Multiwavelength Laser Arrays with 0.4/0.8-nm wavelength spacing

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Next generation DWDM systems will require multiwavelength laser arrays (MWLAs) with 0.4-nm or less wavelength spacing, which challenges the wavelength controllability of the existing fabrication techniques [1]. We proposed and demonstrated a simple approach to realize MWLAs for DWDM applications [2,3]. Our MWLAs use sampled grating DBR (SGDBR) lasers with varying sampling periods across the arrays [2]. Our recent analysis on this type of laser arrays showed that a laser array spanning more than 30 nm of wavelength spectrum could be realized without any change on the grating pitch or waveguide composition of the lasers.

Here, we report the results of laser arrays with 32 wavelengths in 0.8- or 0.4-nm wavelength spacing. For the 0.8-nm spaced arrays, we demonstrate that a much larger range of reflection peak spacing can be realized in SGDBR mirrors, in comparison with previous designs. For the 0.4-nm spaced arrays, we show to our knowledge the best as-fabricated wavelength control for MWLAs that are feasible for DWDM applications.

The design concept is the same as that for laser arrays with adjustable wavelength spacing [2], but the Bragg wavelength is allocated at one side of the gain spectrum since only the first order peaks are used. Each SGDBR laser in a MWLA consists of four sections: gain, phase control, front SGDBR mirror, and back SGDBR mirror [4]. Tuning one of the two mirrors slightly will shift the coincidence of the reflection peaks of the two mirrors from the Bragg wavelength to the first-order peak. With the same amount of tuning all lasers emit light at their first-order peaks, which are spaced by a uniform wavelength spacing of $\Delta\lambda$. The device structure and fabrication procedures have been described in [3]. The only change occurs in the design of sampling periods to make arrays with 32 wavelengths. For 0.8-nm spaced arrays, the periods are designed to vary the peak spacing of the reflection spectrum from 3.4 to 28.2 nm for the front mirror and from 4.2 to 29 nm for the back mirror. For arrays of 0.4-nm channel spacing, since the peak spacing is halved, the maximum spacing is 15.8 nm for the front mirror and 16.6 nm for the back mirror. The laser array fabrication requires only one step of holographic exposure.

The lasers show similar threshold currents and optical spectra as our previous results [2,3] but the output powers are higher (above 1.0 mW at 100 mA for most lasers). The lasing wavelengths are summarized in Fig. 1, where the single wavelength yield is above 87%. Noting that uniformly spaced wavelength combs were obtained with current injection to only one tuning electrode and all the lasers were biased at 100 mA. The wavelengths can be fine adjusted by tuning the other electrodes. The average wavelength spacings are 0.45 and 0.84 nm for arrays with 0.4- and 0.8-nm designed spacing, respectively. The slight difference between the designed wavelength spacing and the measured one is mainly caused by the material nonuniformity, since the laser structure was grown by MOCVD without rotating the substrate [3]. It can be shown that the average wavelength spacing is insensitive to the fluctuations in device parameters, so arrays with

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accurate wavelength spacing can be achieved if laser wafers with good material uniformity could be used. The standard deviation of the wavelength fluctuation from the average wavelength is measured to be 0.11 nm for 0.4-nm spaced arrays and 0.20 nm for 0.8-nm arrays. The wavelength fluctuation is much smaller than that of MWLAs fabricated by other approaches [1]. Figure 2 shows an example of the output spectra of an array when the two mirrors are slightly tuned to generate an ITU wavelength comb of 100 GHz spacing.

In summary, we have demonstrated MWLAs that have 32 wavelengths and very small wavelength fluctuation. A larger number of wavelengths can further be realized when the sampling periods in the photomask can be varied to a higher resolution.

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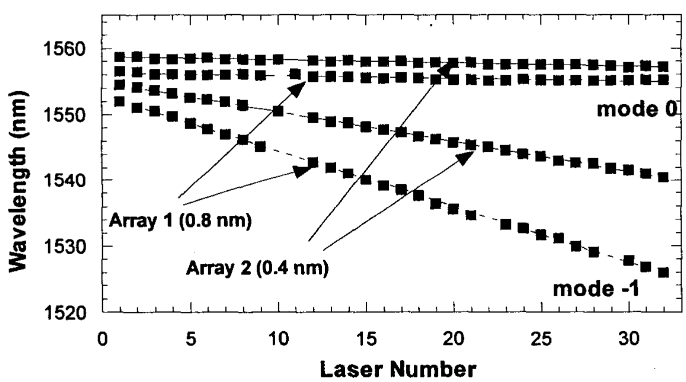

Figure 1 Output wavelengths of SGDBR laser arrays. The wavelengths of Array 2 are upshifted by 2 nm. Mode 0 refers to the wavelength without tuning, while mode −1 refers to the wavelengths when the front mirror is tuned such that the wavelength hops to the first reflection peak at the short wavelength side.

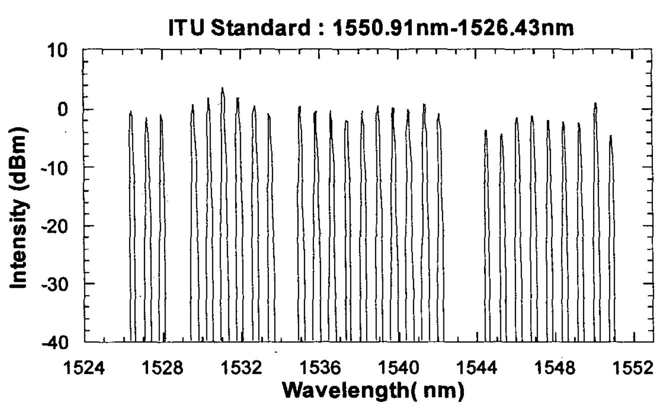

Figure 2 Output spectra of Array 1 when both mirrors are tuned to form uniform wavelength comb that matches the ITU wavelength grid.