Abstract

In this works we fabricated four graphene/silicon heterojunctions, which differ for structure and substrate type, and performed electrical and optical characterization. The first device was realized by depositing a layer of graphene on a trench patterned low n-doped silicon substrate. We obtained a graphene/silicon Schottky diode connected in parallel with a graphene/oxide/silicon MOS (Metal Oxide Semiconductor) capacitor. The device shows a rectification factor of 3 orders of magnitude and a Schottky barrier of $0.56\ eV$. The device displays a reverse current greater than the forward one when exposed to white LED light. We explained this phenomenon by taking into account the MOS capacitor connected in parallel which act as a reservoir of charges. The second device presents the same structure, but a low p-doped silicon substrate was used. In this case, we obtained a Schottky barrier of $0.17\ eV$ which tends to get smaller when annealed to high temperature. This behaviour has been attributed to the boron atoms which diffuse from the silicon to graphene inducing a p-doping, which further reduce the Schottky barrier. The third device was realized by depositing a graphene layer on a pillar-patterned high n-doped silicon substrate. The device shows a Schottky barrier of $0.11\ eV$ and a reverse current which grows exponentially respect to the bias. We explained this result by considering the pillar structure which, magnifying the electric field around its corners, favours the up-shift (down-shift) of the graphene Fermi level reducing (or increasing) the Schottky barrier upon application of a bias. At higher temperature this behaviour tends to disappear since the Schottky barrier variations are overcome by the thermal effects. The last device was fabricated by depositing a graphene layer on a matrix of silicon tips. The device shows a Schottky barrier of $0.36\ eV$ which corresponds to a rectification factor of almost three orders of magnitude and a reverse current which grows exponentially with the bias over the whole temperature range. Similar to the previous junction, the tip geometry magnifies the electric field and allows to tune the Schottky barrier by changing the bias. The device shows an ideality factor closer to the unity meaning that the tip geometry reduces the formation of inhomogeneity, which can affect the junction properties, and allows the formation of higher Schottky barrier.