LUMINESCENCE AND PHOTOCURRENT SPECTROSCOPY OF SELF-ASSEMBLED INAS QUANTUM WIRES ON InP(001).

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There is increasing interest in employing semiconductor self-assembled nanostructures in optoelectronics devices, as lasers, photodetectors and amplifiers, since its exhibit unique electrical and optical properties compared with the conventional quantum well structures. In the case of quantum dot lasers, during the last couple years, a large improvement in the devices was achieved thanks to specific quantum-dot properties like extremely low threshold current densities, reduced temperature sensitivity, ultra wide gain bandwidth and reduced chirp. The most common and best developed structures employ were done with InAs quantum dots on GaAs based material systems emitting in the 1 μm to 1.3μm wavelength range. To obtain long-wavelength (≥ 1.33 μm) in this system is very difficult even though is desirable for long-distance optical communication systems. The large lattice mismatch (7%) between InAs and GaAs makes the growth of large quantum dots difficult. Substrates of InP are preferred for these wavelength, because the lattice mismatch between InAs and InP is smaller (3%). Recently InP-based quantum-dash laser results were presented showing an emission wavelength of about 1.6 μm. In contrast to quantum dot formation on (100) GaAs surfaces, the InAs forms dash-like structures elongated along the [0-11] direction on InP(100) substrates. Nevertheless using (311)B InP substrate high density of spherical dots are formed and laser emission at 1.52 μm has been obtained [ref, 1-3].

In this work we present the characterization by photoluminescence (PL) and photocurrent (PC) of laser structures growth by Molecular Beam Epitaxy (MBE) on InP(100) substrates with active region formed by stacked layer of quantum wires (QWR).

The QWR are formed after deposition of ~2 monolayers (ML) of InAs [4]. The waveguide is formed by a lattice matched (GaInAs)x/(InP)y short period superlattices (SPSL). The 20nm thick spacers between each layer of QWR and the waveguide are formed by a SPSL with x=4 and y=5 used.

Figure 1 shows the photoluminescence emission (PL) of a 1 and 3 stacked QWR layers laser structures from 18 to 300 K. Broad emission associated with QWR are measured for wavelength longer than 1.5 microns. The PL peak centred at 1180 nm corresponds to the waveguide.

Figure 2 shows the Photocurrent spectra of 3 stacked QWR layers laser sample with reverse bias from 0 to 2 V at 18K and 200K. Possible features arising from the interband transitions of the QWRs have not been resolve in these devices. At 18K, the thermal escape of carriers is very low and tunnelling through the barriers is the main mechanism that contributes to the PC. With cero reverse bias the photocurrent generated is very low and when the reverse bias is applied the photocurrent increases with a higher slope in the range of wavelengths associated to the QWR and the waveguide absorptions. At 200K the photocurrent is elevated due to the thermal escape, even at cero reverse bias. These diodes present leakage currents for reverse bias higher than 2V.

In order to get better future device characteristics we have calculated the energy minibands of the superlattices [5]. We have used the electron and hole activation energy from reference [6] for QWR with a photoluminescence (PL) at 1.55 microns. Also, we have calculated the optical confinement factor (Γ) as a function of the number of periods of (GaInAs)X/(InP)y with different x and y values. The calculations show that the 2/2 or the 2/3 SPSL give the best

optical and electrical confinement. Recently we have grown samples of superlattices with composition x/y=2/2 and 2/3 with and with out QWR.
In conclusion, we have grown laser structures with a (GaInAs)4/(InP)5 SPSL waveguide that gives a poor confinement of the carriers into the QWRs. The PL and PC characteristics show a thermal escape of carriers above 200K. We have calculated the optimun period of superlattices to minimize the escape and to increase the optical confinement.

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Figures:

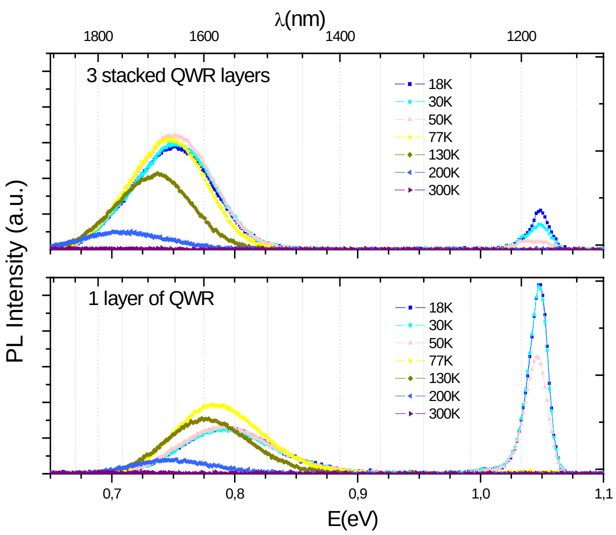

Fig1. Photoluminescence emission (PL) of a 1 and 3 stacked QWR layers laser structures. Broad emission associated with QWR is measured for wavelength longer than 1.5 microns. The PL peak centred at 1180 nm corresponds to the waveguide.

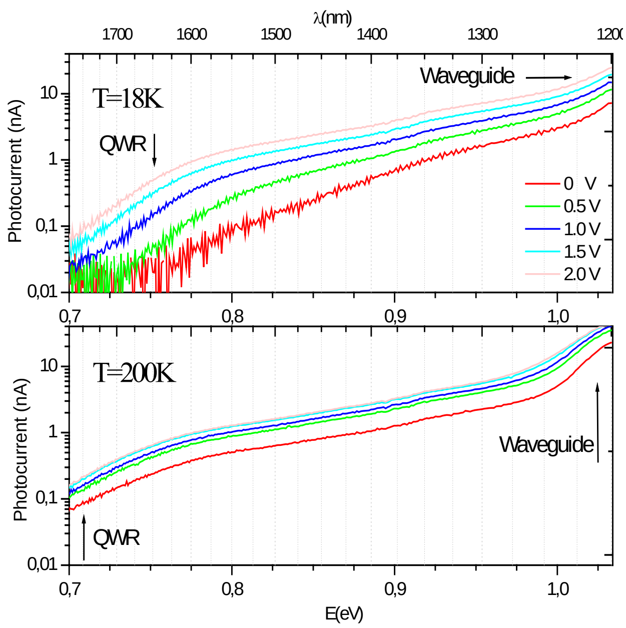

Fig 2. Photocurrent emission (PC) of 3 stacked QWR layers laser structures. The photocurrent increases with a higher slope in the range of wavelengths associated to the QWR and the waveguide absorptions.