Wide Band LED Integrated with Selective Area Growth

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This work presents the integration of an on-chip broadband source into a generic platform. It consists of 4 semiconductor optical amplifier sections with tailored bandgap energies by using the selective area growth technique. The control of current injection in each section enables large bandwidth spectral emission with 3dB bandwidths up to 160 nm.

Introduction

Many optical sensors use a broadband source and a tunable filter in order to acquire spectral information from a sample. Several technologies have been developed to make broadband sources, including edge-emitting LEDs using selective area growth [1]. However, the source and the filter are often provided by 2 separated modules [2]. We propose the integration of a wide-band light emitting diode in a generic platform technology to enable co-integration with a photonic circuit.

Selective area growth (SAG) technology has been implemented into the TU/e (COBRA) generic integration platform in order to choose the bandgap of active building blocks of the platform. In this way it is possible to combine several active sections with shifted bandgaps to extend the wavelength coverage of a device or circuit.

The broadband source presented in this work is based on 4 semiconductor optical amplifier sections with shifted bandgap. The emission bandwidth is extended from typically 40 nm for a single SOA to up to 160 nm with 4 sections.

Device design

The broadband source consists of 4 semiconductor optical amplifiers (SOA) sections with shifted bandgaps. The central emission wavelengths of the SOAs is designed with a 50 nm pitch to provide an overlap between their emission spectra. In this way flat emission spectrum is guaranteed with a proper current injection balance into the different SOA sections. The layout schematic of the device is shown in Figure 1 a), with designed central emission wavelength for each SOA section.

Each SOA section is 500 µm long to provide a trade-off between the amplification and the scattering losses induced in the active waveguide structure. Isolation sections are placed in between the SOAs in order to separate the current paths for each active section. A shallow ridge waveguide is define through the 4 SOA sections to collect the emission of each SOA. An angled as-cleaved output provides off-chip coupling with reduced back-reflection into the device. An absorbing section with a short bandgap is placed at the back of the broadband source in order to prevent spurious reflection. The output light was collected by a lensed fiber and directed to an optical spectrum analyzer (OSA) to measure the emission spectrum.

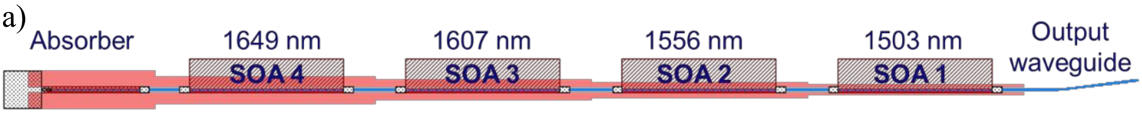
The SOA sections are placed in decreasing bandgap order from the output waveguide. In this way the emission at longer wavelength only experiences scattering losses when passing through wide bandgap sections in the output direction.
The SOA section with wider bandgap being next to the output, its emission is directly coupled out of the chip. The second SOA having a narrower bandgap, part of its emission is amplified by the first SOA when switched on, and the rest of the emission passes through transparently. In the same way, part of the emission of the third SOA is amplified by the second SOA and part of the emission of the fourth SOA is amplified by the third SOA.
This device design allows independent tuning of the current injection into each SOA section and thus fine control over the emission spectrum is possible.

Extended spectral bandwidth

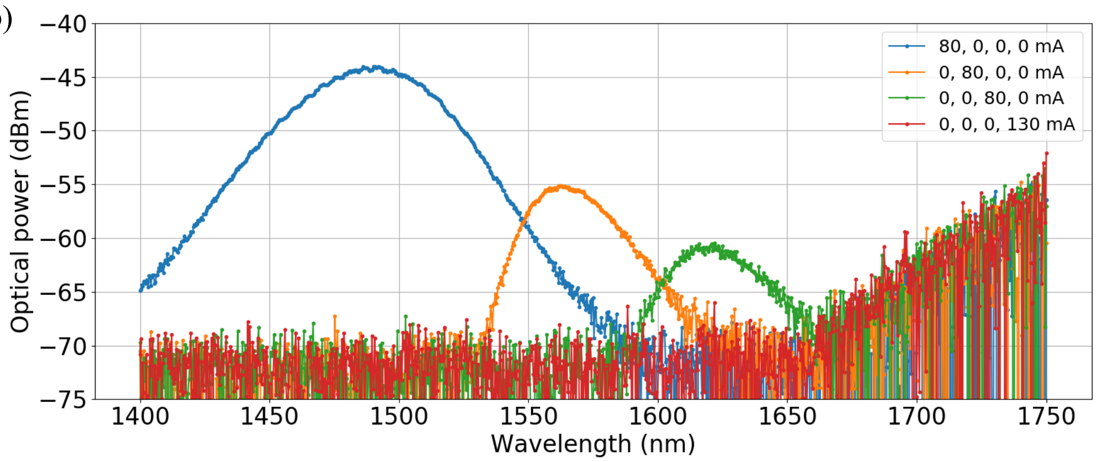
Figure 1 b) shows the emission of SOA sections switched on individually. A current injection of 80 mA is used for the first three SOAs and 130 mA for the SOA for longest wavelengths. The amplified stimulated emission spectrum of the first SOA is directly measured from the chip output. The emission of the three middle SOAs are partly absorbed from their direct neighbor, thus cutting the short-wavelength part of their emission spectrum. The scattering loss induced by the shorter-wavelength active sections before the output waveguide also reduces the power collected out of the chip. The fourth SOA emission spectrum at 130 mA current injection is below the noise level of the OSA for this wavelength range.

