Prototype of a novel graphene base heterojunction transistor

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Abstract: The graphene-base hetero-junction transistor (GBHT [1], see Fig. 1) is an attractive device concept to reach THz operation frequencies. The novel transistor consists of two n-doped silicon layers with a graphene monolayer in between. The structure of the device is similar to an n-p-n bipolar transistor with the base being replaced by graphene. This innovative concept exhibits a vertical arrangement of the emitter (E), base (B) and collector (C). Due to the very low base-transit time the device potentially allows for very high cut-off frequencies (f_T).

Only recently, first attempts were made to put the GBHT into practice by means of amorphous silicon emitter and collector layers [2]. Here we demonstrate improved device performance with current saturation in the transistor's output characteristics. A clear modulation of the collector current by the applied graphene base voltage can be observed (see Figure 2). The vertical transfer current from the emitter via graphene to the collector is much lower than expected from device simulations. A comparison of the graphene-base transistor and a reference silicon n-p-n bipolar transistor is performed with respect to the main DC transistor characteristics. A common-emitter gain of larger than one has been achieved for the reference device while the graphene-base transistor so far exhibits a much lower gain.

Limitations of the GBHT technology and optimization routes to improve gain of the GBHT will be discussed (e.g. permeable base transistor design, alternative 2D base materials, high-low work function materials for the emitter and collector semi-conductor etc.).

References

[1] V. Di Lecce, R. Grassi, A. Gnudi, E. Gnani, S. Reggiani and G. Baccarani, IEEE transactions on electron devices, Vol. 60, No. 12, (2013) pp. 4263-4268

[2] C.A. Chavarin, C. Strobel, J. Kitzmann, A. Di Bartolomeo, M. Lukosius, M. Albert, J.W. Bartha and Ch. Wenger, Materials 11(3) (2018), 345

Figures

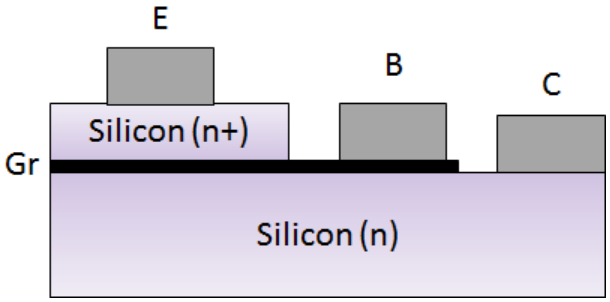

Figure 1: Schematics of the graphene-base heterojunction transistor with graphene (Gr), emitter (E), base(B) and collector (C) as proposed in [1]

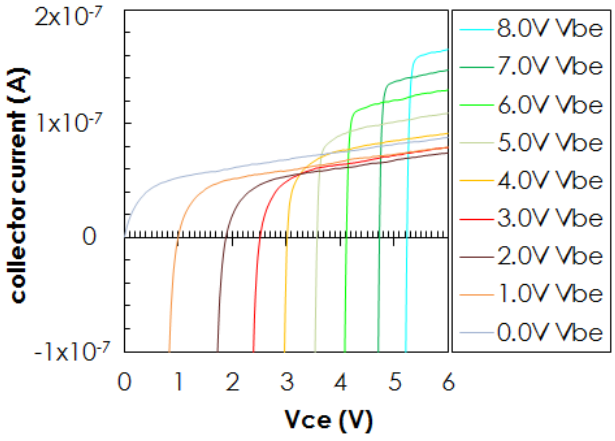

Figure 2: Common-emitter output characteristics of a GBHT for base-emitter voltages (V_{be}) applied to graphene of up to 8 V