

Many-Body Effects on InP-based Optoelectronic Wavelength Converters for WDM Applications

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Wavelength converters are a novel class of photonic integrated circuits that is crucial for future wavelength-division multiplexing (WDM) fiber-optic communication systems. Their main purpose is to transfer signals from one WDM wavelength to another. We present the simulation and analysis of an optoelectronic InP-based tunable wavelength converter (Fig. 1) which monolithically combines a pre-amplified receiver with a post-amplified sampled-grating distributed Bragg reflector (SG-DBR) laser diode [1]. The SG-DBR laser can be tuned to any wavelength of the C-band.

The commercial software PICS3D [2] is employed which was modified for the purpose of this investigation. The three-dimensional (3D) physics-based model takes into account interband gain and absorption in the multi-quantum well (MQW) InGaAsP active region, carrier transport including Fermi statistics and thermionic emission, and optical wave-guiding. For the first time, we integrate advanced many-body gain theory [3] into the 3D simulation of an optoelectronic device [4]. Measured photoluminescence (PL) spectra are used to adjust the inhomogeneous energy broadening in the many-body model, which represents unpredictable growth imperfections of the quantum wells (Fig. 2). The bulk transition matrix element for our quantum well is obtained from non-linear interpolation of binary compound data [5]. Good agreement with device measurements is achieved by adjusting the quantum well Auger coefficient. Figure 3 shows light vs. current characteristics for the laser-amplifier transmitter. Performance limitations of the wavelength converter are investigated in detail. Wavelength dependence and non-linear response to increasing current are strongly affected by the many-body gain model. Significant saturation effects with increasing input power are calculated for the receiver and are connected to the nonuniform carrier density in the quantum wells. Further results will be presented at the conference.

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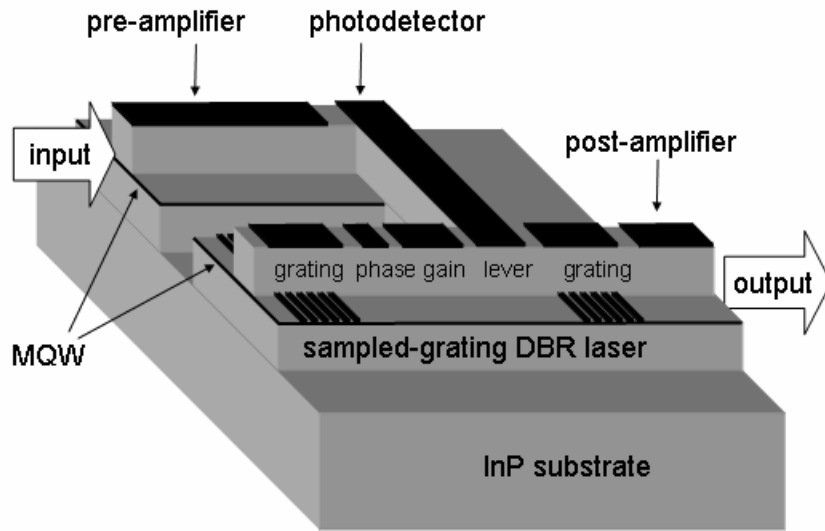


Fig. 1: Schematic view of the monolithic wavelength converter.

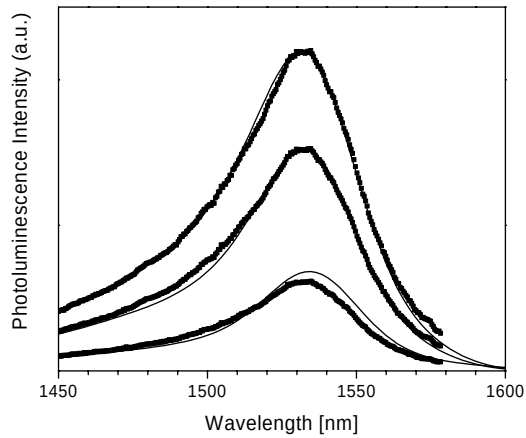


Fig. 2: PL spectra of our MQW active region (dots – measured at $1\times$, $2\times$, and $3\times$ pump intensity; solid lines - many-body calculations at carrier densities of 3.8 , 6.2 , and $7.7 \times 10^{17} \text{ cm}^{-3}$).

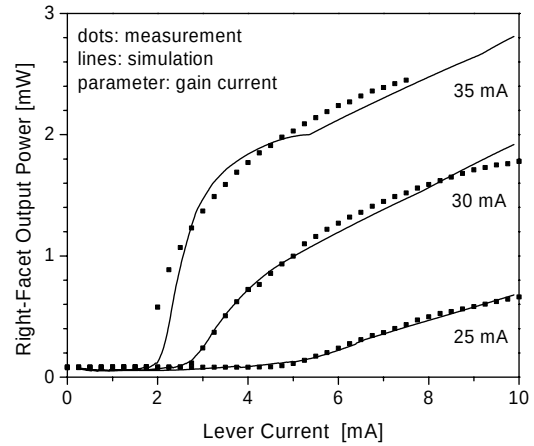


Fig. 3: Sampled-grating DBR laser characteristics with post-amplifier current of 30 mA. The gain section is divided into a constant pump region (parameter) and a lever region that is connected to the photodetector (cf. Fig. 1).