Choice of Substrate Using Thermal Modeling of GaN Based HEMT Devices

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Introduction: GaN plays a crucial role in what is today the most promising technology for high power, high-frequency circuits: AlGaN/GaN HEMTs. The aim here is to show and discuss results of 3D Thermal Simulation of GaN-based HEMT structures differing by substrate material.

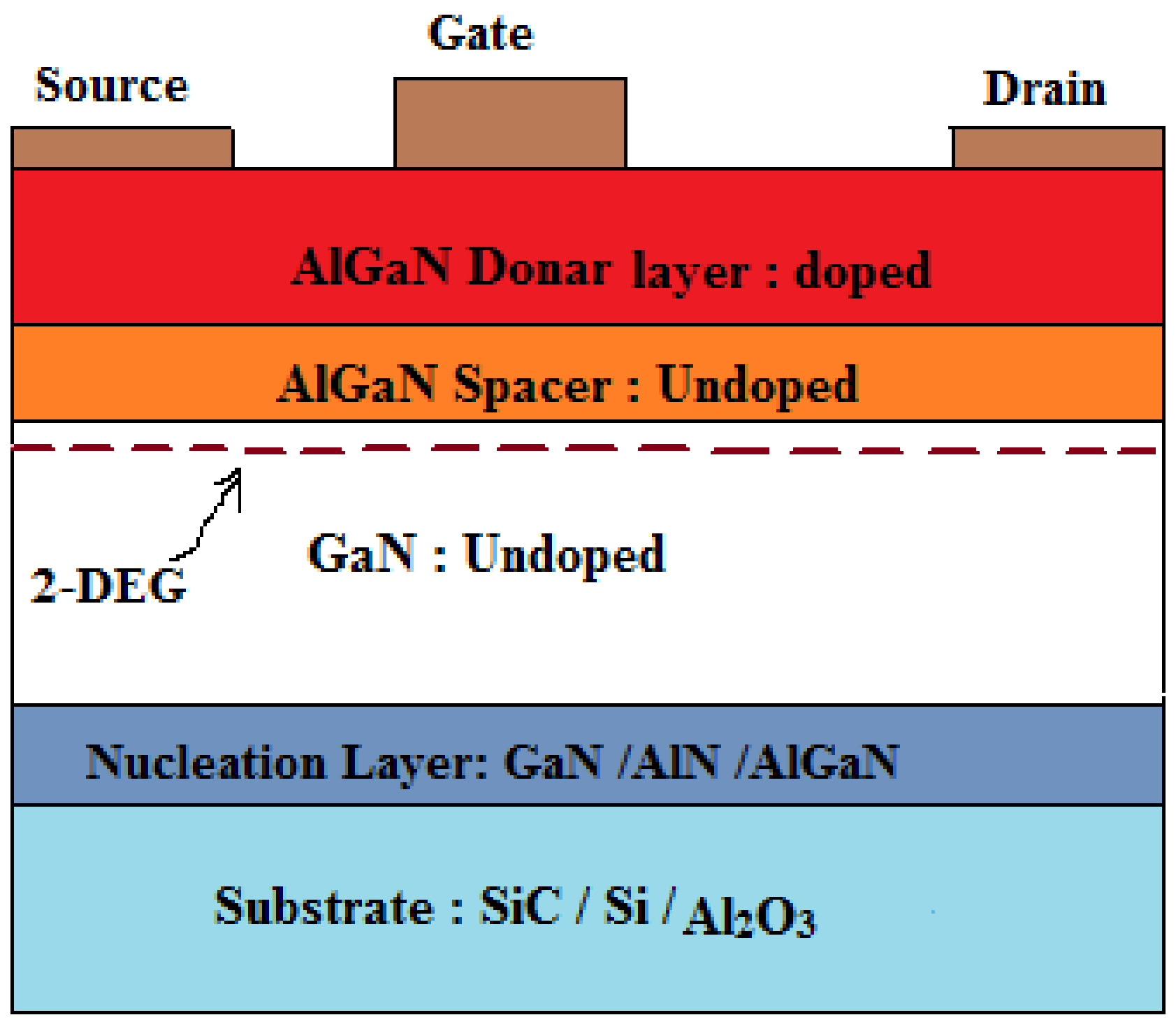


Figure 1.Structure of GaN HEMT

Materials	Thermal Conductivity (W/m.K)
Si	149
Sapphire	27.21
Si C	360
GaN	130

Table 1. Physical Property

Thermal Modeling of HEMT Device: The inward heat flux of 67.42 x10^6 W/m^2 is applied on the surface of the metal layer just above the GaN layer, assuming there is a source of heat. Below the GaN layer, there is a substrate (Si, SiC or Sapphire). Heat distribution is analysed for each substrate used in GaN HEMT.The bottom of the structure consists of a Transistor Case and a Heat-Sink (kept at 300 K).

