Monolithically Mode-Locked Self-Assembled InP Quantum Dot Lasers

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Semiconductor monolithic mode-locked lasers (MLL) emitting in the visible to near infrared region are required for small footprint, low cost and on chip alternatives to the Ti:Sapphire laser and specifically for applications in two-photon fluorescent imaging. Inhomogeneously broadened quantum dot (QD) materials which feature broad optical gain features are promising for achieving ultrashort pulse mode-locking [1]. We demonstrate, for the first time, monolithic mode-locking using InP/GaInP self-assembled quantum dots as the active region that can be extended to cover the 630 - 780nm wavelength range [2] and that can be integrated with biomedical diagnostic configurations [3].

The laser structures given in Figure 1 (A) were grown by MOCVD on n-GaAs (100) substrates oriented 10° off toward <111>. Self-assembled InP QDs were covered by lattice-matched GaInP quantum wells and separated by AlGaInP barriers, with AlInP cladding layers forming the remainder of the waveguide. Broad-area oxide-stripe non-lasing segmented contact devices were fabricated to measure the optical modal gain and absorption spectra, Figure 1 (B), via the segmented contact method [4]. The optical gain measurements have been utilised to design cavity lengths and length ratio of absorber and gain sections using the approach described in [5].

Shallow-etched 2µm wide ridge lasers were fabricated, planarised by BCB and electrically contacted via deposition of p-type and n-type contact metals on the top and bottom sides respectively. Devices of cavity lengths, 2mm, 3mm and 3.5mm, with uncoated cleaved facets and saturable absorber (SA) sections representing approximately 20% of the total cavity length have been examined in mode-locked operation. The mode-locked pulse repetition frequency for the 3mm cavity length is shown in Figure 1 (C) with the device lasing spectrum under mode-locking conditions inset. The mode-locking operating conditions for each of the devices of differing cavity length is summarised in Table 1. The measured pulse repetition frequency of each cavity length is in excellent agreement with the calculated repetition frequencies for each cavity length.

In summary, we have studied the optical gain properties of InP/GaInP self-assembled QD dot-in-well (DWELL) structures and achieved the first monolithic MLLs using this material system.

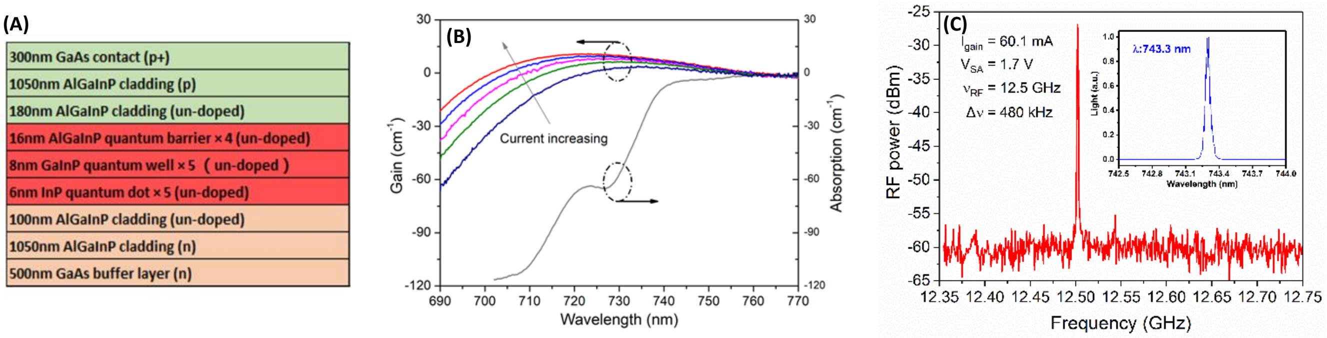

Figure 1, (A) InP/GaInP QD mode-locked laser structure, (B) Measured net modal gain and absorption spectra, (C) RF signal for the 3mm long mode-locked laser and lasing spectrum (inset).

Table 1. Summary of the mode-locking conditions of devices with different cavity lengths.

L_{Cavity}	F_{Rep}	I_{Gain}	V_{SA}	RF linewidth
2mm	15.2GHz	38mA	-1.0V	380kHz
3mm	12.5GHz	60mA	-1.7V	480kHz
3.5mm	10.8GHz	88mA	-1.0V	-

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