To further study the optical performance of the SLD, we measured the electroluminescence (EL) spectra using an Ocean-Optics HR4000 spectrometer at different currents ranging from 100 mA to 1 A (Fig. 2a). A peak emission wavelength of ~ 445 nm was obtained from the SLD. Fig. 2b depicts the current-dependence of the full width at half maximum (FWHM) and peak wavelength of the SLD device. It reveals that the FWHM value decreases from ~18 nm at 100 mA while under spontaneous emission, to 6.5 nm at 1 A due to the higher amplification of spontaneous emission (ASE) near the optical gain maximum [9]. Due to band-filling effects, a blue-shift tendency in the current-dependent peak position is observed, which is later turned into a red-shift due to increased heating associated with high driving currents. We have compared the emission wavelength, device design, optical power, and spectral bandwidth of our device with those from other previously reported violet-blue-SLDs in Table 1. Our SLD shows a promising large PBP of 2970 mW·nm, which is the highest value, to the best of our knowledge, compared to other devices in violet-blue regime. A high-resolution EL spectrum was measured by guiding the emitted light into a single-mode optical fiber and characterized using Yokogawa AQ6373B optical spectrum analyzer (Fig. 2c). This spectrum illustrates a ripple period of ~26 pm at 800 mA, which further confirms the amplified spontaneous emission characteristics of the reported device.

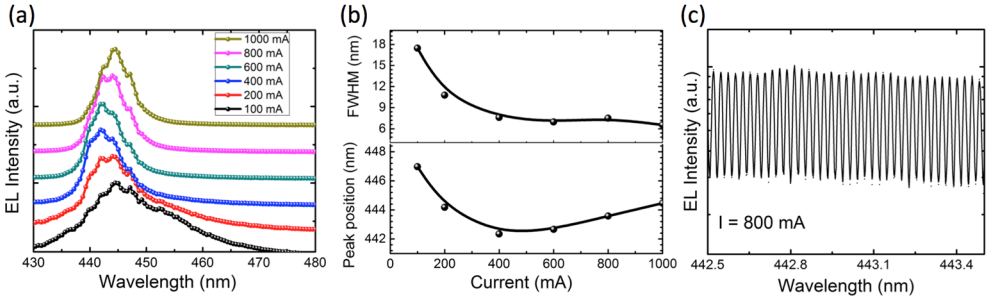

Fig. 2 Characterization of SLD: (a) Electroluminescence spectra of the SLD at different current injection. (b) Plot of FWHM and peak position as a function of driving current. (c) High resolution EL spectrum of the SLD showing the oscillating ripples at 800 mA.

TABLE I. SUMMARY OF DEVICE DESIGN AND PERFORMANCE OF VIOLET-BLUE SLDS.

Wavelength (nm)	Substrate	Device Design	Optical power	Bandwidth (nm)	PBP (mW·nm)	Reference
420	c-GaN	Tilted waveguide, 2 µm ridge	100 mW (pulse)	5	500	[10]
439	m-GaN	Facet roughening, 4 µm ridge	5 mW (pulse)	9	45	[11]
443	c-GaN	Curved waveguide, 2 µm ridge	100 mW (cw)	2.6	260	[12]
447	semipolar-GaN	Passive absorber, 7.5 µm ridge	256 mW (cw)	6.3	1612.8	[4]
445	c-GaN	Tilted facet, 15 µm ridge	457 mW (pulse)	6.5	2970	Our work

3. CONCLUSION

In conclusion, we have demonstrated a record high-power blue emitting SLD of 457 mW at an injection current of 1 A by utilizing a 12° tilted-facet design. A large FWHM of 6.5 nm was measured, resulting in a record high power-bandwidth product of above 2970 mW·nm with wall-plug and slope efficiencies of 7.9% and 0.9 W/A, respectively.

ACKNOWLEDGMENT

We acknowledge the financial support from King Abdulaziz City for Science and Technology (KACST) (Grant No. KACST TIC R2-FP-008). This work was partially supported by King Abdullah University of Science and Technology (KAUST), baseline funding BAS/1/1614-01-01, and equipment and consumables funding, KCR/1/2081-01-01, and GEN/1/6607-01-01.

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