Structural Domain	Dimensions (µm)
Thickness of Metal Layer	2.5
Thickness of GaN Layer	3.5
Substrate Thickness	100
Total Thickness of Structure (GaN + Substrate)	156
Length (W) of Each Heating Finger (Total Six Fingers)	100
Spacing (d) between Fingers	42

Table 2. Specifications of Dimensions of Different layers of HEMT Structure

Band Gap Energy of GaN = 3.44 eV

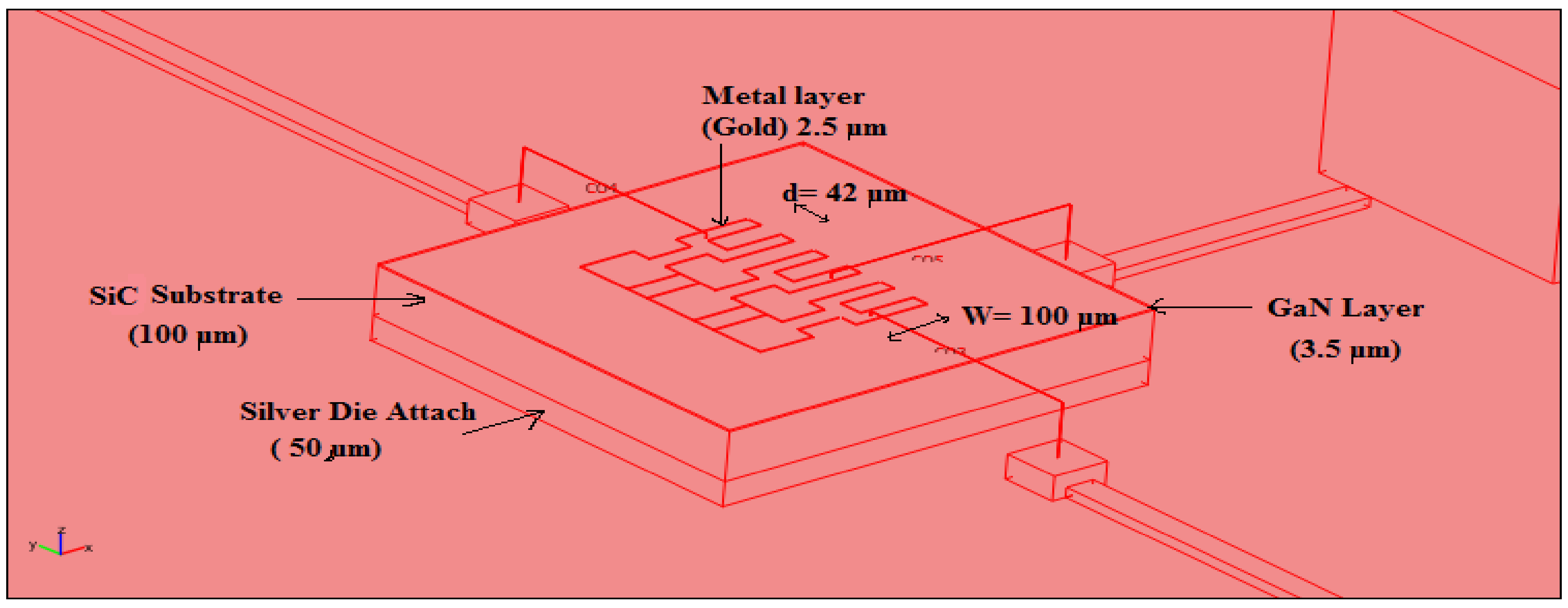
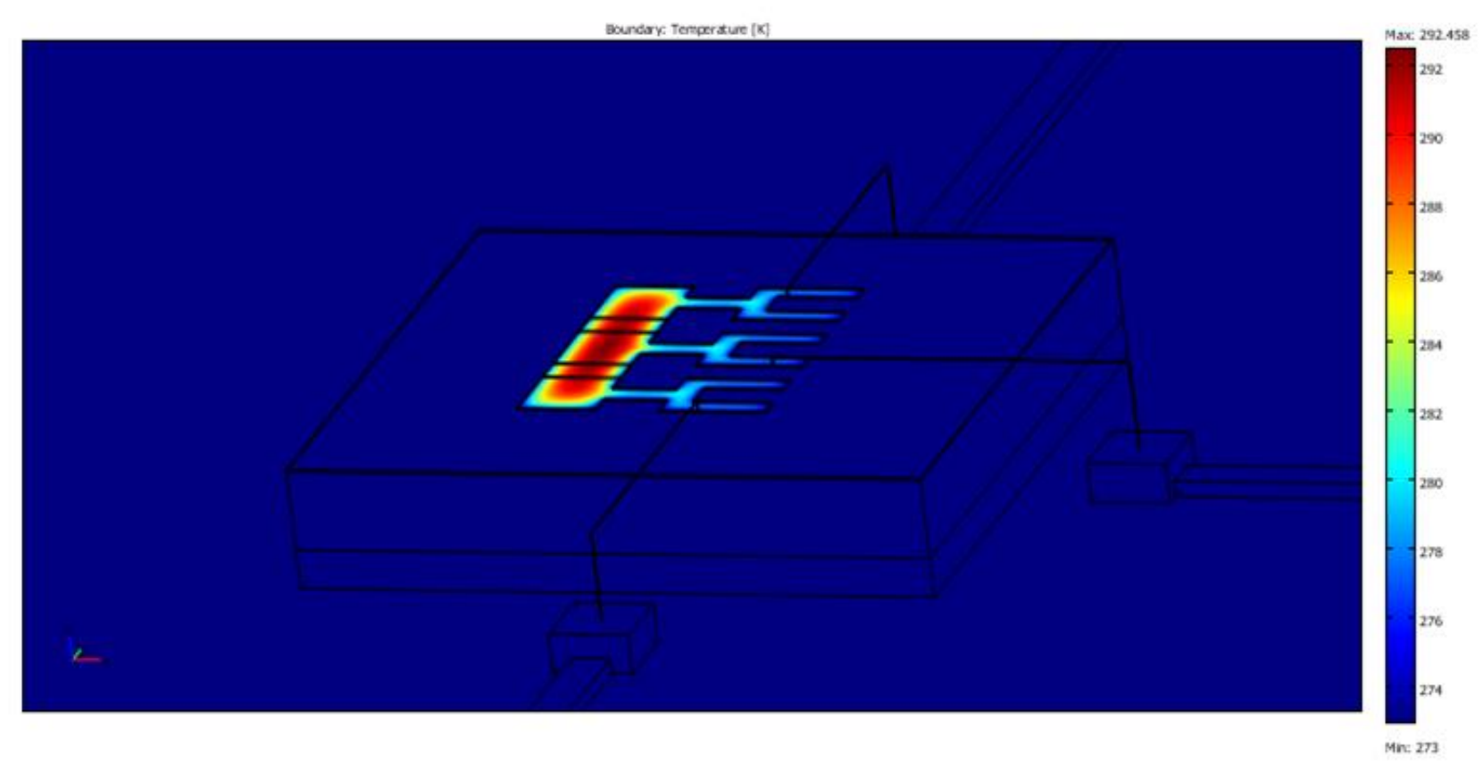


