Graphene Ambipolar Nanoelectronics for High Noise Rejection Amplification

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Abstract

With over half of the world's population having access to cellular phones and other mobile/wearable information devices, there is a definite movement towards the realization of ubiquitously available wireless communication system that are even more compact and portable. Within the context of this rapidly rising demand, new materials beyond silicon, especially the lightweight atomic-thin nanomaterials, such as carbon nanotubes, graphene, MoS_2 and other two-dimensional transition metal dichalcogenides, are actively being explored. Since its first discovery in 2004, graphene has been widely studied both theoretically and experimentally due to its extraordinary properties. Graphene has extremely high intrinsic carrier mobility at room temperature, linear dispersion relation in energy band structure with ambipolar behavior for both electron- and hole-rich regions, high thermal conductivity, high transparency (~97.7%), and high flexibility with excellent mechanical durability. Various applications based on these unique properties have been demonstrated over the past decade, such as ultra-broadband photodetectors, single-molecule sensors, transparent conductive films, rechargeable lithium batteries, and terahertz plasmon oscillator, making graphene a promising candidate for next generation material beyond silicon. In modern wireless communication system, signal amplification is critical for overcoming losses during multiple data transformations/processes and long-distance transmission. By utilizing the unique ambipolarity of graphene in novel device structures, the main limitations in traditional electronics can be successfully surpassed. Here we report a new type of double-gated graphene ambipolar device with the capability of operating under both common and differential modes to realize signal amplification. By exploiting the ambipolar transport property in single layer graphene, we further demonstrate the continuous controllability of the signal output in terms of amplitude and phase under suitable gate biases. In addition, our device has been shown to achieve a common mode rejection ratio (CMRR) of over 80dB without any external supporting circuitry, which is on par with most off-the-shelf commercial amplification systems and sufficient for the generic circuit applications. Combined with other circuit elements already demonstrated in the literatures, such as mixers and modulators, the ultra-compact all-graphene wireless communication system for next generation can be realized in the near future.

Figures (total: 4)