Figure 1 c) shows two different biasing configurations for maximized spectral bandwidth. Thanks to the independent current injection in the different SOAs, the output power of the device can be tuned while keeping a flat bandwidth. An increase of output power by more than 10 dB is obtained with a bandwidth reduction of only 10%.

a)



b)



c)

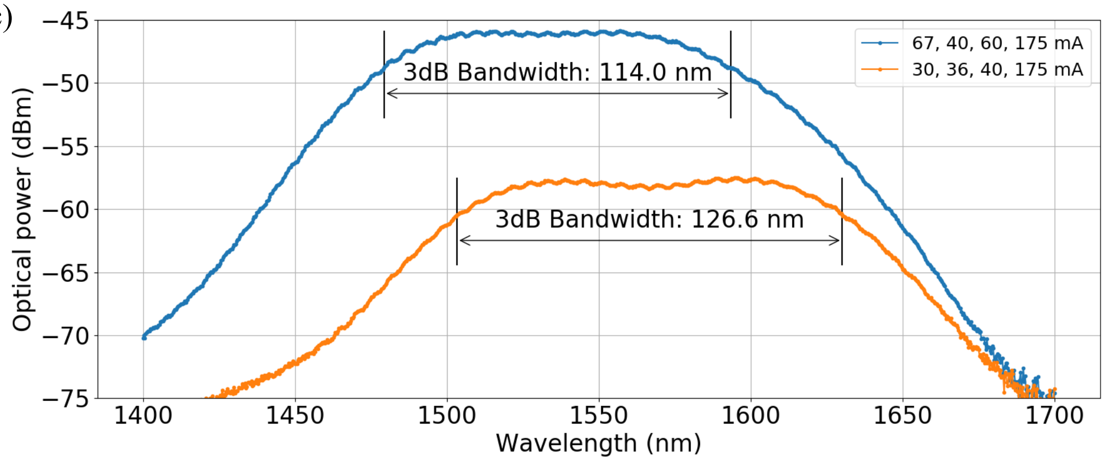


Figure 1: a) Layout of the broadband source with 4 SOAs and their respective photoluminescence peak wavelength. b) Emission spectra of each individual SOA section. c) Emission spectrum of the broadband source with maximized bandwidth for two different power levels. The legend reports the current injection used for each SOA section.

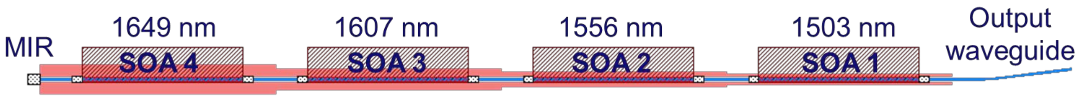
LED with integrated back-reflector

In order to extend the spectral bandwidth of the device, a multi-mode interference reflector (MIR) is placed as a back-reflector on the long-wavelength SOA side. In this way, the backward-propagating emission from the long-wavelength SOA is reflected by the MIR and then amplified by the same SOA before propagating towards the chip output. This amplification provides a significant increase of power emitted at long wavelengths, and compensates for the higher scattering losses induced by the 3 other SOA sections. The layout schematic of this device is shown of Figure 2 a).

