Choice of Substrate for GaN Based HEMT Devices Using Thermal Modelling

P.Kandpal[1], Dr. Meena Mishra [2]

[1]Department of Electronic Sceince KUK, Kurukshetra, Haryana, India
[2]Solid State Physics laboratory (DRDO), Delhi, India

Abstract

Introduction : Gallium Nitride (GaN) is a very interesting and highly promising material system for both optical and microwave high-power electronic applications. The large band gap of GaN makes it a suitable choice for high frequency applications. Thermal evaluation is pivotal in the design, characterization and reliability evaluation of semiconductor devices and circuits. The role it plays is particularly crucial in power amplifiers and specifically in what is today the most promising technology for high power, high-frequency circuits: AlGaN/GaN HEMTs. Accurate thermal characterization is no easy task. In purely thermal simulations, generally carried out with Finite Element (FE) codes, the active device is replaced by a uniform heat source, and the modelling effort is concentrated on the simulation of heat flow patterns extending hundreds of micro meters in 2 or 3 dimensions. This approach allows for much more realistic evaluation of static and dynamic self-heating, possibly including the effect of metal and passivation layers on the wafer top, and package and heat-sink materials at the bottom.

Use of COMSOL: The aim of this research is to show and discuss results of 3D thermal simulation of GaN-based HEMT structures. HEMTs differing by substrate material and heat removal strategy are simulated and compared in order to choose a proper substrate for proper thermal management.

Results: Simulated results indicate the characteristics of heat flowing in HEMT using three different substrates: Sapphire, Silicon, SiC as given in Figure3 & Figure4.
Conclusion: The temperature variation in case of Sapphire substrate is maximum along the finger width as compared to SiC and Si substrate. The temperature non-uniformity along the finger width is the most critical for the case of sapphire (highest temperature decrease from finger center to edge among all substrates), where the substrate's low thermal conductivity tends to confine the heat flow in the thin top GaN layer. So, SiC is considered to be a best substrate among all these three substrates.

Keywords: Finite Element Codes, 3D Thermal Simulation

Figures used in the abstract

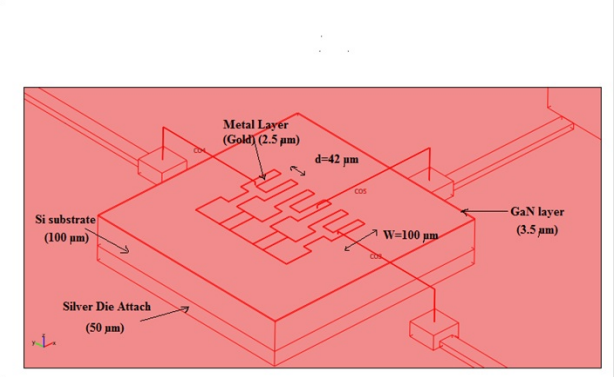

Figure 1: Device model for HEMT using Si substrate

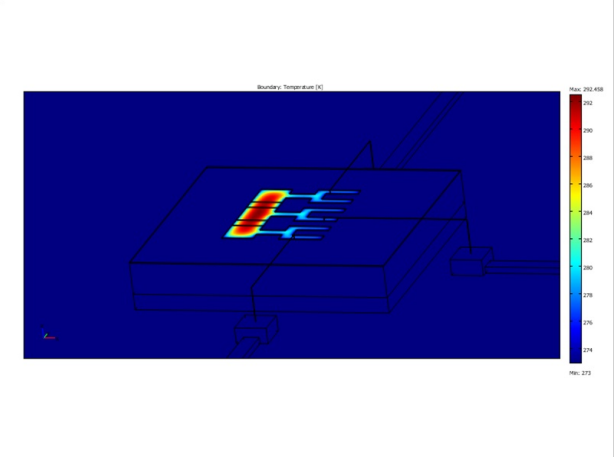

Figure 2: Simulated result of thermal modelling

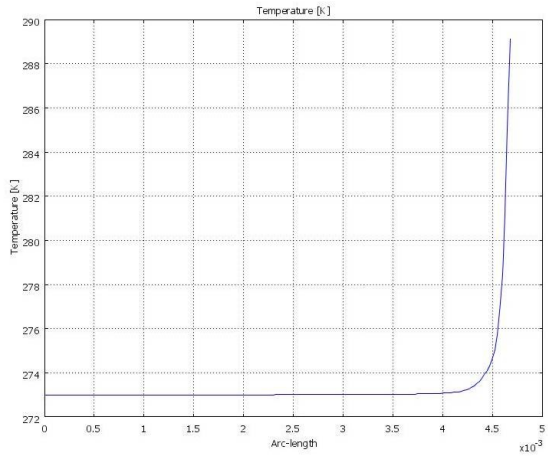

Figure 3: Variation of temperature along arc length in Si substrate

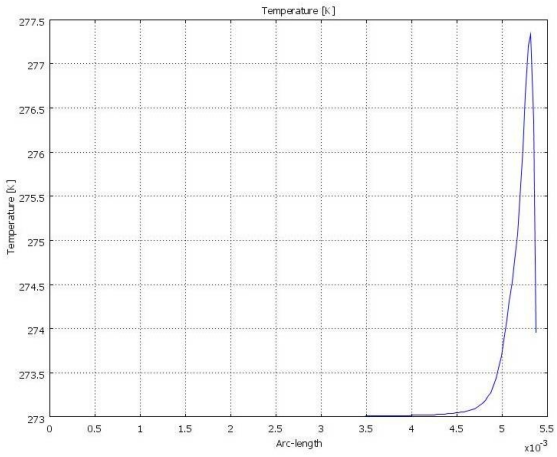

Figure 4: variation of temperature along arc length in SiC substrate