Graphene Field-Effect Transistors on Hexagonal Boron Nitride Operating at Microwave Frequencies

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Due to its high charge carrier mobility, graphene is an ideal candidate for devices operating at microwave frequency[1-4]. Despite the typically low on-off ratio in graphene devices, they may perform well in analog applications. In radio-frequency graphene field-effect transistors (RF GFETs), transit frequencies up to 300 GHz have been reached[4] and even basic integrated circuits were demonstrated[5,6].

We have investigated RF GFETs on hexagonal boron nitride (hBN). Boron nitride crystals are known to increase the mobility by reducing scattering in graphene, since they are atomically flat. At the same time, boron nitride serves as dielectric between the graphene sheet and pre-patterned gate electrode (schematics: fig. 1, optical micrograph: fig. 2). It has been shown that hBN acts as a defect-free dielectric[8]. The hBN flakes can be exfoliated down to few or even one atomic layer enabling very thin dielectrics. Thus, a minimum of charge impurities is introduced to the graphene. Moreover, current annealing remains possible since the graphene channel is not covered by an oxide.

Our GFETs were prepared from exfoliated mono- and bi-layer graphene with a subsequent dry transfer technique. To improve the flatness of the flakes, we employed an all-graphene layout with graphene gate fingers in some of the devices. Losses due to the parasitic capacitances of the coplanar waveguide contacting pads we reduced using sapphire[9], a fully insulating substrate. Several devices with gate lengths down to 100 nm were produced and measured (fig. 3).

Our manufacturing methods allow for integration of the graphene FETs into circuits like amplifiers or mixers. Together with the excellent heat conduction of sapphire they are well suited for cryogenic applications.

References

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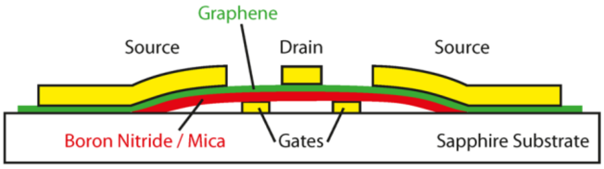
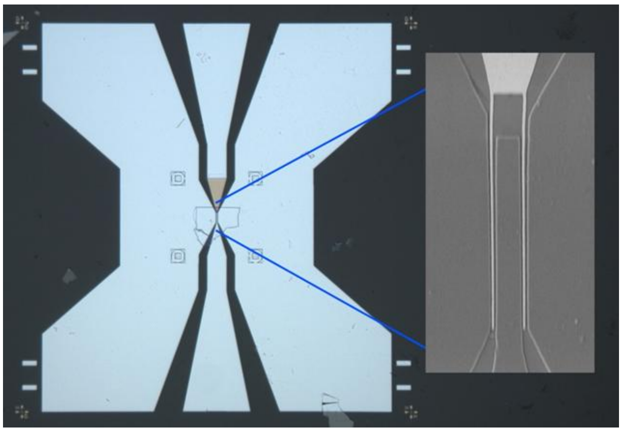
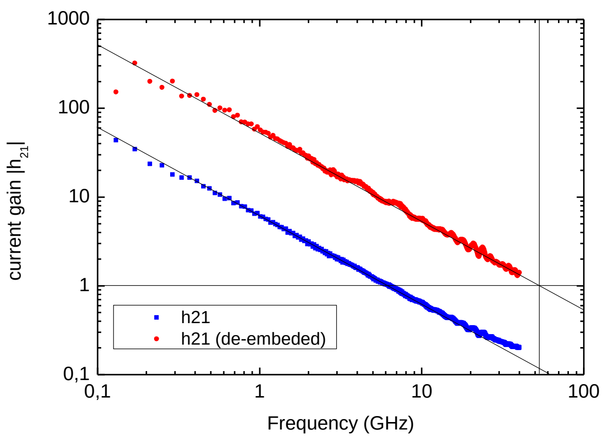
Figures



(1) Crosscut schematics of the device layout



(2) Optical micrograph of one of the devices. In the center, the hexagonal boron nitride flake is visible. The inset shows the active area of the transistor in a GSG-layout with two finger gate.



(3) Current gain vs. frequency for one of the devices with metallic gate