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Flat Frequency Response of TO-Can Packaged Distributed Feedback Laser Diode by Modifying RF Signal Path

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Abstract — **Improvement of frequency bandwidth of TO-can packaged laser diode is investigated. Controlling elements of the package with rearranging signal path from modifying package interconnections have significantly improved 3-dB bandwidth of the laser module.**

Index Terms — **Semiconductor lasers, frequency response, circuit modeling, circuit simulation, semiconductor device packaging.**

I. Introduction

Recently, strong demands for higher throughput and drastic price reduction of optical components have made a fiber-optic data transmission a commodity in mainframe computer systems or in local area and subscriber networks. Since the uprising new optical communication market is focused on the access network such as fiber-to-the-home (FTTH), free space optics (FSO), radio over fiber (RoF) systems, and other optical transmission systems fused with wireless communications, optical modules for higher bit-rate of more than 1 Gbit/s whether used in Ethernet or SDH/SONET, and for low-cost and compactness are required. Accounting these various last mile solutions, TO-can packaged laser module provide the solution for cheap and compact light source.

To date, many experimental and/or theoretical researches in high bit rate transmission systems offered the way of impedance matching to the laser module for various types of packaging. However, conventional method for parameter extraction of laser package was a relatively complicated procedure with measuring and fitting the characteristics of scattering parameters (S-parameters). Furthermore, they had ignored the parasitic components of the packages by inserting just series chip resistor or had used the distributed type elements by designing stub transformers which could be used in specified band applications [1]-[3].

In this paper, frequency response of conventional TO-can laser module has been improved by changing the signal path for widening the 3-dB frequency bandwidth, where the path could be modified with simply changing the internal RF signal path of module package. The equivalent circuit model of laser module is precisely extracted from the package, and in order to improve the characteristics of frequency response, the impedance matching circuit is applied to the device as well as transforming the package structure.

II. Conventional TO-Can Package

The cross sectional view of laser diode chip is shown in Fig. 1(a) and the equivalent circuit models for each junction, interface, and contact are given in Fig. 1(b). It was not only impossible and but also unnecessary to use this exact equivalent model where the parameters are not achievable. Instead throughout the following analysis, the well-known diode model of resistor with parallel capacitance and series inductance (R//C-L) is used.

Conventional TO-can laser module is packaged as in Fig. 2(a), where the bonding wire and package leads are considered as inductors, dielectric spaces form the capacitors between the metal plate and glass powder for electrical insulation, and the laser diode (LD) consists of parallel combination of resistor and capacitor and the overall equivalent circuit model is given in Fig. 3(a). From the SPICE simulation results, without comprising matching circuit, the 3-dB frequency bandwidth of the package itself is less than 850MHz and the response curve rapidly changes as the frequency increases. These limitations on the frequency response are mainly due to the capacitance in the TO-can laser module acting as a low-pass filter.

Therefore, frequency response of TO-can laser module can be improved to achieve extended 3-dB frequency bandwidth by adding inductive components to cancel out the capacitance in packages. Due to the opposite phase between reactance of the capacitance and the inductance, inductive components compensate the reduction of frequency response of the laser package. It can be added by bonding wires, but we cannot obtain a consistent