Figure 2. Structure of GaN HEMT designed for Thermal Modeling

***FUTURE APPLICATION** : HEAT SINK Designing*

Simulation Results : Thermal Distribution for



(Si Substrate) Figure 3. Boundary Plot

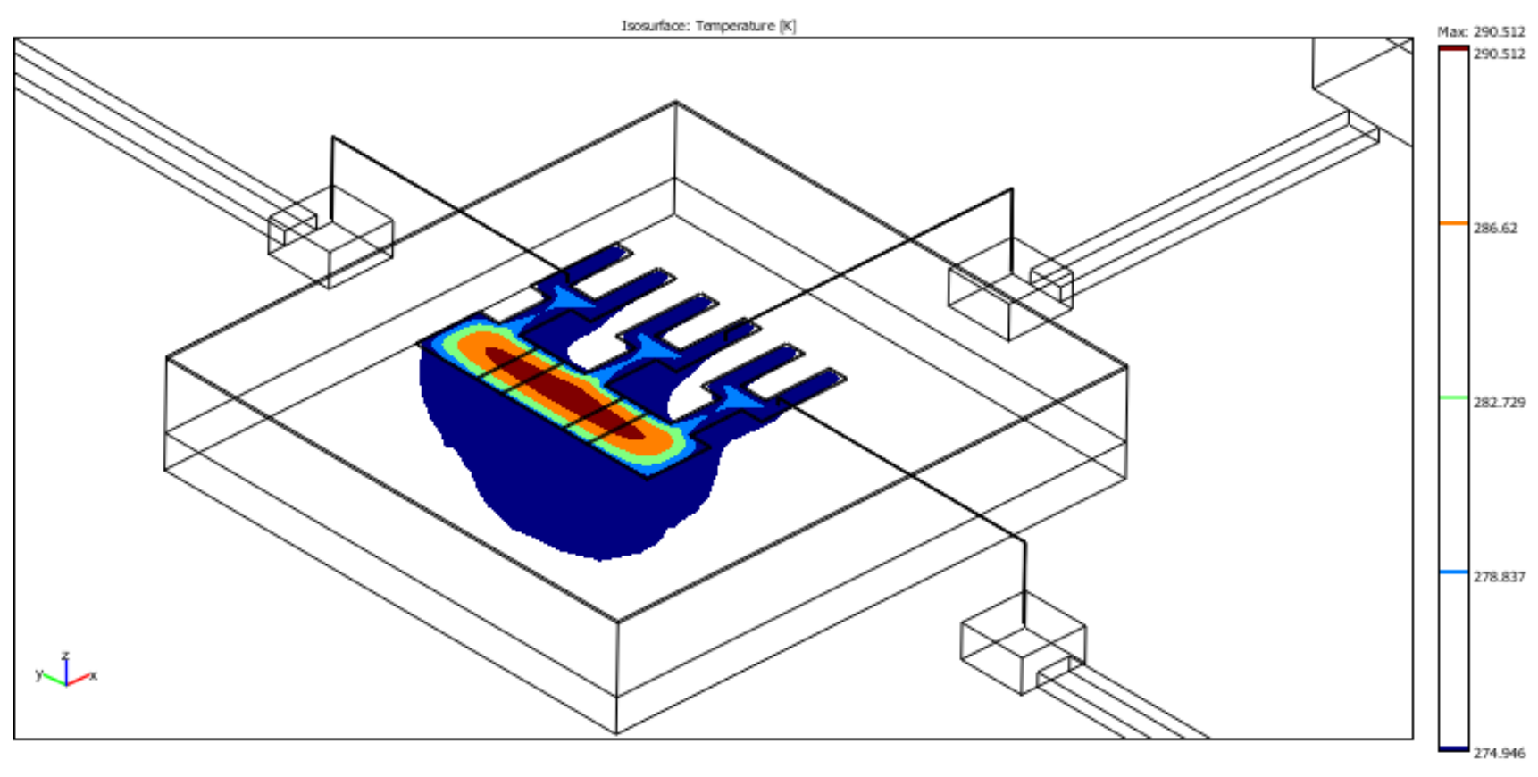
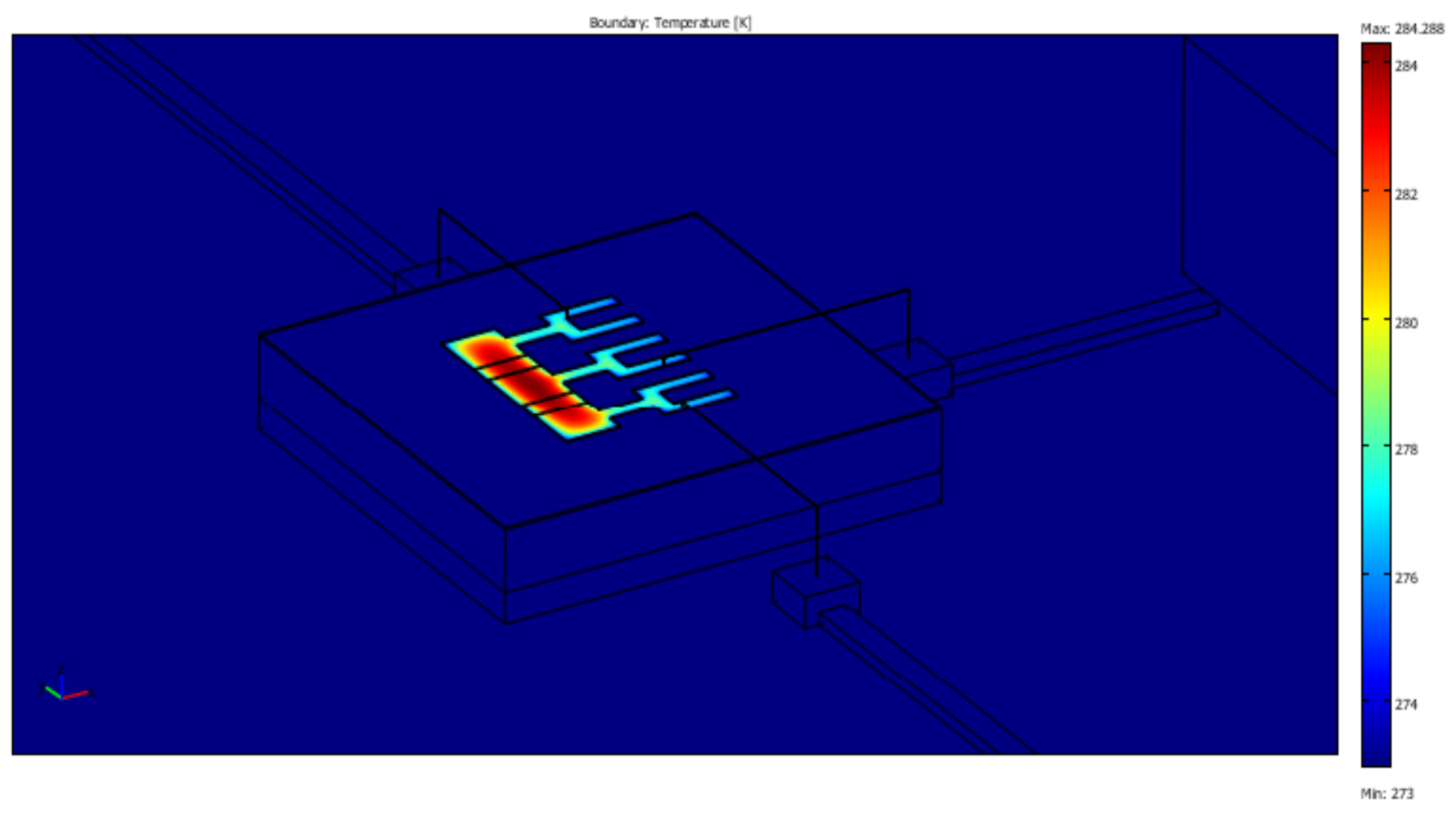


