An InAs/InP(100) QD Waveguide Photodetector for OCT application

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The application of the wavelength range of 1600 nm to 1800nm in optical coherent tomography (OCT) is attractive for its deeper penetration through the tissue due to a reduction of scattering [1]. One of the important elements in the OCT setup is the photodetector. The performance of commercial standard InGaAs detectors is limited due to low response for wavelengths above 1600 nm and p-doped InGaAs detectors have a significantly higher noise level. Thus a low noise photodetector working efficiently in this wavelength region is desired. In this contribution, we present our first results on quantum-dot (QD) waveguide photodetectors, which are realized by applying a reverse-bias voltage on a quantum dot semiconductor optical amplifier (QDSOA).

The QDSOA structure is realized in the COBRA active-passive optical integration schemes [2]. The average size of the InAs QDs is tuned to have emission wavelengths around 1700 nm [3]. By applying a reverse-bias voltage on the p-i-n junction, the QDSOA structure can be utilized as a photodetector. Thus no extra fabrication steps for waveguide photodiodes are needed. Moreover, the absorption spectrum of the detector has a good match with the emission band of light source since the same active layer stack is used for both on a single chip.

The dark current levels of the presented 2 µm wide waveguide detectors of four different lengths are shown in Fig. 1(a). As we can see from the figure, the dark currents stay low (<5 nA DC) when the applied reverse voltage is less than -2 V for all four devices. This is promising compared to the p-doped InGaAs detector which has a typical dark current of 5 µA for 300 μm^2 active area [4]. The dark currents increase rapidly when the bias voltage rises. And it is clear that the dark current increases with device length. Fig. 1(b) shows the photocurrent generated in the 200 µm-long detector when an external laser with 1640 nm wavelength is input using a lensed fibre. The input power to the detector is controlled by an attenuator. The increase of bias voltage will increase the efficiency of the photodetector. The photocurrent generated by weak light input (-43.3 dBm) is still detectable (15 nA @ -2 V bias). The wavelength dependence of the responsivity of the 200 µm-long detector is measured using a tunable laser source and is given in Fig. 1(c). We find that the responsivity increases as the applied reverse voltage. This can be attributed to increased carrier collection efficiency due to a higher reverse voltage. A commercial InGaAs detector typically has a responsivity of less than 0.1 A/W at 1700nm and quickly diminishes for longer wavelengths [5] while the photodetector presented here has an average responsivity of nearly 0.4 A/W within the 65 nm wavelength range when the reverse voltage is -2 V. The responsivity of our detector keeps flat over the whole wavelength range. It can be expected that the responsivity will still be considerable when the wavelength goes beyond 1800 nm.

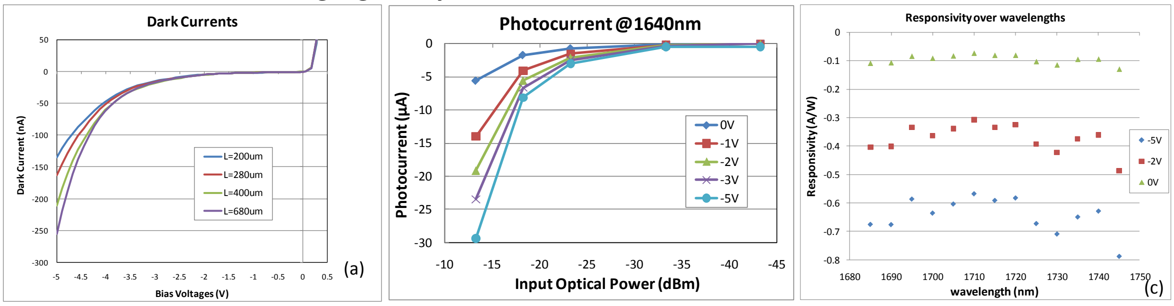

Fig. 1 (a) The dark current of the photodetector with different lengths. (b) photocurrents generated in the 200µm-long detector when the input light has various attenuations. (c) The responsivity of the detector versus wavelengths at three different voltages.

In conclusion, the QD photodetector using reverse-biased SOA shows good perspective in the application of OCT system. It has much lower dark current than commercial p-doped InGaAs detectors. The spectral responsivity is also an advantage over typical InGaAs detectors.

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References

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