Numerical Modeling-Enabled High-Temperature Characterization of Boron Doped Diamond Ohmic Contact and Material Resistivity Using a Simplified TLM Structure

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SUMMARY

Power electronics plays a central role in the ongoing global electrification transition, while diamond-based semiconductor devices are emerging as promising candidates for high-power and high-temperature applications due to their exceptional material properties. Nevertheless, the development of diamond devices remains limited by difficulties in accurately characterizing material resistivity and metal-semiconductor contact properties, particularly under extreme thermal conditions. Conventional techniques such as the Transmission Line Method (TLM) and circular TLM (cTLM) exhibit significant limitations when applied to diamond structures, as they rely on restrictive geometric assumptions, including contact length being much longer than the transfer length [1], thin-film conduction hypotheses [2], and large standardized samples. These constraints are incompatible with the current state of diamond fabrication processes, where available samples are often limited in size and exhibit non-ideal geometries.

This paper presents a numerical modeling methodology for extracting the diamond resistivity (ρ) and specific contact resistivity (ρ_c) from non-ideal TLM structures without relying on the assumptions imposed by classical analytical approaches [2]. The proposed method combines finite-element simulations with realistic sample modeling to reproduce current distribution and electrical behavior under practical experimental conditions. Unlike conventional TLM analysis, the method does not require a linear relationship between resistance and contact spacing, thereby enabling accurate parameter extraction from small and irregularly shaped samples.

Experimental characterization was carried out using a high-temperature measurement setup capable of operating up to 600°C. Ti/Pt/Au ohmic contacts were fabricated on doped diamond. Using the proposed methodology, diamond resistivity values ranging from 1.21 Ω.cm to 0.02 Ω.cm and specific contact resistivity values ranging from 4.71×10^{-4} $\Omega.cm^2$ to 4.00×10^{-5} $\Omega.cm^2$ were successfully extracted between 27°C and 427°C.

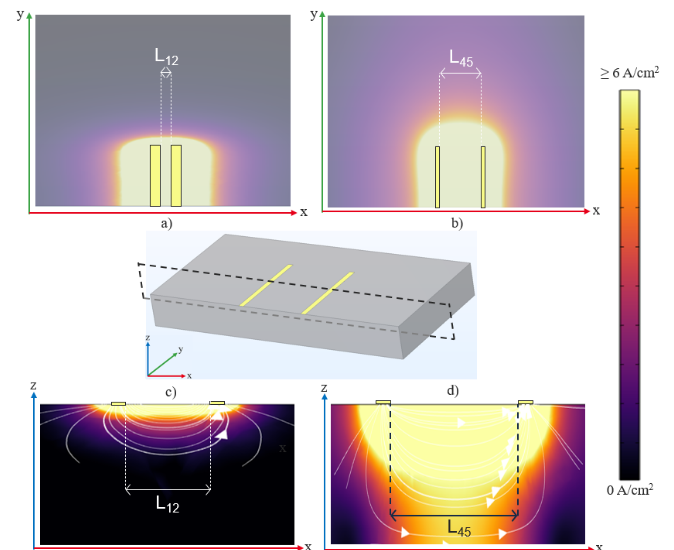

Figure 1 Finite element simulation (COMSOL) of the current density repartition. On the top, a) and b) show the current density repartition from bird view (x-y plane) for distance L_{12} and L_{45} respectively. On the bottom, c) and d) show the current density repartition in the x-z plane cross-section plan for distance L_{12} and L_{45} respectively.

The proposed methodology provides a flexible framework for the reliable characterization of diamond power devices under high-temperature conditions and non-standard geometries. Future work will focus on automated parameter extraction through optimization algorithms and on evaluating the influence of IIb diamond substrate.

REFERENCES

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