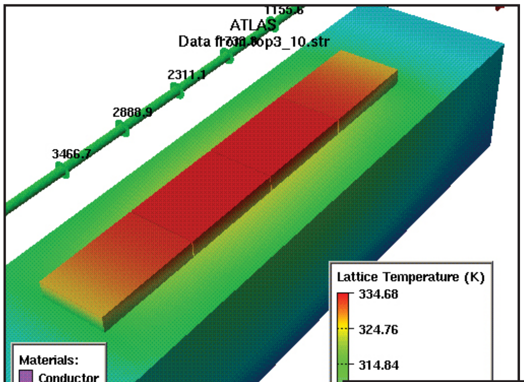
Thermal3D

THERMAL PACKAGING SIMULATOR

Thermal3D is a general heatflow simulation module that predicts heatflow from any power generating devices (not limited to semiconductor devices), typically through a substrate and into the package and/or heatsink via the bonding medium. Operating temperatures for packaged and heat sinked devices or systems can be predicted for the design and optimization phase or for general system analysis.

Key Features

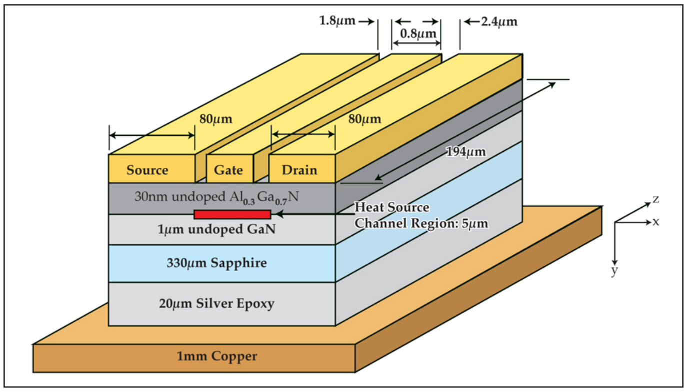
- Predicts heat flow and temperature rise for material systems and any number of heat generating sources
- Models validated using measured data
- Three models for heat dependent thermal conductivity to choose from for each of the materials in the system
- User definable thermal conductivities and coefficients for each material
- Very fast simulation times allow many combinations to be tried for system design optimization
- Seamlessly integrated into Silvaco's device simulation software framework, ATLAS
- Industry leading, easy to use, multi-dimensional visualization tools for results analysis
- Interactive, user friendly and flexible runtime environment for quick result generation and analysis with numerous examples



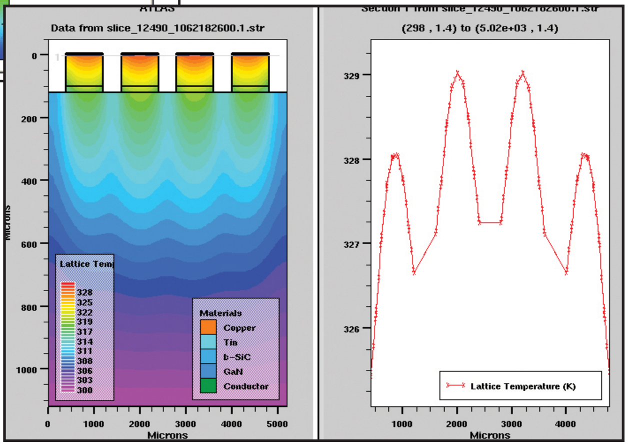
Another temperature simulation in Thermal3D of GaN HEMT devices this time fabricated onto a b-Silicon Carbide substrate mounted onto a copper heat sink.

Thermal3D Experimentally Verified Working Example

- The experimental AlGaN-GaN HFET structure shown diagrammatically, was constructed in Thermal3D
- The experimental data and thermal conductivities were taken from Jeong Park et al., IEEE Electron Device Letters, Vol.24, No.7, July 2003
- The heat sink on the bottom of the structure was held at 295K (22°C)
- Unlike the reference, in this Thermal3D simulation example a wider heat sink, together with gold based contacts and air above the structure was also included in the calculations
- In order to validate the simulation, two device power levels were simulated, that corresponded to the two power levels in the reference for which the device surface temperature was actually measured using liquid crystal



AlGaN-GaN HFET structure here showing only one of the two gates tested with Liquid Crystal under two device power outputs. The same device was simulated using Thermal3D to verify simulator accuracy.



Thermal3D was then used to investigate the optimal spacing between the devices and the effect on operating temperature profile. Here a cut line through the center of the devices is shown together with surface temperature.

