

鑽石計畫成果

Enhanced light output power and growth mechanism of GaN-based light-emitting diodes grown on cone-shaped SiO₂ patterned template.

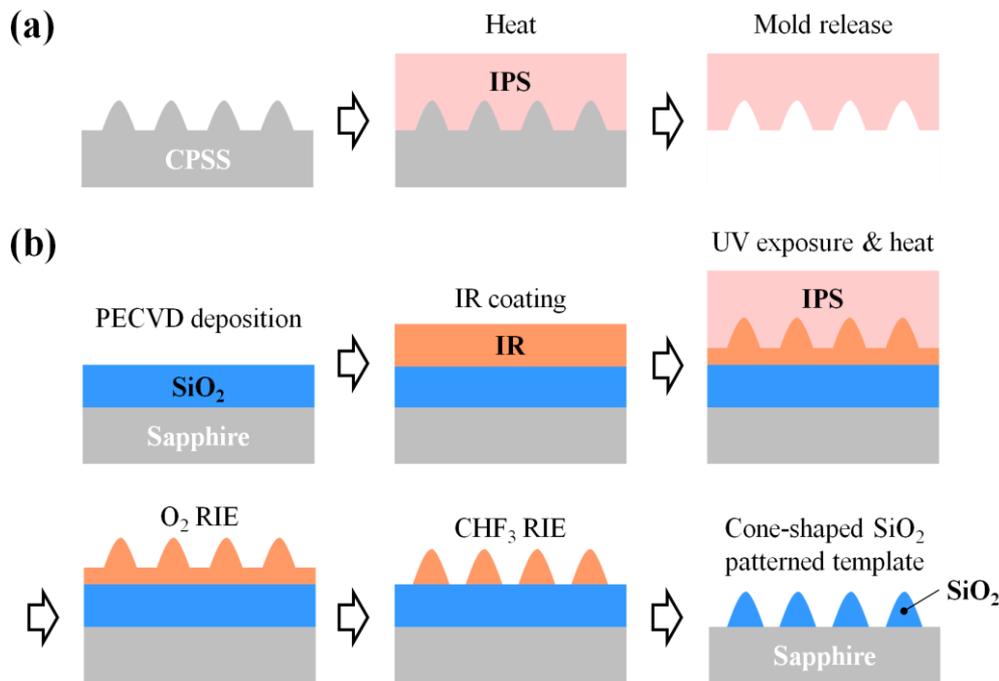
學生：陳政勤

學號：9924003

指導教授：郭浩中



Experiment

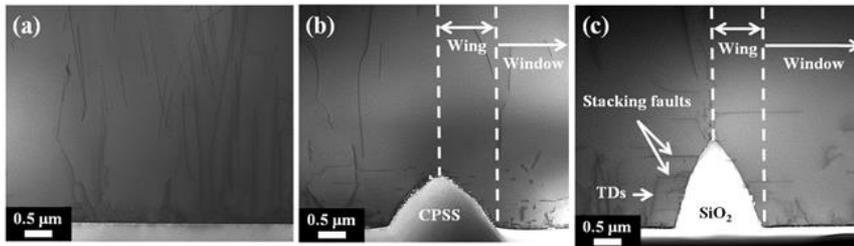


- The reverse cone-shaped mold was constructed by imprinting a CPSS on the intermediate polymer stamp (IPS).
- The SiO₂ was deposited by PECVD. Then an imprint resist (IR) layer was coated on the SiO₂ layer
- After that, the IR was etched by a reactive ion etching (RIE) process.
- Finally, the cone-shaped SiO₂ patterns were formed.



