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between undoped GaAs layers in a separate confinement structure, was prepared by molecular beam epitaxy (MBE). The constraints on well depth and thickness in a strained layer system coupled with higher lateral mode losses provide for dominant recombination from the barriers, due to excessive carrier spillover at higher injection levels. Investigations on the time-averaged pulsed emission spectra over a 40 nm wavelength range and a current range covering both QW and barrier transitions show the presence of a broad gain spectrum at the higher injection levels that could, in principle, be used to generate very short pulses by using standard mode-locking techniques in addition to use in applications that require wavelength switching. The change in gain with drive current was seen to be fairly high at the gain peak of the shorter lasing region, whereas strong gain saturation effects were observed at the longer wavelength, resulting in spectral hole burning at high currents.
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MZ3   2:45 pm

Multiple pulse gain switched operation of surface-emitting semiconductor lasers, M. Mahbobzadeh, A. Mukherjee, and S. R. J. Brueck, *Center for High Technology Materials, University of New Mexico, EECE Building, Room 125, Albuquerque, NM 87131.* Surface-emitting semiconductor lasers are attractive for applications in optical computing, coherent communications, high-power two dimensional arrays, and integrated optoelectronics. For applications involving information processing, high speed pulsed operation of these lasers is necessary. The very short cavity length (~2–5 μm) results in a very short transit time; however, the required high-Q resonator substantially lengthens the cavity lifetime, and hence the gain-switched pulsewidth. Recent optical pumping experiments have demonstrated ultrafast gain-switched operation with pulse widths as short as 3.9 ps. In this report, we present the first results on optically pumped double-pulse excitation with pulse delays as short as 10 ps. Independently switched high-bit-rate multiple pulse trains are required for transmitting information. For pumping with a pair of time delayed pulses, we observe output pulse separations shorter than the input pulse separation. This suggests the use of SELs for optical multiplexing and signal processing. Output pulse separation and pulse width as a function of the input pulse separation at a constant pump power show good agreement with the theoretical simulation. For large pulse separations, the input and output pulse separations are iden-

tical. The shortest output pulse separation having a 7:1 peak to background ratio, for a BER of <10⁻⁹, was about 35 ps for an input pulse separation of 50 ps. This is readily extendable to smaller pulse separations for higher speed pulses by using lower-Q resonator structures.

MZ4   3:00 pm

Density of states in finite-barrier quantum wells, Marek Osinski, Mohammad Mojahedie, and Michael W. Prairie,* *Center for High Technology Materials, University of New Mexico, Albuquerque, NM 87131-6081.* Density of states in finite-barrier quantum wells is examined critically. In the infinite barrier limit, the two-dimensional (2D) density of states (DOS) has been shown to correspond to the bulk case.[1] When finite wells are considered, this correspondence may no longer hold. In this paper, we propose a modification to the finite-well DOS, which retains the elegance of the infinite-well case while preserving the effects of the finite barrier. This is accomplished by either defining an effective infinite-well width that matches the parameters of the finite well or by defining a new effective mass. Both approaches are based on rigorous calculations of the quantized wave vectors. In the spirit of the effective mass concept, we concentrate on the latter case, particularly in the limits of very thin and very thick wells. We investigate the relationship between the DOS and the quantum-well effective mass, based on the allowed wave vectors. Examples will be given illustrating the conventional definition of 2D DOS, the modified DOS, and their comparison with the bulk case.

1. M. W. Prairie and R. M. Kolbas, Superlattices and Microstructures **7**, 269 (1990).

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MZ5   3:15 pm

Simple model for carrier spill-over in quantum-well lasers consistent with local charge neutrality, Y. Cai, R. Engelmann, and R. Raghuraman, *Oregon Graduate Institute of Science and Technology, 19600 N.W. von Neumann Drive, Beaverton, OR 97006.* For separate confinement heterostructure (SCH) quantum well (QW) lasers, carrier injection levels can be controlled by changing cavity losses. In the low injection case, carriers are confined within the QW, and spill-over into the barrier can be neglected. In the very high injection case, on the other hand, carriers in the barrier are dominant, and the QW contribution be-

comes insignificant. In the intermediate injection range, carrier distribution in both QW and barrier need to be taken into account. A simplified band filling model is developed for this case, in which charge neutrality condition plays a very important role with the band-offset ratio used as an adjustable parameter. Because of the structural difference between conduction and valence bands, the band offset ratio may be very sensitive to the charge neutrality criterion in both QW and barrier. For a particular SCH InGaAs/GaAs QW device (7.5 nm QW, 250 nm barrier) that we have studied in detail, local charge neutrality forces the conduction band offset ratio, Q_c, to change from 0.60 to 0.63, for injection levels (described by total number of carriers) ranging from 0.2×10^{13} to 8.5×10^{13} (cm⁻²). Gain spectra are calculated based on the model including QW and barrier transitions.

MAA   1:30 pm
Taos

Symposium on Using Nonlinearities to Analyze Visual Mechanisms

Walter Makous, *University of Rochester, Presider*

MAA1 (Invited)   1:30 pm

Spatial and temporal integration in relation to the nonlinearity of light adaptation, Donald I. A. MacLeod, *Psychology Department, University of California at San Diego, C-009, La Jolla, CA 92093-0109.* Stimuli that are spatially and/or temporally periodic, but too high in frequency to be subjectively resolvable, appear by definition uniform and steady. If processing is linear up to the stage at which resolution losses obliterate the stimulus modulation, this stimulus will match a uniform and steady stimulus of the same average luminance. The phenomena of difference-frequency gratings and contrast-modulation flicker are exceptions to this principle for unresolvable gratings in cone vision, and the direction of deviation from linearity suggests that a compressive or sensitivity-regulating nonlinearity precedes any neural spatial integration in the cone system. This nonlinearity is a dynamic one rather than an instantaneous compression. In the rod system, on the other hand, the spatially integrated signals are very nearly linear, even at saturating levels. In the short-wavelength cone system, compressive nonlinearity precedes both spatial and