Room-temperature continuous-wave electrically injected III-Nitride laser diode grown on Si

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With the support by the National Natural Science Foundation of China and Chinese Academy of Sciences (CAS)，the research team led by Prof. Yang Hui（杨辉）and Prof. Sun Qian（孙钱）at the Key Laboratory of Nano-devices and Applications，Suzhou Institute of Nano-Tech and Nano-Bionics (SINANO)，CAS achieved the first InGaN-based laser diode directly grown on Si，operating under a continuous-wave current injection at room temperature，which was published in *Nature Photonics*（2016，10：595—599）.

Given the exponential growth of the information industry，a global Internet traffic is set to increase dramatically and surpass the zettabyte（2^{70} bytes）threshold soon. Hence broadband high-speed data transmission at low power consumption is highly desirable for signal processing and high-performance computing. Optical interconnections via Si photonics technology have been widely recognized as a potential solution to this problem. However，Si as an indirect band-gap semiconductor is hardly considered as an efficient light-emitting material. The lack of efficient on-chip light sources remains as the key roadblock of Si photonics and its low-cost large-scale integration with Si electronics for decades. It is highly desirable to grow III-V semiconductor laser directly on Si for a monolithic integration with Si photonics to take a full advantage of the low-cost high-yield fabrication foundries.

Besides the conventional III-V semiconductors，(Al，Ga，In) N light-emitting materials with a direct-band emission wavelength ranging from deep ultraviolet to near infrared offer a new technical approach towards on-chip light source. Commercial GaN-based laser diodes are unambiguously grown on small-size，costly free-standing GaN substrates，which hinders their wide applications. By utilizing large-diameter cost-effective Si substrates，GaN-based laser diodes may serve as an electrically driven on-chip light source at a slashed cost.

The hetero-epitaxial growth of GaN on Si encounters a large mismatch in both lattice constant and coefficient of thermal expansion，often resulting in a high density of defects and even micro-crack networks. By inserting a ‘hand-shaking’ buffer layer between Si and GaN，SINANO scientists have successfully tackled the problem and achieved crack-free high-quality GaN film on Si. They have demonstrated the first operation of InGaN-based laser grown on Si under a continuous-wave current injection at room temperature，with a threshold current density of 4.7 kA/cm^2. With a further improvement in material quality，device performance and lifetime，GaN-on-Si technology holds a strong hope in commercializing III-nitride laser on large diameter Si. Moreover，by growing GaN upon Si(111)-on-Insulator-Si(100)，InGaN-based laser as a new promising candidate for on-chip light sources may pave the way for optoelectronic integration.

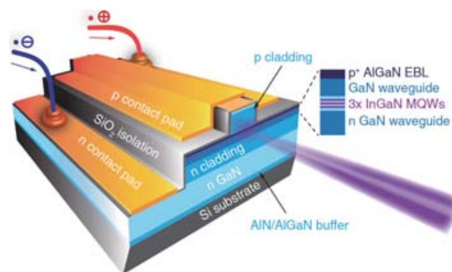

Figure Schematic architechture of GaN-based laser directly grown on Si.