Figure 4. Iso Surface Plot



(SiC Substrate) Figure 5. Boundary Plot

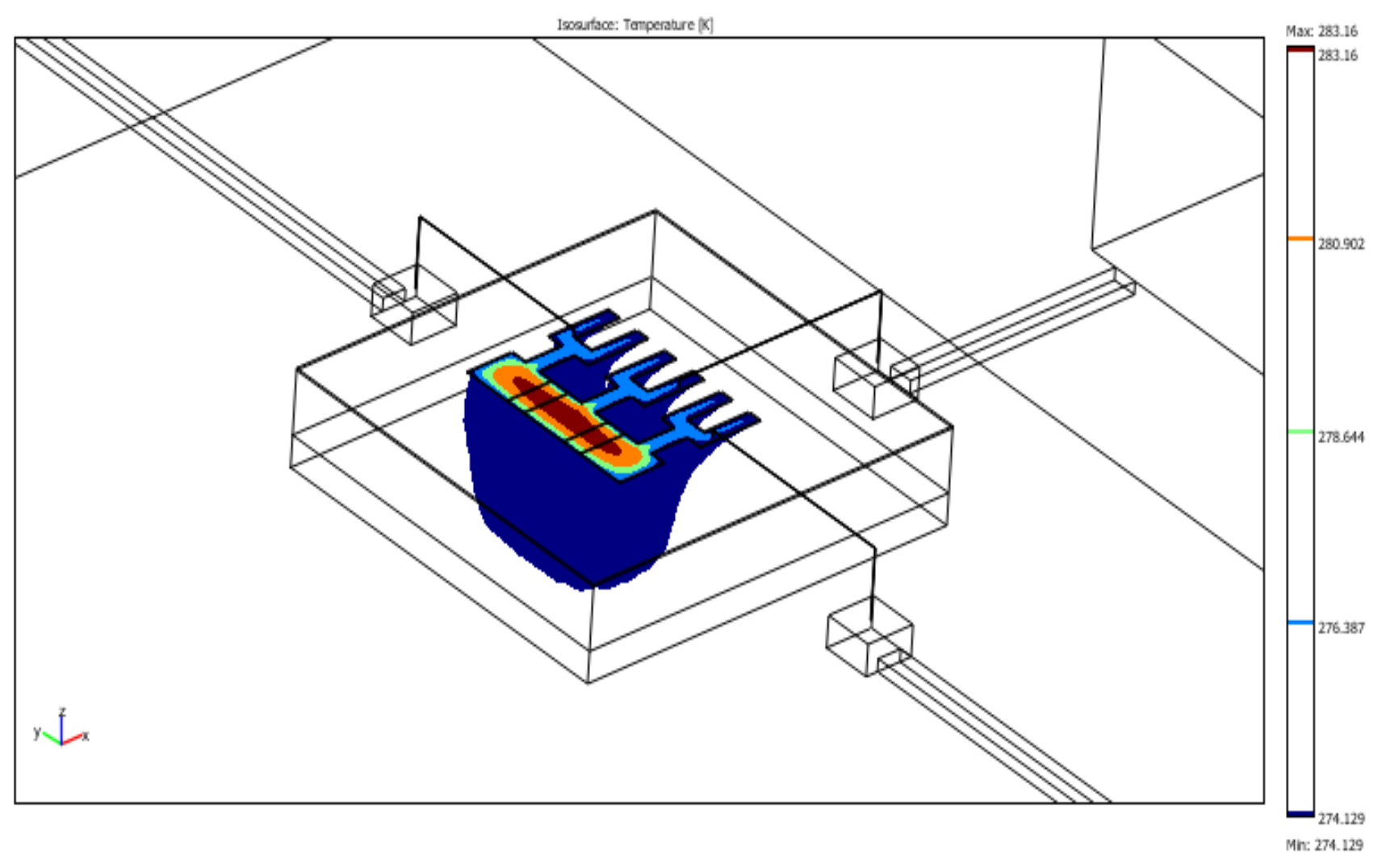
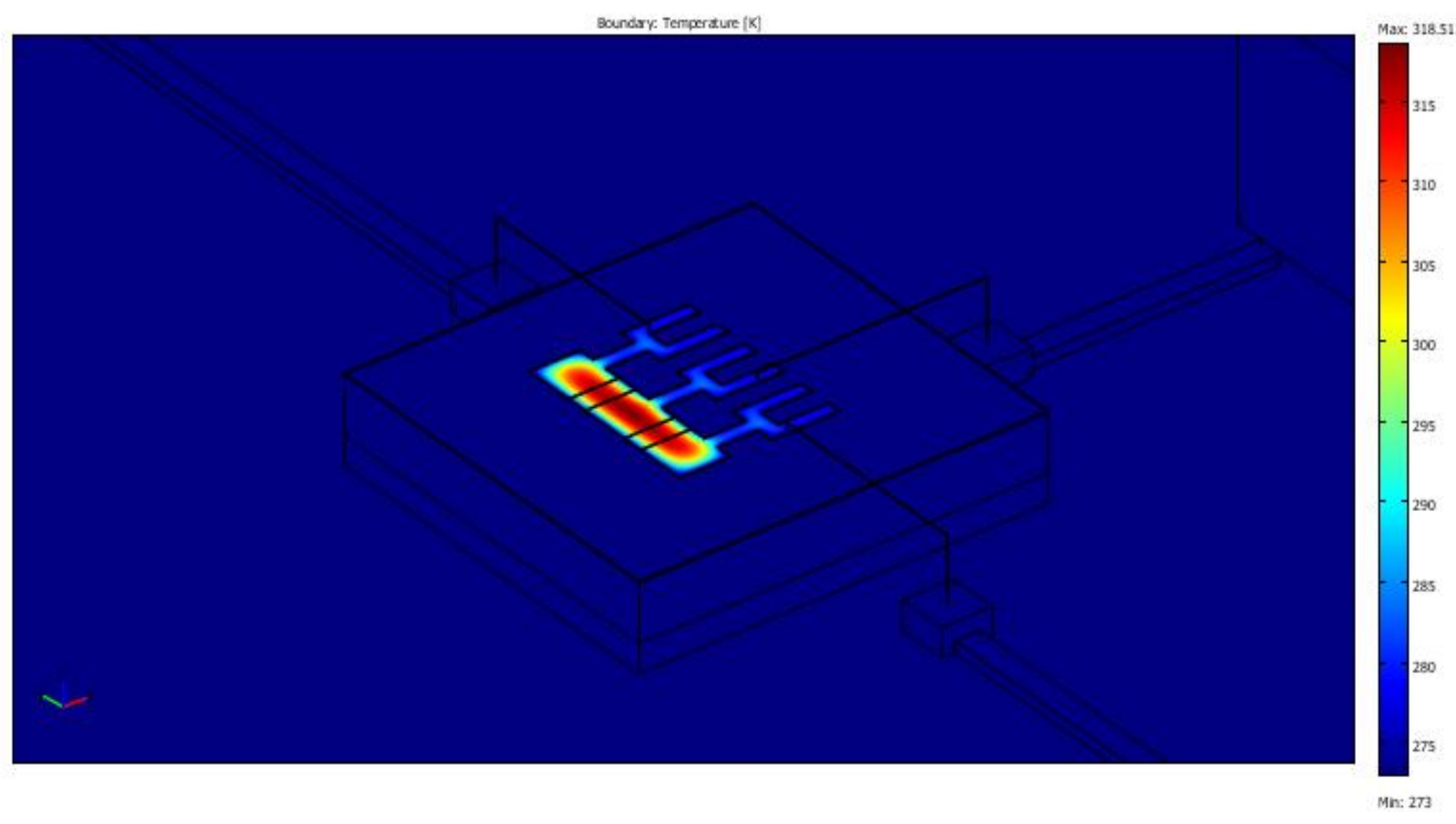


