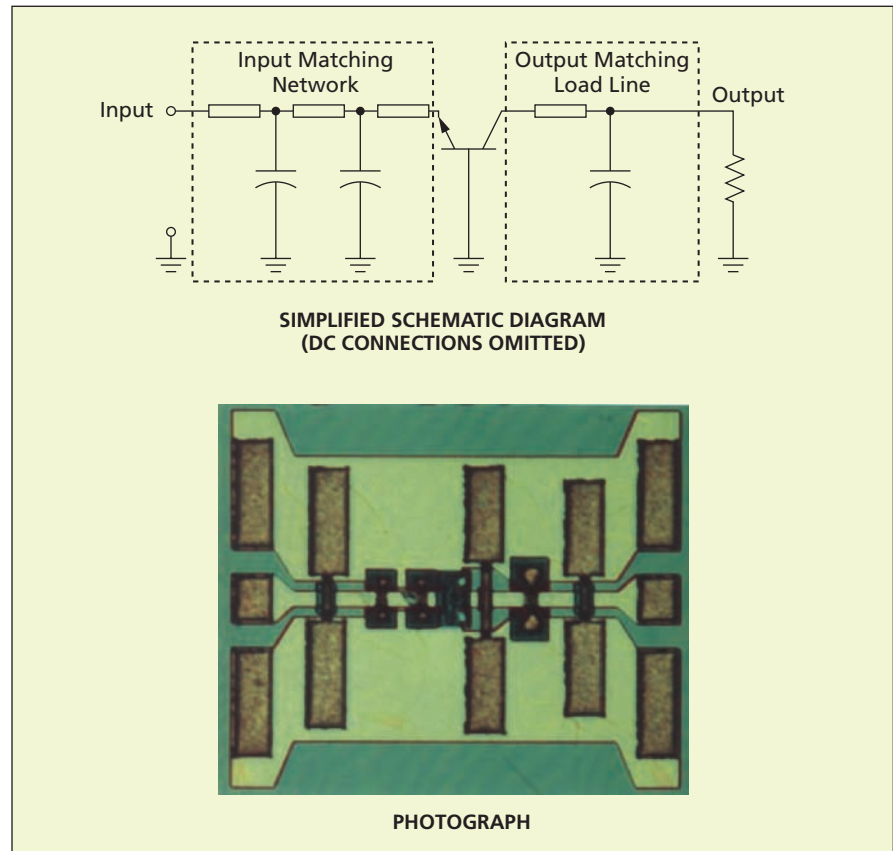


Figure 1. This **Common-Base, Single-Transistor Amplifier** is designed to provide useful power gain in the frequency band of 170 to 180 GHz.