Hexagonal Boron Nitride for Thermal Management of Chips

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Some 2D materials have excellent in-plane thermal conductivities, which make them promising for thermal management applications. In particular, graphene has a thermal conductivity well over 1000 W/m/K, especially when encapsulated by hBN [1], and in the Dirac fluid regime even a (short-lived) thermal conductivity over 30,000 W/m/K [2]. Furthermore, hBN itself has a thermal conductivity well over 300 W/m/K [3]. Importantly, these materials – and in particular hBN – can be placed in atomic proximity of active, heat-generating regions of electronic and optical chips without disturbing device operation and performance. We therefore believe that these materials are ideally suited for cooling local hotspots in chips, which cannot be cooled by conventional means, such as metallic shunts.

Recently [4], we have demonstrated that these 2D materials indeed improve thermal dissipation around local hotpots. Specifically, we used metal nanostrips as model systems for electronic chip components, and demonstrated a decreased metal temperature and increased breakdown current density by placing hBN flakes and hBN-encapsulated graphene stacks on the nanostrip (Figure 1, left). Furthermore, we demonstrated that hBN leads to a much lower electron temperature and less frequent breakdown of direct-bandgap hexagonal SiGe nanowires (Figure 1, right), which are promising for photonic chips [5].

References

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Figures

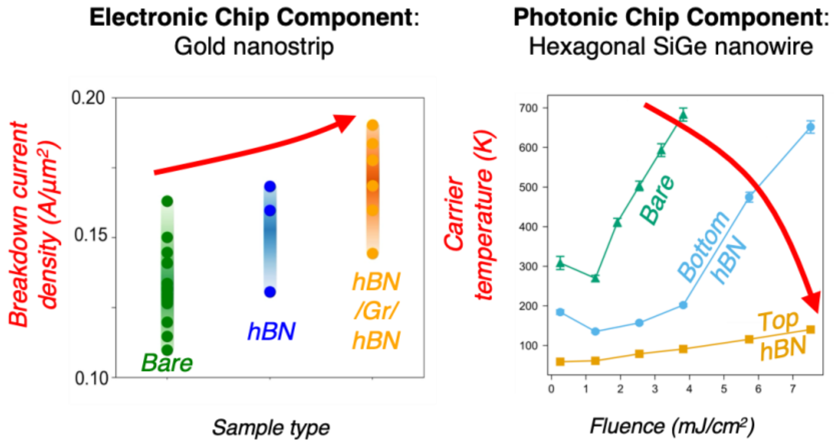

Figure 1: Demonstration of the effect of hBN and hBN-encapsulated graphene for cooling electronic chip components, where the breakdown current density is increased by ~30% (left), and the effect of hBN for cooling photonic chip components (right), where the local carrier temperature is decreased by a factor ~6 (right).