Photoluminescence of CVD graphene layers transferred onto SiO_2 coated silicon substrate

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Graphene composed of sp^2 bonded carbon atoms arranged in a two-dimensional honeycomb lattice structure is the thinnest and strongest ever known material with fascinating and exotic properties. Moreover, graphene is semiconductor attractive for application in various electronic devices due to outstanding transport properties such as high electron mobility and conductivity. However, owing to the zero bandgap width an observation of efficient photoluminescence on the high-quality graphene samples requires tuning the graphene electron band structure either by doping with various functional groups or by reducing the size of a graphene sheet down to a nanometer scale because isolated graphene clusters may have large bandgaps due to the finite number of atoms in the clusters. Graphene functionalized by fluorine, oxygen, nitrogen, or hydrogen is highly promising material for advanced optoelectronic applications. Functionalization of graphene by plasma treatment is one of the facile ways to tune the graphene properties and doping level without using wet chemicals in order to it becomes an applicable luminescent material.

We studied photoluminescence properties of the monolayer and bilayer graphene samples at room temperature in the spectral range from 350 to 850 nm. Graphene was grown by the CVD method at 1020°C on copper foil using a mixture of methane and hydrogen. The synthesized graphene was transferred one time or two times onto silicon substrate coated with 300 nm thick SiO_2 film in the case of monolayer and bilayer samples, respectively. Then the samples were exposed to oxygen or nitrogen plasma at room temperature. Photoluminescence of as-transferred and oxygen plasma treated samples mainly originated from substrate for both graphene monolayers and bilayers. On the other hand, the nitrogen plasma treated bilayer graphene sample exhibited in contrast to the monolayer sample exposed to the same plasma treatment additional efficient photoluminescence in the UV-green-red spectral region that under excitation at 250 nm consisted of three emission bands peaking near 390, 470, and 620 nm. The origin of this efficient photoluminescence discovered on the nitrogen plasma treated bilayer graphene will be discussed.

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