III-Nitride Semiconductor Growth on Si for Photonic and Electronic Devices

Qian Sun[1]

[1]*Suzhou Institute of Nano-Tech and Nano-Bionics (SINANO), Chinese Academy of Sciences (CAS), Suzhou 215123, P. R. China*

Direct growth of III-Nitride semiconductors on large-diameter cost-effective Si is a promising game-changing technology to GaN-based optoelectronics and power electronics industry. However, 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 carefully engineering the Al-composition step-graded AlN/AlGaN multilayer buffer between Si and GaN, we have not only successfully eliminated the crack formation for 10-µm-thick continuous GaN thin film grown on Si, but also substantially reduced the threading dislocation density down to the order of 10^7 cm^{-2} [1].

Upon the high-quality GaN-on-Si platform, we have not only commercialized highly efficient blue, white, and UVA LEDs [2-4], but also realized the first room-temperature electrically injected blue, violet, and UVA edge-emitting laser diodes [5-9], superluminescence diode [10], as well as microdisk laser diodes [11, 12]. And preliminary integration of GaN-based laser, modulator, and detector will also be presented [13]. Meanwhile, the challenges and technical solutions in fabricating normally-off HEMTs on Si with a p-GaN gate [14-17] and GaN-on-Si vertical power diodes will be discussed. In addition, GaN-based RF HEMTs grown on Si with a thin AlGaInN barrier exhibited an encouraging performance in both cut-off frequency and gate leakage [18].

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Presenting author Email address: qsun2011@sinano.ac.cn