The influence of AlN buffer layer on the Growth of Self-Assembled GaN Nanocolumns on Graphene

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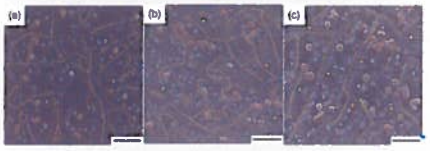
Introduction

Previous works [1, 2] have successfully demonstrated high-density, vertically-aligned GaN NC growth on multi-layer and single-layer graphene, respectively, by employing a thin AlN buffer layer. These works are the foundation for our most recent work in utilizing graphene as the substrate and bottom electrode for GaN-based UV-A LEDs [3]. However, the influence of the AlN buffer layer on GaN NC growth and its impact on graphene properties are still not well understood.

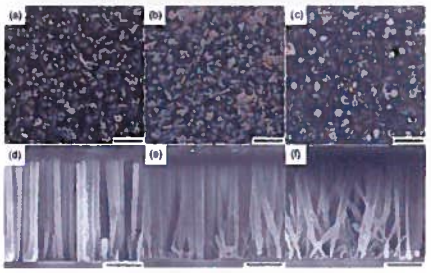
AlN buffer growth (RF-PAMBE)

Growth temperature of AlN (805 °C) was nominally similar to ref. [2]. (a), (b) and (c) are top-view SEM images of different AlN buffer layers formed on graphene, obtained via 20 (sample A1), 40 (sample A2) and 80 (sample A3) MEE cycles. Scale bars are 1 µm.



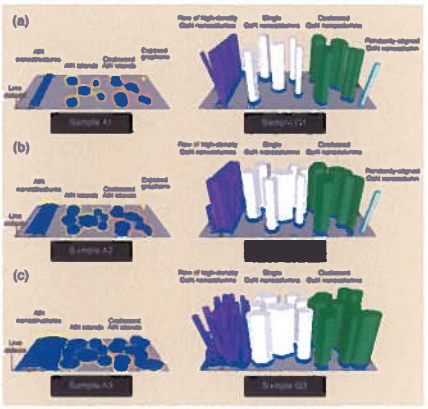
GaN NC growth (RF-PAMBE)

To identify the influence of AlN, GaN NC growth conditions were kept nominally the same with that of on silica glass [4]. (a, d), (b, e) and (c, f) are top- and side-view of GaN NCs grown on graphene via 20 (sample G1), 40 (sample G2) and 80 (sample G3) AlN MEE cycles. Scale bars are 1 µm for (a-c) and 500 nm for (d-f).



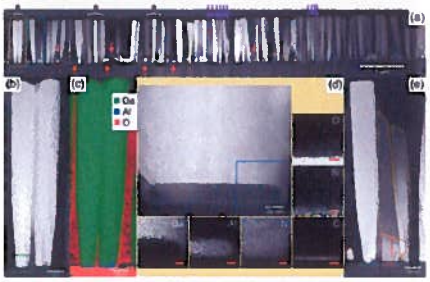
Growth schematics

Simplified illustrations of the AlN buffer structures and GaN NC formation on graphene for samples (a) A1-G1, (b) A2-G2 and (c) A3-G3.



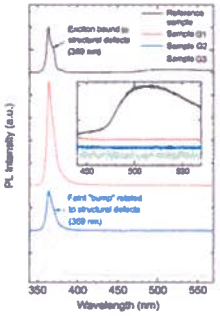
TEM of sample G1

(a) Overview HAADF STEM image of GaN NCs
(b) HAADF STEM image of two GaN NCs (yellow frame in a) and (c) its EDS/EELS .
(d) Magnified image of the green frame in b, with the elemental mapping near the interfaces (blue frame). The red scale bars are 5 nm.
(e) HAADF STEM image of the light-blue frame in a.



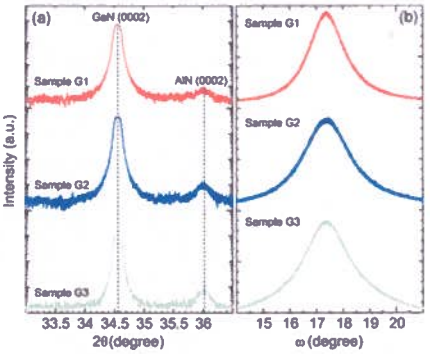
RT-µPL results

Emission at 364 nm →wurtzite GaN, is observed in all NC samples, including ref. sample (HVPE-GaN). Sample G1 has the most intense emission. Also, no yellow- nor exciton bound to structural defect emission is noticed in sample G1.



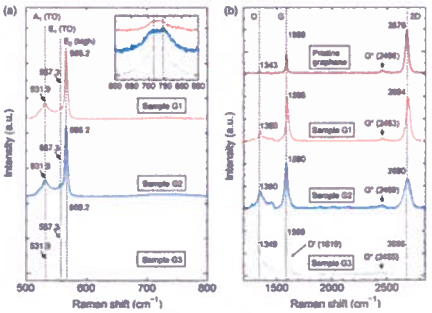
HRXRD measurements

(a) 2θ-ω scanning curve.
(b) ω scanning curve.



µRaman spectra

(a) A1(TO), E1(TO) and E2 (high) phonon peaks indicate stress-free wurtzite GaN. Inset shows weak peaks related with SO and LPP modes.
(b) Graphene becomes more defective for GaN NCs grown with higher AlN MEE cycles.



Conclusion

- Distinct growth behavior of the GaN NCs on graphene is identified when the AlN MEE cycles are varied.
- Due to the weak nucleation on graphene, instead of an AlN thin-film, two distinguished AlN structures are observed which affect the subsequent GaN NC growth.
- A limited direct growth of GaN NCs on graphene is also noted.
- Surprisingly, AlN formed with less MEE cycles leads to the high-quality and vertical GaN NCs while maintaining the graphene quality.

References

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