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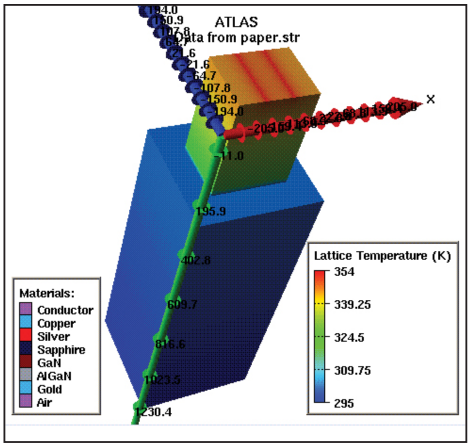
3D Results

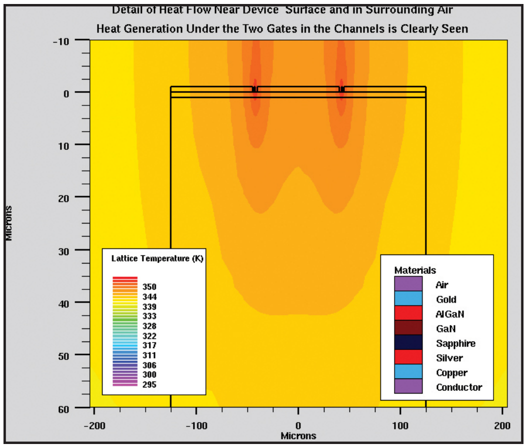
- The created structure can be viewed and zoomed from any angle or cross-section using easy to use, intuitive mouse movements
- Any parameter calculated in the simulation, such as temperature rise in this case, can be displayed in 3D as a color contour plot
- The 3D structure can be edited or cross-sectioned to view color contour plots of any calculated parameter anywhere inside the structure. In below for example, the air has been removed to view the temperature of the structure at the device surfaces



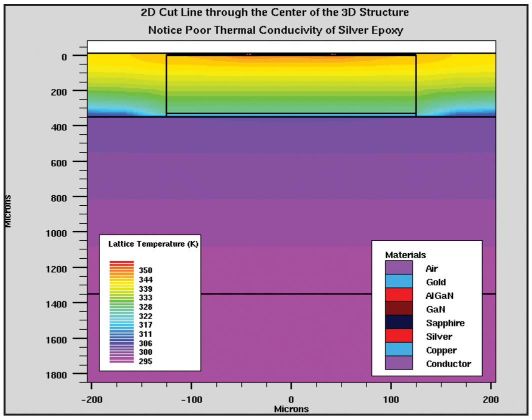
Calculated temperature distribution in the 3D double-gated AlGaN-GaN HFET structure. The air has been removed from the structure for clarity.

2D Results

- 2D slices anywhere in the structure are obtained using the "cut line" tool in the 3D viewer. The "cut line" is then exported to the 2D viewer, TonyPlot, for further analysis
- The detail of the temperature rise near the surface of the device in the "cut line" is shown for a device power output of 0.42 Watts. Notice the highest temperatures are in the ohmic region of the device, in the channels, under the two gates



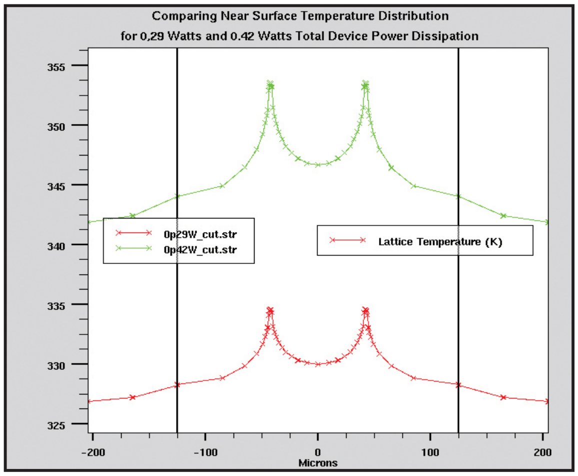
Detail of temperature distribution around the AlGaN-GaN HFET power source for a 0.42 Watt total power dissipation. Notice temperature rise around the two channel regions under the two gates



A 2D cross section of the full structure, including air above it, showing the temperature profile. This graphic was a cut plane constructed from the 3D tool which automatically loads the result into the 2D graphic tool.

1D Results

- Once the 3D "cut line" has been exported to the 2D viewer, TonyPlot, it can be further analyzed by creating a 1D cross section anywhere in the structure



1D horizontal cross-section near the surface, showing temperature profile for the active device dissipating 0.29 Watts and 0.42 Watts.

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