InAs/InP (100) quantum dots in InP photonic integrated laser systems

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The technology of monolithically integrated semiconductor circuits on an InP substrate allows for the integration of passive waveguide devices such as passive optical filters, optical amplifiers and electro-optic phase modulators. This technology thus enables the integration of quite complex circuits with up to hundreds of components. For the optical amplifiers commonly multi quantum well (MQW) gain material is being used. At the COBRA research institute however optical amplifiers based on InAs quantum dots (QD) on InP (100) substrate that are fully compatible with an existing optical integration technology have been developed[1]. These QD amplifiers have unique properties that can be utilized in fully integrated laser systems with special performance characteristics. Although the InAs/InP(100) QD material has a similar temperature dependence as conventional semiconductor gain material, it's carrier dynamics and gain bandwidth in particular make it a relevant material for innovative devices. A particularly interesting capability in this material system is the fact that the wavelength of the dots can be tuned in peak optical gain wavelength from 1.5μm up to at least 1.8μm with relatively large optical gain bandwidths in the order of 150nm.

In this paper we will give an overview of results obtained with QD material that contains five layers of InAs QDs were placed in the center of a 500 nm thick lattice-matched InGaAsP waveguide core and a study on optical gain in a recent single layer high density QD material. The five layer material has been used at COBRA to realise modelocked lasers [2], widely tunable lasers [3] and photodiodes [4]. Also a theoretical model was used to explain the gain spectrum as a function of injection current density and to analyze the behaviour of the material in photodiodes. A prime example of a realized chip used QD material in a tunable laser is presented in Fig. 1. It shows a top view of a laser that can tuned using two electro-optically tuned arrayed waveguide gratings around 1700nm for the purpose of optical coherence tomography. When the QD gain material is used in modelocked lasers extremely chirped pulses are observed [2]. The origin of this dynamics is not yet fully understood.

In order to have a higher optical gain in the optical amplifier a high density InAs QD layer that is on grown on top of an InAs quantum well has been developed [5]. Lasers using this material have been demonstrated successfully and the high density layer performance is currently studied in detail. Measurements of the amplified stimulated emission from which the gain determined of a test amplifier for different injection current densities are presented in Fig. 2. These also show the wide gain bandwidth that can be obtained.

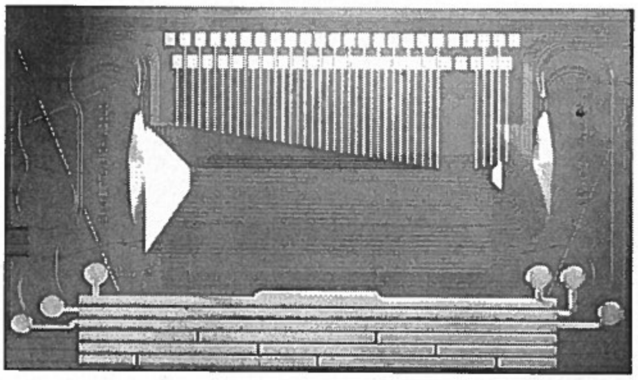

Fig.1. Photograph of a tunable QD laser system integrated on an InP chip of 10mm x 6mm.

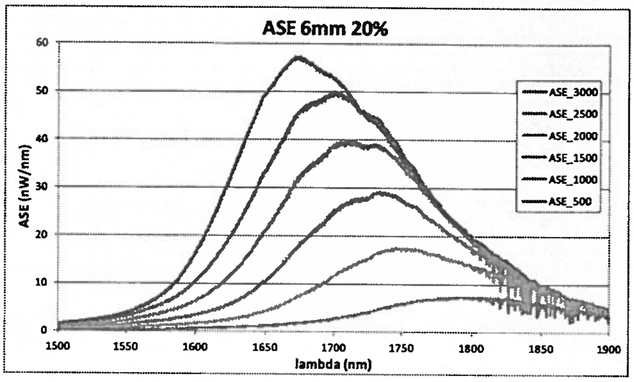

Fig.2. Photograph of a tunable QD laser system integrated on an InP chip of 10mm x 6mm.

Referernces

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