Figure 2 b) shows the influence of each SOA section over the total emission spectrum. A bandwidth extension of 17, 41 and 51 nm is obtained respectively from the three additional SOA sections.
Some ripples are visible on the spectrum of the long-wavelength section with a periodicity of 2.5 nm, corresponding to a 140 µm-long cavity. This cavity length corresponds to the distance between the isolation section of the long-wavelength SOA and the MIR reflector.

Figure 2 c) shows the spectrum for a maximum bandwidth configuration. A total of 160.5 nm 3 dB bandwidth is obtained. The output power could not be increased further at long wavelengths without reaching lasing regime for this device.
The lasing operation is thought to be due to spurious reflection at the active-passive butt-joint interface of one of the SOAs, or at the edge of the isolation sections.

a)



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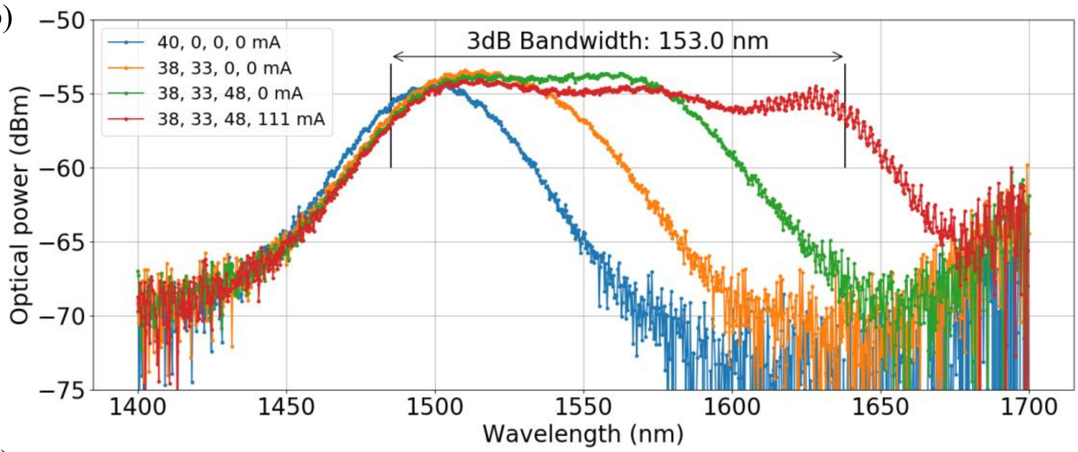

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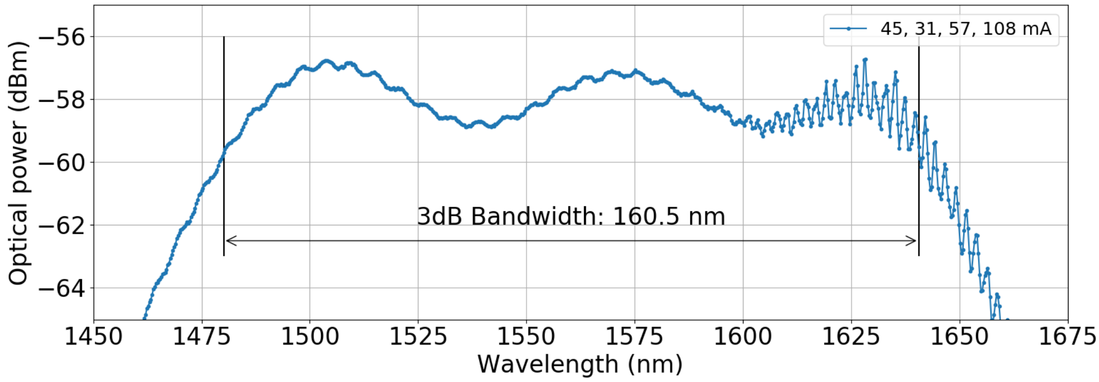

Figure 2: a) Schematic of the second broadband source design including a multimode-interference reflector (MIR) for back-reflection. b) Influence of each SOA section on the emission spectrum. c) Record bandwidth obtained with the source.

Conclusion

We demonstrate the integration of a multi-section light emitting diode device on a generic platform. The combined emission of 4 active sections with shifted bandgaps provide a 160 nm-wide 3 dB spectral bandwidth. A flexible control over the emission spectrum of the source and the availability of TU/e generic platform components makes it possible to co-integrate this source with a photonic circuit.

References

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[2] L. Jin, M. Li, and J. He, "Optical waveguide double-ring sensor using intensity interrogation with a low-cost broadband source." Optics letters, vol 36, no. 7, p.1128-1130, 2011