Digest of Tech. Papers *The 11th Conf. (1979 International) on Solid State Devices, Tokyo*

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(Invited)

$Ga_{1-x}Al_xAs$-GaAs Heterostructure Lasers Grown by Metalorganic Chemical Vapor Deposition

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The growth of $Ga_{1-x}Al_xAs$-GaAs heterostructures by vapor-phase-epitaxial (VPE) processes has received relatively little attention, undoubtedly due to the difficulties encountered in the production of uniform, homogeneous layers of $Ga_{1-x}Al_xAs$ by most vapor-phase processes, and, in particular, by the halide-transport process commonly used for the growth of other III-V binary, ternary, and quaternary semiconductors.

Recently, we have reported the first successful growth of $Ga_{1-x}Al_xAs$-GaAs double-heterostructure (DH) lasers by a vapor-phase process, i.e., the chemical vapor deposition (CVD) of thin films of $Ga_{1-x}Al_xAs$ by the use of metalorganic and hydride sources. [1,2] $Ga_{1-x}Al_xAs$-GaAs broad-area DH lasers have been grown by this process that exhibit lower threshold current densities than the best similar devices grown by any other III-V materials technology. [3] Also, stripe-geometry DH lasers grown by the metalorganic chemical vapor deposition (MO-CVD) process have operated continuously at room temperature with low thresholds and high external differential quantum efficiencies. MO-CVD lasers with channel-guide active regions have operated cw in a single longitudinal mode over a wide range of currents and exhibit linear light-versus-current characteristics. [4] In addition, the MO-CVD process has been used to grow high-efficiency $Ga_{1-x}Al_xAs$-GaAs heterostructure solar cells [5], low-threshold DH lasers with $Ga_{1-y}Al_yAs$ active regions [2], and high-performance $Ga_{1-x}Al_xAs$-GaAs phototransistors [6].

Another feature of the MO-CVD process is the capability to grow ultra-thin epitaxial layers having thicknesses in the range 50-200 Å, and to grow uniform multiple-layer structures with individual layers in this thickness range. [7] Such single- and multiple-quantum-well structures have been shown to exhibit unique laser properties related to the ultra-thin layer thicknesses employed. In particular, single- and multiple-quantum-well optically-pumped and injection lasers that exhibit quantum-size effects have been grown by MO-CVD. [7,8]

This paper will describe the MO-CVD process and the laser device structures and their performance characteristics.

1. R. D. Dupuis and P. D. Dapkus, Appl. Phys. Lett. 31, 466 (1977).
2. R. D. Dupuis and P. D. Dapkus, IEEE J. Quantum Electron. QE-15, 128 (1979).
3. R. D. Dupuis and P. D. Dapkus, Appl. Phys. Lett. 32, 473 (1978).
4. R. D. Dupuis and P. D. Dapkus, Appl. Phys. Lett. 33, 724 (1978).
5. R. D. Dupuis, P. D. Dapkus, R. D. Yingling, and L. A. Moudy, Appl. Phys. Lett. 31, 201 (1977).
6. R. A. Milano, T. H. Windhorn, E. R. Anderson, G. E. Stillman, R. D. Dupuis, and P. D. Dapkus, Appl. Phys. Lett. 34, to be published.
7. R. D. Dupuis, P. D. Dapkus, C. M. Garner, C. Y. Su, and W. E. Spicer, Appl. Phys. Lett. 34,

338 (1979).

8. N. Holonyak, Jr., R. M. Kolbas, W. D. Laidig, B. A. Vojak, R. D. Dupuis, and P. D. Dapkus, in *Gallium Arsenide and Related Compounds 1978*. London: Institute of Physics, 1979, p. 387.