Towards silicon-graphene based heterojunction transistors

C. Strobel¹, C.A. Chavarin², J. Kitzmann², Ch. Wenger³, M. Albert¹, J.W. Bartha¹

¹ Technische Universität Dresden, Semiconductor and Microsystems Technology Laboratory, Nöthnitzer Straße 64, 01187 Dresden, Germany
² IHP, Im Technologiepark 25, 15236 Frankfurt (Oder), Germany
³ Brandenburg Medical School Theodor Fontane, 16816 Neuruppin, Germany
carsten.strobel@tu-dresden.de

Abstract: The graphene-base heterojunction 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), thus potentially allowing for very high cut-off frequencies (fT) due to the very low base-transit time.

To realize a graphene-base heterojunction transistor it is necessary not only to transfer graphene to a silicon surface, but also to deposit a silicon layer on top of graphene. Up to now, reports about the deposition of silicon on graphene are scarce. Recently, a deposition technology (very high frequency plasma enhanced chemical vapor deposition – VHF PECVD) was successfully introduced for the fabrication of silicon-based thin-film layers on graphene without creating defects in the underlying monolayer [2]. This method is used in the present study to deposit n-doped amorphous silicon (a-Si:H) on graphene.

In this work the current state of GBHT development at TU-Dresden/IHP will be presented. First, the innovative non-destructive deposition technology for n-a-Si:H on graphene will be highlighted. Next, the successful control of the graphene/silicon interfaces is described. Up to now, highly rectifying Schottky diodes (I_on/I_off 10⁴ - 10⁵, +/- 1V) have been achieved for both the BE and BC graphene-silicon interface [3]. Finally, first GBHT prototypes were prepared and analyzed. It is verified, that the vertical current between the (n)-a-Si:H layers is successfully controlled by the ultra-thin graphene base voltage [4]. While current saturation is yet to be achieved, a transconductance of ~230 µS was obtained, demonstrating a moderate modulation of the collector-emitter current by the ultra-thin graphene base voltage.

References

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