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High Brightness Blue/UV Light-Emitting Diodes Enabled by Directly Grown Graphene Buffer Layer

Single-crystalline group-III nitrides (III-Ns, i.e. GaN, AlN) based light-emitting diodes (LEDs) with high-efficiency and long lifetime are the most promising solid-state lighting source compared with conventional incandescent and fluorescent lamps.[1] However, the lattice and thermal mismatch between III-Ns and sapphire substrate always induce high stress and high density of dislocations and thus degrade the performance of LEDs.[2] Here, we report the growth of high-quality III-Ns films with low-stress and low density of dislocations on graphene (Gr) buffered sapphire substrate for high-performance LEDs. Gr films are directly grown on sapphire substrate to avoid the tedious transfer process and III-Ns is grown by metal-organic chemical vapor deposition (MOCVD). The introduced Gr buffer layer greatly releases biaxial stress and reduces the density of dislocations in III-Ns film and multiple quantum well structures. The as-fabricated LED devices therefore deliver much higher light output power compared to that on bare sapphire substrate, which even outperforms the mature process derived counterpart. The III-Ns growth on Gr buffered sapphire only requires one-step growth, which largely shortens the MOCVD growth time. This facile strategy may pave a new way for applications of Gr films and bring several disruptive technologies for epitaxial growth of GaN film and its applications in high-brightness LEDs.

References

[1] Kim, Y. et al. Nature 544 (2017), 340–343.
[2] Chen, Z. L. & Liu, Z. F. et al. Adv. Mater., 30 (2018), 1801608.

Figures

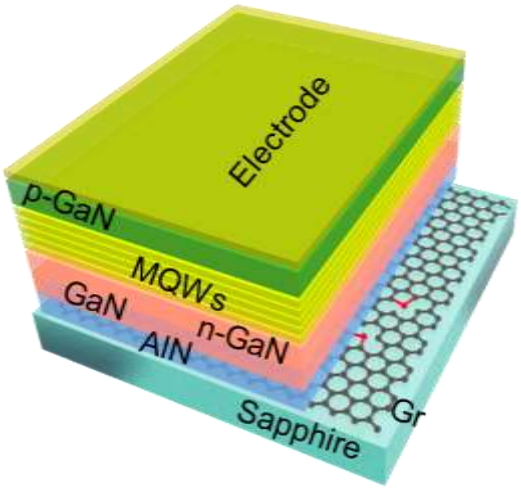

Figure 1: The structure of LEDs grown on Gr/sapphire substrates.