Direct PE-CVD growth of graphene on GaN under N_2 atmosphere

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Gallium nitride (GaN) has gathered a lot of attention over the last years as the material of choice for modern ultra-violet Light Emitting Diodes (UV-LEDs) [1]. One performance limiting bottle-neck towards more efficient UV-LEDs is the poor *p*-type conductivity of $Al_xGa_{1-x}N$ which is used as a top layer material for current spreading and current injection into the active region of the LED. One promising approach to tackle this challenge is to use graphene on top of the $Al_xGa_{1-x}N$-layer as a transparent electrode due to its high conductivity and low absorption losses over a broad spectral range [2]. Common thermal chemical vapor deposition (T-CVD) methods use temperatures above 900 °C and H_2 as a process gas, parameters well known for enhanced etching effects on GaN [3].

Here, we report the successful growth of graphene via plasma-enhanced CVD (PE-CVD) directly on GaN based LEDs under N_2 atmosphere and reduced temperatures (800 °C). We can show that N_2 instead of the commonly used H_2 as a process gas minimizes the surface degradation of the GaN-LED during the PE-CVD process while enabling the growth of graphene [**Figure 1**]. By reducing the CH_4 flux from 15 to 5 sccm it is possible to decrease the growth rate, thus increasing the quality of the grown layers ($I_{2D}/I_G \sim 1.5$). Thus, we were able to improve the sheet resistance from ~ 77 $k\Omega/\square$ to ~ 3 $k\Omega/\square$. Transmission measurements show a loss of 6 ± 1% in transparency which indicates the growth of 2-3 graphene layers. Analyzing fully processed devices yields a significant improvement of the lateral current spreading (by a factor of 4), indicating the potential of PE-CVD graphene grown under N_2 atmosphere as transparent top contact in GaN-LEDs [**Figure 2**].

References

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[3] M. A. Mastro, O. M. Kryliok, T.J. Anderson, A. Davydov, A. Shapiro, J. Cryst. Growth, 274 (2005) 38-46

Figures

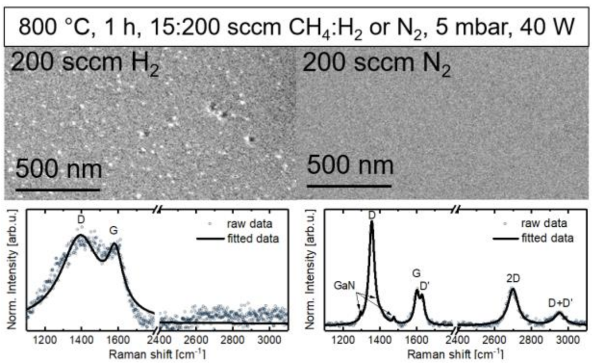

Figure 1: SEM pictures of the GaN surface under H_2 (left) and N_2 (right) atmosphere after the PE-CVD growth process with corresponding Raman spectra of the graphene layers (lower panel).

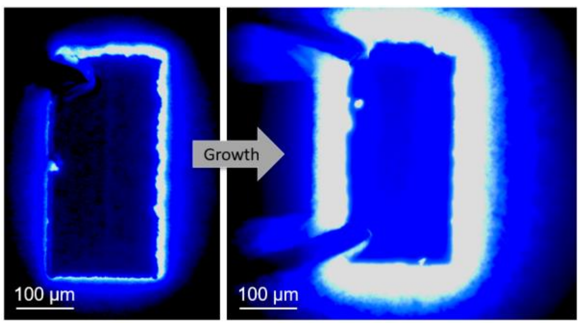

Figure 2: Microscopic image of a GaN-LED without (left) and with (right) graphene layers at 20 mA.