Figure 6. Iso Surface Plot



(Sapphire Substrate)Figure7. Boundary Plot

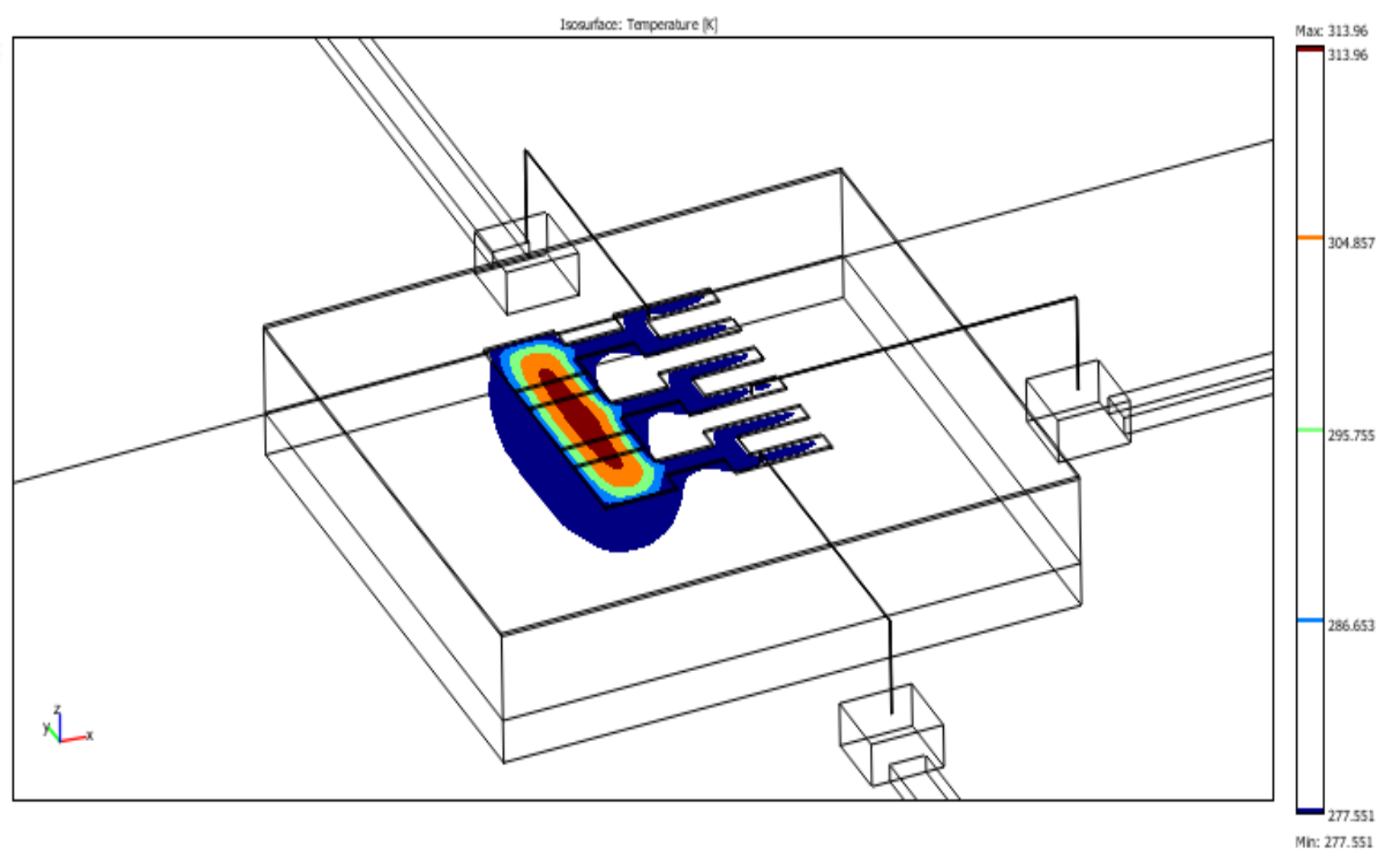


Figure 8. Iso Surface Plot

Substrate	Temp. variation (K)
Si	273-290
SiC	273-277.5
Sapphire	273-314

Table 3. Temperature Variations in Substrate used

Conclusions: The Temperature non-uniformity along the finger width is the most critical for the case of sapphire (highest temperature decrease from finger centre