GaN/Si hybrid integrated photonic platform in UV-blue light region

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Photonic integration platforms working in the UV-blue light wavelength range, with the advantages of a smaller footprint and a larger bandwidth compared with their infrared counterparts, hold the promise for the applications in augmented reality (AR)/virtual reality (VR) systems, light detection and ranging (Lidar), visible light communications, quantum photonic chips, bio-photonic chips, and so on. In order to fabricate such an integrated platform, both GaN based emitters and the passive Si photonic devices are required. In this emerging research area, there are few preliminary works in the emitters and low-loss waveguides in UV-blue wavelength range, [1,2] the established parameters for design a full UV-blue integrated platform is still missing.

In this work, we proposed and fabricated a hybrid UV-blue photonic integrated platform which consists of a Distributed Bragg Reflector enhanced light emitting diode (DBR-LED) flip-chip bonded to Si photonic circuits. The latter is comprised of Al_2O_3 grating couplers and optical tapers with optimized parameters fabricated on Si to effectively couple the light from the DBR-LED (with improved emission directivity and brightness) to the waveguides, which deliver optical signals to the rest areas in the integrated photonic circuits. Regarding the active emitter, SiN/SiO_2 DBRs were fabricated on a 450 nm blue LED with 10 pairs in the back side and 5 pairs in the front side. The DBR-LED exhibits a 10 times higher emission intensity in the vertical emission direction and a reduced linewidth from 26 to 17 nm. The major Fabry–Pérot peak is defined at 446 nm. For the passive photonics, we adopted atomic layer deposited (ALD) Al_2O_3 waveguide-based devices as it is demonstrated an ultra-low propagation loss of <3 dB/cm in the UV and <0.3 dB/cm in the blue region. The dimension of Al_2O_3 waveguide is 400 nm in width and 85nm in the thickness, supporting single mode with wavelengths from 250 to 490 nm, with a simulated propagation loss less than 1dB/cm. Vertical grating couplers with a period/duty cycle of 600 nm/0.27 were fabricated with an expected coupling efficiency of 6%. Following that it is a trapezoidal optical taper with width and length of 4 and 10 μm to generate a pure single mode in the waveguides.

As the first demonstration in GaN/Si UV-blue integrated photonics with well-defined parameters in both active emitters and passive devices, we believe our work is instructive to the future work in GaN/Si photonic integrated systems.

Acknowledgements: The authors acknowledge UKRI-EPSRC's support under the program grant of "QUantum Dot On Silicon systems for communications, information processing and sensing (QUDOS)" (EP/T028475/1) and platform grant of "Electronic-Photonic Convergence: A Platform Grant" (EP/N013247/1).

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