transmitter which is connected by fibre to a receiver at one of the nodes. Similar results were obtained using both signal summing schemes, so we are presently investigating the performance trade-offs between the two schemes. Obviously, the simplicity of current summing is an attractive feature.

We demonstrated generalised crossbar switch operation. For instance, we independently scanned four detector arrays to each of five input channels, while two other arrays received a broadcast from a single input and the remaining two arrays were toggled between two inputs. A photo of the scope trace for five channels being sequentially received is shown in Fig. 4. The dwell time is 400 μs on each channel, and outputs are detected on adjacent detectors. The channel scanning was done with a CMOS analogue multiplexer distributing the bias voltage under TTL level addressing.

In conclusion, we have demostrated an 8 × 8 optoelectronic crossbar switch with nonblocking broadcasting and asynchronous switching capabilities. The crosspoints are MSM detectors with high isolation due to the inherent device symmetry. Operation up to 175 Mbit/s and reconfiguration time $< 1\,\mu s$ were demonstrated.

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SURFACE-EMITTING MULTIPLE QUANTUM WELL DISTRIBUTED FEEDBACK LASER WITH A BROAD-AREA GRATING COUPLER

Indexing terms: Lasers and laser applications, Semiconductor lasers

A surface-emitting laser diode with a 100 × 200 μm^2 grating coupler was fabricated. Narrow beam divergence angles of 2° × 0·32° and a maximum output power of 210 mW were obtained.

Introduction: Grating-coupled surface-emitting (SE) lasers[1–4] have the following advantages: first, a very narrow beam divergence angle can be obtained by a wide emission aperture, and secondly, one- or two-dimensional arrays are easily fabricated, since cleaved facets are not required. Recently, we have reported continuous wave operation of an SE multiple quantum well (MQW) distributed feedback (DFB) laser with an integrated grating-coupler.[4] The dimensions of the grating-coupler were 4 × 200 μm^2, and therefore the beam divergence angles perpendicular and parallel to the cavity were 12° and 0·22°, respectively. To narrow the angle perpendicular to the cavity, the stripe width should be broadened, which is also effective for high power operation. In this letter, we report a broad area SE MQW DFB laser with high output power and narrow beam divergence angles.

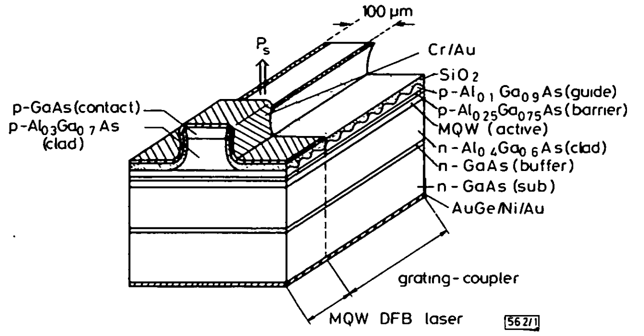

Fig. 1 *Schematic diagram of an SE MQW DFB laser with a broad-area grating-coupler*

Fabrication: Fig. 1 shows a schematic diagram of an SE MQW DFB laser with a broad area grating-coupler. The laser was made by two-step molecular beam epitaxy.[5] The grating-coupler can easily be integrated thanks to the properties of low loss and easily saturable absorption in the MQW structure as previously reported.[4] The MQW structure consisted of five undoped GaAs wells ($l_z \simeq 100$ Å) and four $Al_{0.2}Ga_{0.8}As$ barriers ($l_b \simeq 50$ Å). The lengths of the laser and the grating-coupler were 180 μm and 200 μm, respectively. The stripe width was 100 μm. Therefore, the dimensions of the grating-coupler were 100 × 200 μm^2. The surface of the coupler was coated with an antireflection (AR) film, whereas both facets were left as cleaved.

