Large enhancement of Raman spectra in graphene deposited on GaN nanowires

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Since graphene is transparent and has good conductivity, it is considered to be a proper candidate for replacing ITO in solar cells. On the other hand, it has been shown recently that nanowire structures can substantially increase efficiency of solar cells.[1] Therefore, possibility of using graphene as a transparent electrode deposited on GaN nanowires (NWs) is very attractive. In our studies we focused on Raman spectroscopy and contactless microwave transport measurements[2] of graphene grown by Chemical Vapor Deposition method, and transferred onto top of GaN NWs grown by Molecular Beam Epitaxy. The results were compared with the ones obtained for graphene deposited on epitaxial GaN layer.

Large enhancement of Raman spectra deriving from graphene deposited on NWs in comparison with the corresponding spectra of graphene on epilayer was observed (Fig. 1). Value of enhancement varied from 55 times for the most enhanced 2D peak to 35 times for D' peak. Two dimensional Raman micro mapping showed correlations between Raman peak parameters and nanowires distribution underneath of graphene. Periodic modulation of electron concentration and homogenous strain found in graphene on NWs suggested that Raman enhancement could be explained by influence of strong electric field induced by electric charges located on the top of the nanowires, similar to the Tip Enhancement Raman Scattering (TERS) mechanism.[3] This effect is confirmed in transport measurements where positive magnetoconductance signal for low magnetic field for both samples was observed (Fig. 2). The signal amplitude was reduced for graphene on NWs which was caused by reduction of coherence scattering length L_φ comparing to graphene on epilayer. Nonzero offset in $L_\varphi^{-2}(T)$ linear dependence, present only for graphene on NWs, showed additional, temperature independent scattering mechanism reducing coherence scattering length. This can be related for example to charges induced on the NWs surface by spontaneous and piezoelectric polarization of GaN,[4] which due to a very small distance of NW from graphene sheet can modulate electron concentration in graphene, and furthermore be responsible for the enhancement of the Raman spectra.

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(4) Ambacher, O. el al., Journal of Physics:Condensed Matter 14, (2002), 3399–3434

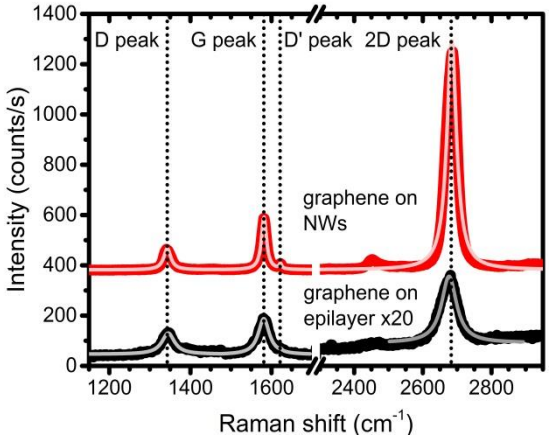

Figure 1. Raman spectra measured for graphene deposited on GaN nanowires, and on GaN epitaxial layer.

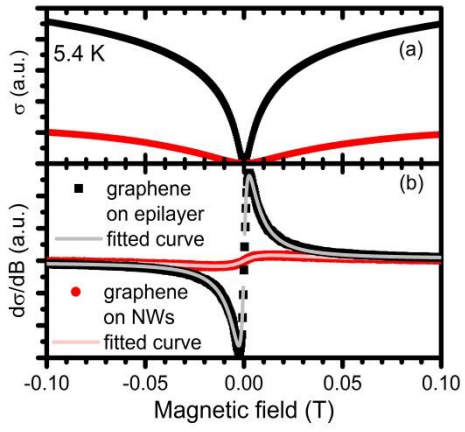

Figure 2. Magnetoconductance signal (a) and its derivative on magnetic field (b) for graphene deposited on GaN NWs, and on GaN epilayer.