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Graphene-Based Terahertz Detectors

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Graphene has excellent electronic, mechanical, thermal, and optoelectronic properties. In particular, graphene has the longest mean free path of carriers of any known electronic material at room temperature. However, very few types of novel electronic device structures have been reported to harness this extraordinary property to achieve a higher performance than conventional electronic materials. To date, most effort on graphene electronic devices has focused on transistors by, e.g., generating a suitable bandgap for a high on/off ratio while preserving the carrier mobility. In contrast to transistors, the functionality of some diodes does not necessarily require a large bandgap. Here, we review our recent work on two types of nano-rectifiers, known as the ballistic rectifier and the self-switching diode that can greatly benefit from the extremely long carrier mean-free-path in graphene but not significantly affected by its bandgap. The ballistic rectifier structures were fabricated by creating an asymmetric cross-junction in a single-layer graphene sandwiched between two boron nitride flakes. A mobility of around 200,000 cm^2/Vs is achieved, ensuring a mean-free-path well beyond that required for the device to operate in the ballistic regime. This enables a very high intrinsic responsivity at room temperature. Taking advantage of the four-terminal device architecture in which the output channels are orthogonal to the input channels, we show that the device noise is hardly influenced by the input and is mainly limited by thermal noise, and this enables an exceptional noise-equivalent power in the order of $pW/Hz^{1/2}$. High-frequency characterisation and imaging experiments have also been carried out up to 640 GHz.

References

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