

Directional Mode Stability in Semiconductor Ring Lasers

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Finding the conditions for unidirectional oscillations in semiconductor ring lasers has been a long-standing problem^{1,2}. Unidirectional operation improves device performance by increasing the output power and by improving the frequency stability. We have been investigating the directional mode properties of large-diameter semiconductor ring lasers, weakly coupled to a straight output waveguide³. Different devices have been fabricated on GaAs/AlGaAs and InGaAs/InGaAsP material systems, with ring radii ranging from 500 μm to 1000 μm .

A diagram of the devices is shown in fig.1 with the position of the ohmic contacts. The two separate contacts on the output waveguides are reversed biased to minimise the back reflections into the ring cavity and to provide a direct measure of the two counterpropagating modes.

Fig. 2 shows a typical L-I curve for a GaAs/AlGaAs device. Just above threshold, the device shows a bidirectional behaviour in which both modes oscillate in the cavity. For higher current values, unidirectional operation occurs, either in one direction or the other, and the optical power switches several times from the clockwise to the counterclockwise mode as the laser ring current is increased. For current biases exceeding twice the laser threshold, one of the two modes tends to dominate and the device exhibits complete unidirectional operation. In this regime, the direction of oscillation can be reversed by injecting a current pulse in one of the two output waveguides, indicating that the device exhibits unidirectional bistability.

Presently we are investigating the capabilities of these devices for all-optical switching applications and the effects of size reduction on the directional mode selection.

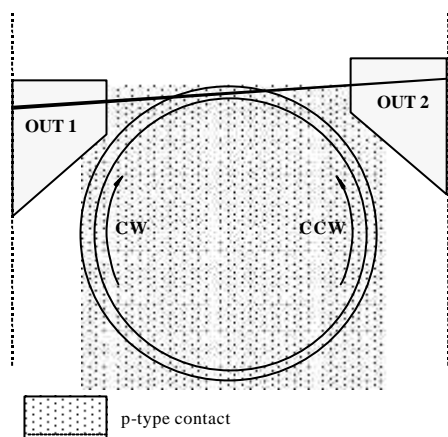


Fig.1 Device layout with the position of the ohmic contacts. The output waveguides are 5° tilted to minimise the backreflection.

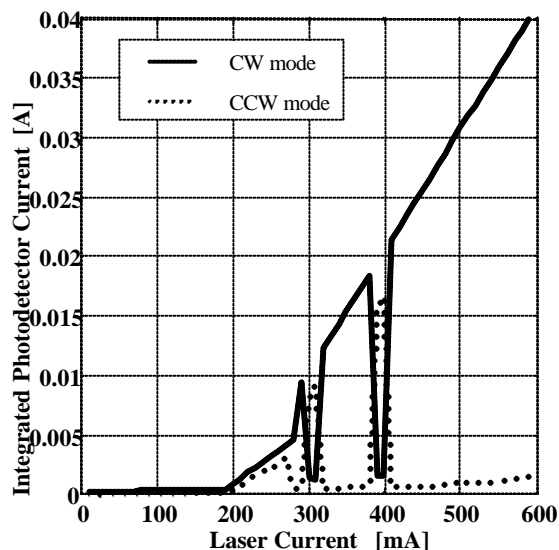


Fig.2 Light-current curve for a GaAs/AlGaAs device with a radius of 1000 μm . Note the complete unidirectional behaviour for high current values.

¹J.P.Hoimer, G.A. Vawter, D.C. Craft, "Unidirectional operation in a semiconductor ring diode laser", *Appl. Phys. Lett.* **62**, 1185 (1993)

²J.J.Liang, S.T.Lau, M.H.Leary, J.M.Ballantyne, "Unidirectional operation of waveguide diode ring lasers", *Appl.Phys.Lett.* **70**, 1192 (1997)

³ M.Sorel, G.Giuliani, S.Donati, P.Laybourn, "Control of unidirectional operation in semiconductor ring lasers", LEOS Annual Meeting, 11-15 Nov., San Diego