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High-Frequency Characteristics of GaAlAs Injection Lasers

L. Figueroa, C.W. Slayman and H.-w. Yen. "High-Frequency Characteristics of GaAlAs Injection Lasers." 1982 Transactions on Microwave Theory and Techniques 30.10 (Oct. 1982 [T-MTT] (Special Issue on Optical Guided Wave Technology)): 1706-1715.

This paper discusses the results of an extensive experimental study of the high-frequency characteristics of several commercial (GaAl)As injection lasers. The lasers tested included the Hitachi buried heterostructure (BH), the Hitachi channel substrate planar (CSP), the Mitsubishi transverse junction stripe (TJS), the General Optronics stripe (GO), and the RCA constricted double heterostructure (CDH). We find that the maximum practical analog modulation frequency f/sub o/ is in the range of 5 GHz. This practical modulation frequency is limited by a combination of laser-relaxation resonance, laser parasitic, and drive current necessary for long-life operation. The relationship between laser-relaxation oscillation resonance frequency f/sub o/ and drive current can be expressed as f/sub o/ = K(I/I/sub th/ - 1)/sup 1/ 2/ GHz where I and I/sub th/ are the laser drive and threshold currents, respectively. The value of K is experimentally determined to lie in the range 3.0< K < 5.3 GHz for all the lasers studied. An equivalent circuit for the injection laser for frequencies in the range of 100 MHz-6 GHz has been experimentally determined. We find that the isolated injection laser can be modeled by the parallel combination of a resistance R/sub j/ and a capacitance C/sub j/. The product of R/sub j/C/sub j/ has been experimentally determined for both the Hitachi CSP and BH laser and lies in the range of 1-1.1 X 10/sup -10/s. The effect of laser mount and packaging can also be included in the equivalent circuit by the addition of series inductors and shunt capacitors. Lastly, all injection lasers studied displayed a dip in the small signal modulation response prior to the onset of the relaxation oscillation resonance. In particular, there is a pronounced dip even for lasers with good lateral carrier confinement at dc, such as the buried heterostructure (BH). Previous workers have attributed the dip in the modulation response as resulting from either lateral diffusion of injected carriers, or the effect of junction capacitance. Our experimental results indicate that while the effect of the junction capacitance may play some role in explaining the dip for the BH laser, it is not the dominant mechanism. We speculate that lasers with good lateral carrier confinement at dc (BH) may suffer a significant degradation of carrier confinement at gigahertz rates. A simple qualitative model is proposed to explain this mechanism and methods for reducing the effect are

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