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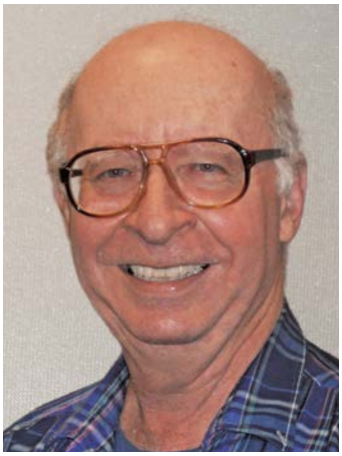
Of Modeling and Materials



Materials play a large part in the future of electronic circuits and systems. The impact of gallium nitride (GaN) on commercial and defense radar systems, for example, has been profound over the last few years, providing transmit power at microwave/millimeter-wave frequencies while reducing the size and bias requirements of the older vacuum-tube devices they are replacing. This latest installment of *Defense Electronics* offers several examples of how the choice of materials can make significant differences in electronic designs.

Development of new electronic materials requires a number of orchestrated efforts before any new material can be put to practical use. A new material must first be "discovered," typically by researchers who gain an understanding of a material's different properties—such as its dielectric constant—and how they might benefit an electronic design. It must then be manufactured in large-enough quantities to be made practical.

Users of III-V semiconductor materials, such as GaAs, know this to be a painfully slow process. It takes a long time before wafers of sufficiently large size can be produced with adequate device yields per wafer to drive down the cost of each device.

Once a material *can* be produced in practical quantities, it must then be put to use where its particular properties can provide benefits to an application. In the "good old days," this involved building a number of amplifier prototypes—for example, from different circuit laminates with different thermal properties—and then making measurements to determine how the circuits and their materials responded under different conditions.

In high-power systems like radar transmitters, heat can stop a circuit or system dead in its tracks. Whether it is a circuit-board material, an adhesive, a solder, or a heatsink, thermal stability and predictability are essential to the long-term health of an electronic design. The complexity of measuring an electronic material's behavior under different power loads and changing thermal conditions can be extremely complex. This may explain the current trend of defense electronic-system designers moving away from building prototypes and instead reaching for simulation software.

For as long as early software programs such as SPICE have been available, design engineers have created mathematical models of circuits and their associated materials in attempts to better understand what will happen under different power levels and temperatures. Early simulation efforts involved "global" thermal models in which different operating temperatures were applied for the simulation of a design to understand the predicted performance at that temperature. But such global models do not accurately predict the complex relationship of power and temperature for many designs.

In radar systems, power is not continuous; it occurs in pulses in very transient form. As a result, the heating effects occur for an extremely short time, followed by a short time of cooling, and then another burst of energy and heat. Increased temperature can have many effects on a material, such as changes in dielectric constant, which in turn affects the impedance of transmission lines, and thus alters circuit performance. In radar, the short-term heating effects place tremendous thermal stresses on materials, which expand and contract with temperatures at different rates and by different amounts.

Simulation software allows a designer to better understand all of these complex interactions caused by power and heat, on the way to developing new electronic materials. Those materials are the future of electronics designs in all markets, but they will go nowhere without the software.