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Temperature Dependence of Responsivity in Sub-THz band of AlGaN/GaN and Graphene Transistors

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The temperature dependences of photo-response in sub-THz regime (0.14 THz) of AlGaN/GaN and graphene transistors were studied at temperatures from 10 to 300 K. Instead of measuring the voltage response using a lock-in amplifier, the current induced by the incoming sub-THz radiations was measured directly using the semiconductor parameters analyzer (SPA). This approach allows fast and multiple THz signal detection measurements as a function of temperature.

AlGaN/GaN heterostructures were grown by the metalorganic vapor phase epitaxy (MOVPE) method in the closed coupled showerhead 3×2 inch Aixtron reactor (Aixtron, Herzogenrath, Germany). The epi-structure consisted of a 2 nm GaN cap layer, 25 nm Al0.24Ga0.76N barrier layer, a 1.2 nm Al0.66Ga0.37N spacer, and a thick GaN buffer layer. Growth of all mentioned epilayers was done on the sapphire substrates. Graphene back gate transistors were fabricated from high-quality single layer graphene encapsulated in h-BN. The device design and high-quality graphene allowed us to achieve the electron mobility of ~3 m2/Vs at room temperature.

At all temperatures, the current response as a function of the gate voltage was in good agreement with the phenomenological expression assuming its proportionality to the first derivative of conductivity over the gate voltage.

With temperature decrease, the responsivity of both kinds of the studied devices increased and saturated at T~100K. The noise equivalent power continued to decrease with temperature decrease till the lowest measured temperature of 10K.

It was found that the enhancement in the current responsivity with temperature decrease is much steeper for graphene than that for GaN-based devices. The temperature dependence of the response was analyzed based on the model of non-resonant detection in filed effect transistors [1]. These results show an advantage of the graphene-based detectors over the GaN-based ones while operating at low temperatures.

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