An investigation into the thermal reliability of newly proposed 2D MOSFETs using the non-equilibrium Monte-Carlo simulation of the PBTE

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In nano-electronics, the overall thermal reliability is determined by the temperature of the hottest zone on the die. Thus, the material selection and also the heat spreader design, as the thermal management solutions for manipulating the temperature of the hotspots, are always the matters of interest. While the attempts to find the proper methods for heat removal are being performed, recognition of low-dimensional silicon replacement nominees, with the lowest maximum temperature, is also ongoing as the easier and more feasible choice for the nano-electronics industry. Accordingly, the transistor with a lower maximum temperature is easier kept under the threshold temperature. Among the candidates, 2D SiC, with a very high melting point, making it suitable for warmer ambient condition spaces, has attracted a huge attention in recent years. In the present research, the thermal reliability of the 2D SiC MOSFET has been examined, tracing the achieved peak temperature under the influence of self-heating. The framework is non-equilibrium Monte-Carlo simulation of the phonon Boltzmann equation. The formalism is used to comparative study of the well-known 2D replacements for Si channels such as graphene, blue phosphorene, germanene, silicene, MoS2, the 2D complex MA2Z4 structures of MoSi2N4 and WSi2N4, and the recently famous 2D SiC. Our calculations establish that WSi2N4 present the lowest peak temperature rise in comparison to the other investigated 2D materials with maximum temperature of 400 K. Our favorite material, 2D SiC, stands in the second place with the peak temperature of 480 K. However, considering the stability at high temperatures, the replacement of Si with SiC channel, seems to be more favorable. In fact, owing to the higher melting point, 4050 K, which allows the MOSFET to operate at higher temperature, the propitious peak temperature, alongside the faster switching and higher breakdown voltage, SiC, is a brilliant candidate for Si replacement.

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