Lasing characteristics: Fig. 2 shows the current/SE light output power characteristic under pulsed conditions at room temperature. The pulse width was 50 ns and the repetition

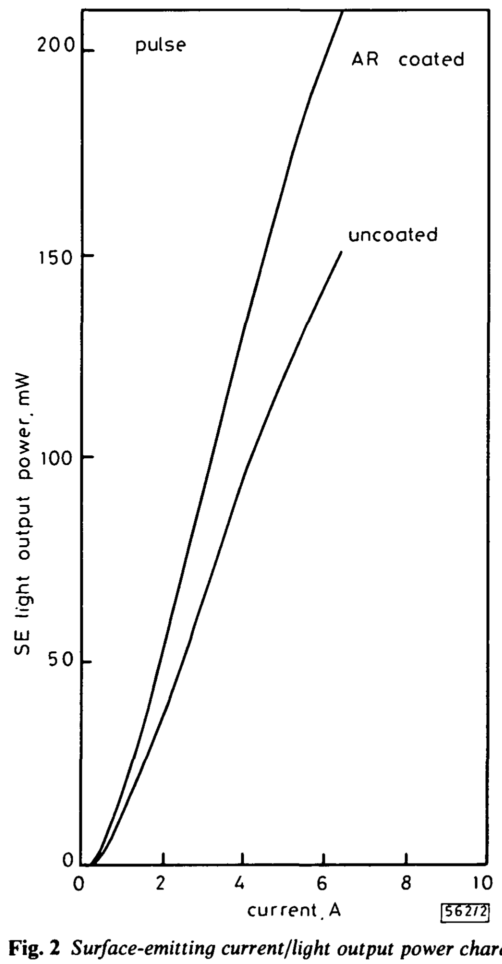

Fig. 2 *Surface-emitting current/light output power characteristics*

period was 0·2 ms. The threshold current was 250 mA. The maximum output power was as high as 210 mW, although it was limited by the capacity of the current source used. The output power was increased by a factor of 1·4 by the AR coating.

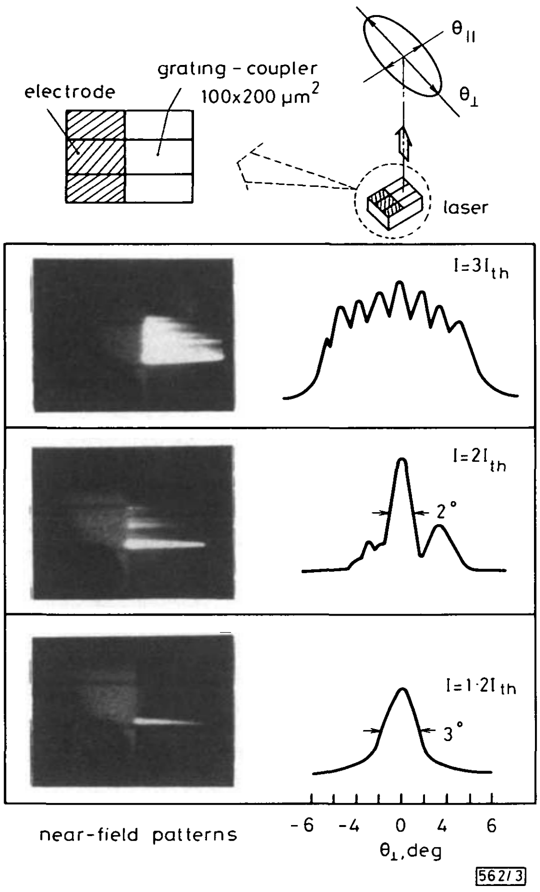

Fig. 3 *Near-field and corresponding far-field patterns perpendicular to cavity at various injection levels*