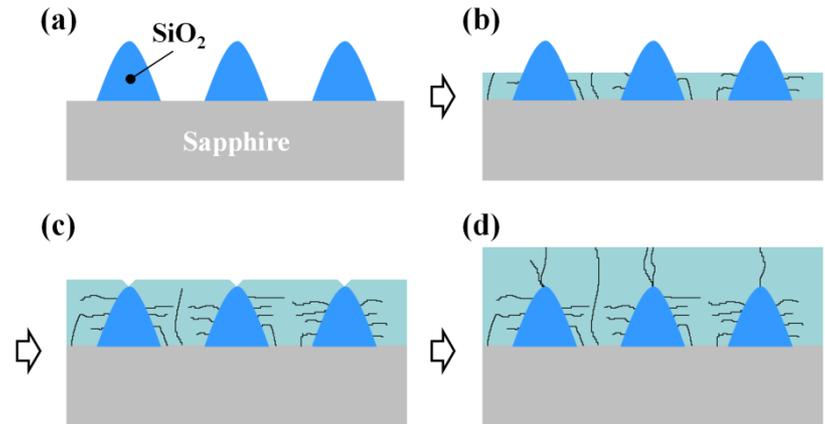
Results & Discussion

TEM images



- The cross-sectional TEM images of GaN epilayer grown on (a) planar sapphire substrate, (b) CPSS, (c) cone-shaped SiO_2 patterned template.

- From (c), the stacking faults can effectively suppress and block the TDs in the window region from propagating to the upper GaN epilayer and MQWs.



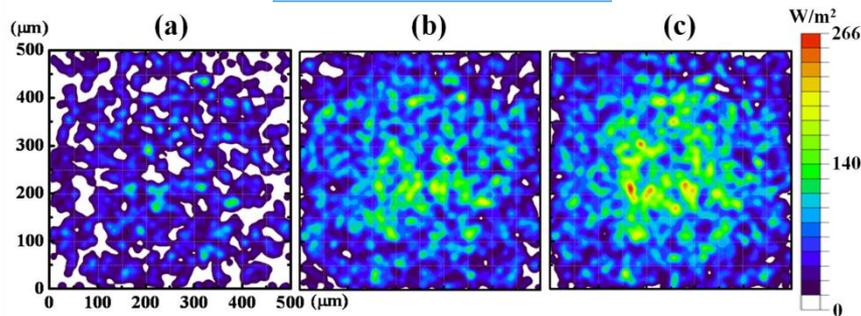
- The figure above show the sketch of epitaxial lateral overgrowth (ELOG) behavior, which lead to dislocation bending.

- The dislocation bending effect can reduce the dislocation density of active layer .



Results & Discussion

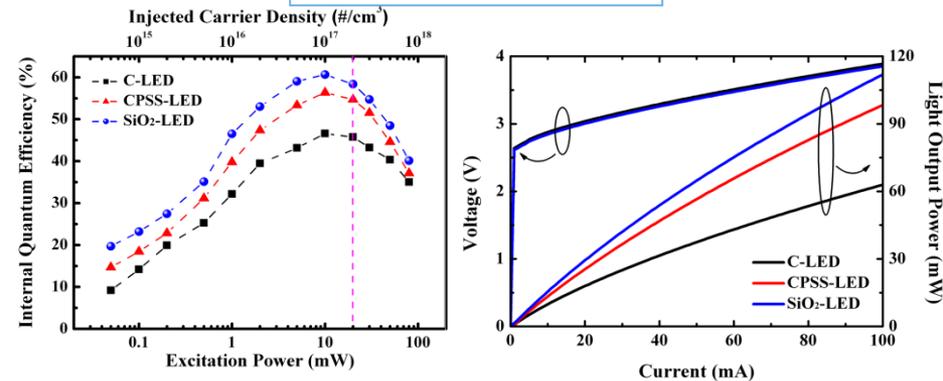
Ray-tracing simulation



- Illuminance maps of (a) C-LED (b) CPSS-LED (c) SiO₂-LED by Monte Carlo ray-tracing simulation

- The light extraction efficiency of SiO₂-LED can be enhanced due to the smaller refractive index for SiO₂ than sapphire.

IQE & L-I-V measurements



- At 20 mW of excitation power, the IQE for C-LED, CPSS-LED, and SiO₂-LED were 45.7%, 54.7%, and 58.4%.

- With an injection current of 20 mA, the forward voltages are 3.04 V , 3.02 V, and 3.00 V, and the light output powers are 18.0 mW, 25.5 mW, and 29.4 mW for C-LED, CPSS-LED, and SiO₂-LED.



Conclusion

- In this work, we successfully fabricate cone-shaped SiO_2 patterned substrate LEDs by using nanoimprint lithography (NIL).
- The TEM images suggest that the stacking faults can effectively suppress the threading dislocation density.
- The SiO_2 -LED shows the highest light output power in these three cases due to the better performance for both internal quantum efficiency (IQE) and light extraction efficiency (LEE).