Thermal Measurement of RF and Microwave Devices using a Novel Thermal Probe

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Infrared Microscope

Specification
Quantum Focus Infrascope II
256 × 256 pixel InSb detector
Field of view: 230 µm × 5 mm
3 µm spatial resolution
300 ºC temperature range

Conventional IR Imaging

Conventional IR imaging can be used to obtain non-invasive 2D thermal measurement on microwave and other electronic devices, in both wafer and packaged forms. Amongst other applications, the technique has been used to monitor the temperature of the GaAs Gunn diode and also identify thermal hotspots on MMICs and MEMS devices.

Thermal image of a GaAs Gunn diode.
Thermal image of an active MMIC device.
Thermal image of an active MEMS heater.

Micro-Sensor Technique

A new technique has been developed to improve the accuracy of IR temperature measurements made on semiconductor devices. The new technique uses high emissivity micro-particle sensors as thermal probes.

Micro-sensors can be used to obtain accurate temperature measurements on any material, including low emissivity metals and optically transparent semiconductors. There is no need to coat a device with a high emissivity layer, which causes heat spreading and damage.

Thermal profile measured across a GaN TLM heater structure using conventional IR (coated) and micro-sensor techniques. High emissivity coating causes heat spreading, depressing the surface temperatures.

Micro-particle sensors as small as 3 µm in diameter can be detected using IR imaging. The detected radiation level from the sensors decreases as their size approaches the diffraction limit of the microscope’s resolution.

Gallium Nitride HEMT

The IR micro-sensor technique has been used to monitor the temperature of a AlGaN/GaN HEMT*. A single high emissivity micro-sensor (3µm diameter) was placed in the channel region of the device. The micro-particle sensor was manipulated and used to obtain temperature measurements on different areas of the structure. Micro-sensor measurements offer improved temperature accuracy on the transparent semiconductor layers.

A micro-sensor placed in the channel region of an AlGaIn/GaN HEMT.

Device operating temperature measured using the micro-sensor and conventional IR techniques.

*“Probe Propels IR Thermal Microscopy To A New Level”, Chris Oxley, Richard Hopper, Dominic Prime, Mark Leaper and Gwynne Evans (De Montfort University) and Andrew Levic (National Physical Laboratory), Compound Semiconductors, March, 2011.