Near-field patterns were observed by an infra-red camera

Fig. 3 shows the near field and the corresponding far field patterns perpendicular to the cavity at various injection levels. A nonuniform spatial power distribution was observed across the cavity. Its full width at half maximum (FWHM) value (w_p) was 15 μm at $I = 1{\cdot}2I_{th}$, and the corresponding FWHM beam divergence angle ($\theta_\perp$) was 3°, which agrees well with that calculated as emitted from the uniform 15 μm aperture. At $I = 2I_{th}$, w_p was increased to 22 μm, and $\theta_\perp$ was decreased to 2°. However, weak lateral submodes were observed, which caused the other peak in the far field pattern. For $I \gtrsim 3I_{th}$, the lateral modes were completely multimoded, and therefore multilobed far field patterns were observed, and the FWHM angle was increased. We should optimise the stripe width to obtain a stable, narrow beam divergence angle.

The laser oscillated in a single longitudinal mode ($\lambda \simeq 866$ nm) at low excitation levels ($I \lesssim 1{\cdot}2I_{th}$). For $I > 1{\cdot}2I_{th}$, however, multilongitudinal mode oscillation was observed mainly owing to the instability of the lateral mode. The FWHM beam divergence angle ($\theta_{\parallel}$) parallel to the cavity was increased by the multimode oscillation. The observed angles at $I = 1{\cdot}2I_{th}$, $2I_{th}$, and $3I_{th}$ were 0·22°, 0·32°, and 0·72°, respectively. These values agree well with those calculated taking account of the multilongitudinal mode oscillation.

Conclusion: We have fabricated an SE MQW DFB laser with an integrated broad area grating-coupler. A narrow beam divergence angle of 2° × 0·32° (at $I = 2I_{th}$) and a maximum output power of 210 mW were obtained. The optimisation of the stripe width will lead to a stable, narrow beam divergence angle.

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SIMPLE IMPEDANCE TRANSFORMING FEED SYSTEM FOR LOW-GAIN QUADRIFILAR AND BIFILAR SATELLITE TERMINAL ANTENNAS

Indexing terms: Antennas, Antenna feeders, Satellite links

An impedance transforming balun feeder system has been devised for low-gain antennas such as quadrifilar helices and spirals, consisting of four coaxial cables and a microstrip circuit. The arrangement allows physically orthogonal 'balanced pair' outputs with quadrature phasing, in space limited configurations.

There is currently great interest in wide beam circularly polarised L-band antennas, for low data rate, low cost satellite earth station applications, and also for satellite GPS (global positioning system) receivers. Common antennas for these applications are quadrifilar helices,[1] bifilar conical spirals,[2] and quadrifilar conical spirals.[3] These radiators require quite complex feed systems. For example, a quadrifilar helix antenna has four, resonant length, wire radiating elements; these are fed as two orthogonal balanced mode pairs in phase quadrature. Thus the feed system must provide an output of two orthogonal sets of balanced lines with the correct impedances for matching to the antenna radiating elements, with relative phases in quadrature, and with equal amplitudes, from an input of (usually) a single 50 Ω connector and coaxial cable. The customary solution for feeding a quadrifilar helix antenna is to incorporate a phase quadrature device such as a 3 dB hybrid or branch-line coupler (realised in microstrip or stripline) connected to an orthogonal pair of impedance transforming baluns via two coaxial cables, each impedance transforming balun consisting of a coaxial cable quarter wavelength balun, followed by a quarter wavelength 'twin-wire' impedance transformer. Such an arrangement is quite complex mechanically, and involves the assembly of a number of critical tolerance parts into a small volume (e.g. a central balun shielding tube). An alternative, mechanically simpler, feed arrangement has been devised and is described below. It is applicable to a wide range of quadrifilar and bifilar element antennas, with impedances ranging from about 40 to 250 Ω.

Fig. 1 shows the feed system for a quadrifilar antenna. It consists, basically, of four coaxial cables, plus a small microstrip board in which a 50 Ω input line is transformed to a lower impedance line with a simple quarter wavelength section transformer. At the top of the feed system formed by the four cables, i.e. at the antenna element feed point, each