Student Paper

An Investigation of ZGNR-Based Transistors

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Graphene, a recently discovered form of carbon, has received much attention for possible applications in nanoelectronics, due to its excellent carrier transport properties [1]. Graphene nanoribbons (GNRs) are thin strips of graphene, where the electronic properties depend on the chirality of the edge and the width of the ribbon. Zigzag GNRs (ZGNRs) show metalic behavior, whereas armchair GNRs (AGNRs) are semiconductors and their band-gap is inversely proportional to their width [2]. Therefore, narrow AGNRs have been recently suggested as a material for transistor channels. However, line edge roughness and substrate impurities can significantly degrade the ballistic transport in AGNRs, especially in narrow ribbons [3].

In contrast, in ZGNRs, ballistic transport is sustained in the presence of line edge roughness and substrate impurities. Very recently, the band folding and the transport properties of ZGNRs with extended line defect along the ribbon's length (ELD-ZGNR) have been investigated [4]. The bands corresponding to the line defects result in an asymmetry between electrons and holes (see Fig.1-c) and the band folding causes the transport of holes to become diffusive in the presence of the long-range defects. On the other hand, a conducting path is formed around the line defect, which is located far from the ribbon's edges. As a result, the electron transmission in this path is less sensitive to the roughness of the edges. Therefore, one can open up a transport gap between electrons and holes in ELD-ZGNR by employing the line edge roughness. As shown in Fig.2, a transport gap of nearly 0.2 eV is opened up in the average transmission probability of ELD-ZGNR(7,7) at a length of 750 nm.

We propose this structure as a channel in nanoelectronic devices and investigate the transistor behavior of ELD-ZGNR(7,7). The transfer characteristic of this structure is shown in Fig.3. Our results show that an I_{on}/I_{off} ratio of more than 200 can be achieved. In addition it is possible to obtain a steep inverse subthreshold slope. ELD-ZGNRs benefit from line-edge roughness and substrate impurities, in that a transport gap forms. Our simulation results indicate that the performance of ELD-ZGNR-based transistor is only weakly degraded in the presence of line-edge roughness and substrate charge impurities.

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References

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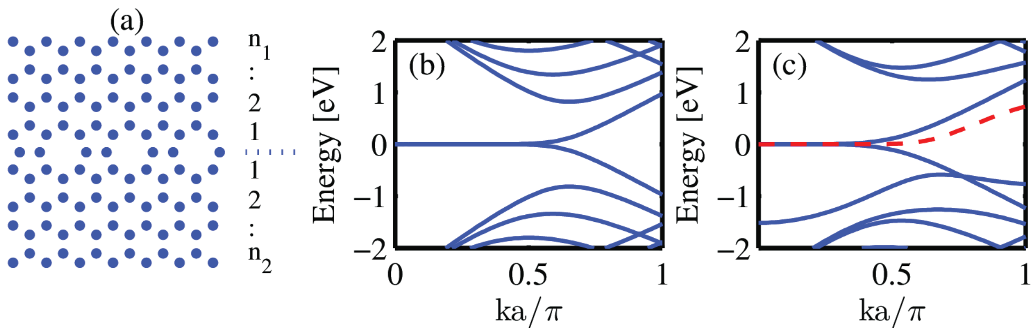

Fig. 1 (a) The geometrical structure of ELD-ZGNR(n_1,n_2). The band structure of (b) ZGNR(14) and (c) ELD-ZGNR(7,7). The band structure of ZGNR(14) is also folded for a better comparison. The band corresponding to the quantum wire is represented with a dashed line. The translation vector is given by a=0.49 nm.

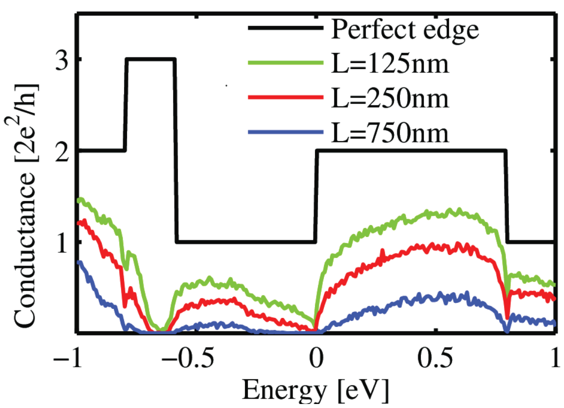

Fig. 2 Electrical conductance of ELD-ZGNR(7,7) with perfect edges and with rough edges at various channel lengths.

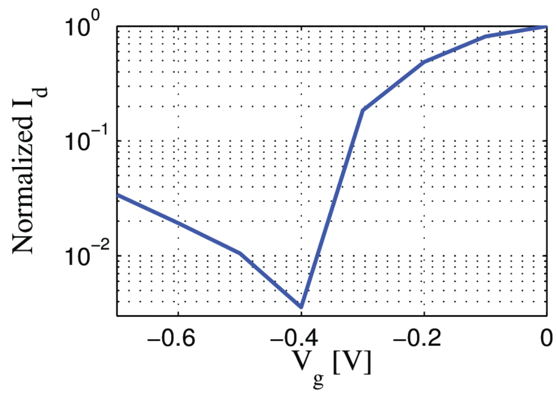

Fig. 3 Transfer characteristic of ELD-ZGNR(7,7) with a length of L=750nm. The Fermi level of the source and the drain contacts are E_{FS} = 0.1eV and E_{FD}=-0.2eV, respectively. The drain voltage is V_D=0.3V. The current is normalized to I_{on}.