to edge among all substrates), where the substrate's low thermal conductivity tends to confine the heat flow in the thin top GaN layer. SiC has Minimum Temperature Variation along the Finger width. So, SiC is considered to be a Best Substrate

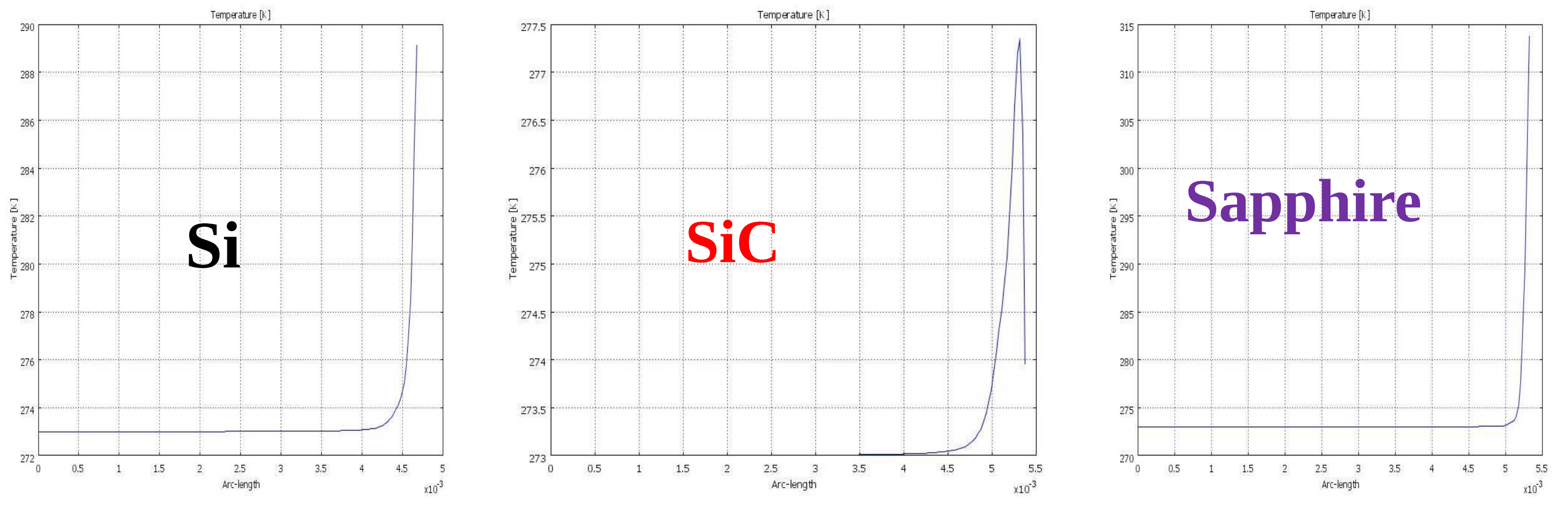


Figure 9. Temperature variation along Arc Length of (a) Si (b)SiC (c) Sapphire

References:

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