Non-linear behavior of three terminal graphene junctions at room temperature

Wonjae Kim[1], Pirjo Pasanen[2], Juha Riikonen[1], Markku Rouvala[2], and Harri Lipsanen[1]

[1]Aalto University, Micronova, P.O. Box 13500, FI-00076 Aalto, Espoo, Finland
[2]Nokia Research Center, P.O. Box 407, FI-00045 Nokia, Helsinki, Finland

wonjae.kim@tkk.fi

Graphene is an attractive material for device applications due to its high carrier mobility in two dimensional charge carrier transport [1]. The transport behavior of two dimensional electron gas has been studied using three terminal ballistic junctions based on III-V semiconductors [2-8]. Recent study has also demonstrated non-linear electrical properties at low temperature on graphene using three terminal junctions fabricated by etching three trenches on a graphene flake [9]. Here we have further investigated electrical properties of the graphene device with three terminal T-branch structure at room temperature and shown that the rectified effect is around 10% at room temperature.

T-branch devices were patterned on exfoliated single layer graphene prepared on a 300-nm-thick silicon dioxide using O_2 plasma etching (Fig. 1a). The width and length of the channel from the left to right is 200 nm and 600 nm, respectively. The center branch is around 100 nm wide and 300 nm long. The metal contact is formed with Ti/Au (5 nm/40 nm) by e-beam evaporation.

In the measurements anti-symmetric voltage sources, so-called push-pull configuration (V_L=-V_R), are applied to the left and right terminals simultaneously and the output voltage is measured at the center branch with various the backgate voltages. The substrate of highly doped silicon is used as a global back gate electrode. All measurements were carried out at room temperature.

As shown in Fig. 2(b), when the left and right terminals are biased by push-pull manner with a backgate voltage, the output voltage at the center branch is dominantly negative or positive regardless of the sign of input voltage. Moreover, the output voltage becomes almost zero when the backgate voltage reaches the carrier neutrality point as expected. The Dirac point is found around 20 V of the backgate voltage (Fig. 1c). Also, the curvature of rectification becomes stronger when the Fermi level is increased by the backgate voltage. This implies that the curvature of rectification is dependent on the carrier density. Furthermore, the sign of the rectified curve is altered by changing the carrier (hole or electron) type. Positive rectification occurs at electron transport region and negative rectification at the hole transport region.

We assume that the inhomogeneous charge carrier distribution can result in non-linear rectification of the electric potential along the channel [11-12]. The carriers can be also affected by the impurities and space charge on the graphene surface. It is important to understand this type of effect since they can have a large impact on how circuits made of graphene will behave.

References

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Figures

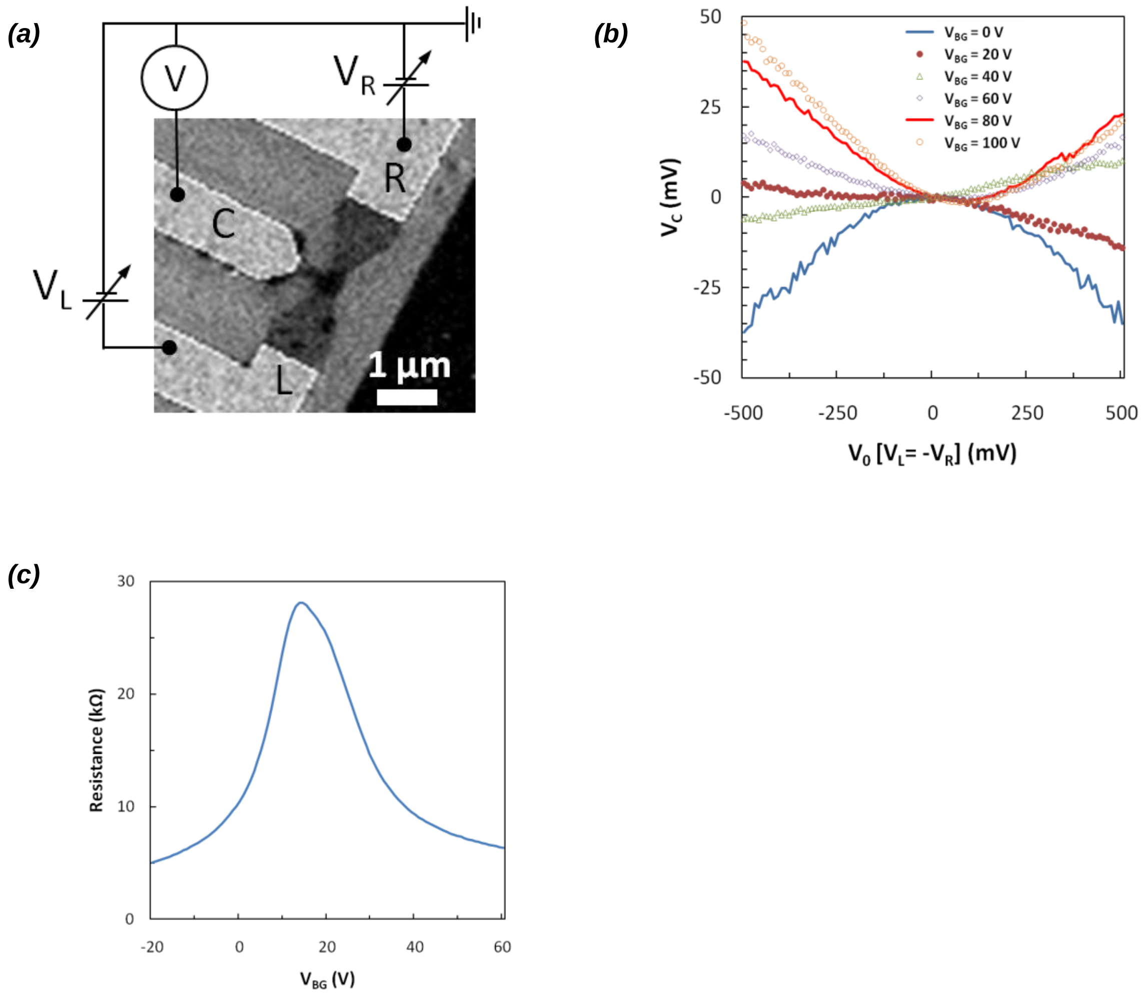

*Figure. 1. (a) SEM image of T-branch structure and schematic of measurement configuration. (b) Measured output voltages at the center terminal **C** as a function of anti-symmetric bias voltage V_0 (push-pull, $V_L = -V_R$) with various backgate voltages at room temperature. (c) Resistance of the channel between the left and right terminals as a function of the backgate voltage when the left terminal is biased and others are grounded.*