A High Electromagnetic Immunity Plastic Composite Package for a 10-Gb/s Optical Transceiver Module

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Abstract—A high electromagnetic immunity and low-cost plastic package for a 10-Gb/s optical transceiver module is developed by using a woven carbon-fiber epoxy composite (WCEC). The WCEC package with a thickness of 1.0 mm and 4.8% carbon fiber has a shielding effectiveness (SE) performance of 60 dB at 10 GHz as the package is grounded to the system ground, and the SE can reach approximately 38 dB for the realistic packaged module operated at 10 Gb/s. In addition, the excellent electromagnetic immunity of the package is demonstrated by the eye patterns and the bit-error-rate (BER) test. Under the interference of the radiated noise, the package housing significantly improves the jitter and mask margin performance of the 10-Gb/s signals. Compared with an unpackaged module, it is found that over 4 dB of optical power can be gained to keep the BER at $10^{-12}$ for the packaged optical transceiver modules. This proposed package is suitable for use in low-cost 10-Gb/s lightweight transmission systems with excellent electromagnetic susceptibility (EMS) performance.

Index Terms—Electromagnetic immunity, electromagnetic susceptibility (EMS), shielding effectiveness (SE), woven continuous carbon-fiber composite, 10-Gb/s optical transceiver module.

I. INTRODUCTION

THE WIDESPREAD deployment of low-cost and high-speed optical access networks for fiber-to-the-home (FTTH) applications will necessitate a considerable reduction in the cost of key components such as optical transceiver modules to operate at higher transmission rates. The high-speed driving and receiving electronic circuits are designed and integrated with the optical components in a standard 1 × 9 type small-form-factor packages or a 2 × 9 package [1]–[4]. Because the trend of high-speed electronics is low voltage and low power, the electromagnetic susceptibility (EMS) or electromagnetic immunity of the optical transceiver modules to the electromagnetic interference (EMI) is becoming one of the major concerns to maintain good signal quality of transmission rates over 10 Gb/s [5], [6]. Designing high electromagnetic shielding package/housing is a good solution to improve the immunity performance of the optical transceiver modules. It is well known that metallic housings provide excellent shielding effectiveness (SE). However, due to its low cost and ease-of-manufacturing requirement, the plastic composite package has been considered to be one of the major choices of fabricating optical transceiver module package for use in FTTH applications [7]–[10].

Plastics alone are inherently transparent to electromagnetic (EM) radiation and provide no shielding against radiated interference. To improve the EM shielding for the plastic packaging, electronic conductive properties have to be added into the plastic hosts for adequate EM shielding. The currently available techniques for preventing EMI include conductive sprays, conductive fillers, zinc-arc spraying, electroplating or electrolysis plating on the housing surfaces, modifications of electrical properties during the molding stage, and other metalization processes [11], [12]. Recently, several types of plastic composite packages for the optical transceiver modules with an effective EM shielding ability have been proposed. There are nylon reinforced with short carbon fiber [1], liquid crystal polymer (LCP) reinforced with long carbon fiber [2], and epoxy composite with carbon fibers [2], [8]. Although these plastic composite packages perform good SE, two drawbacks are seen. One is that the pervious package needs a composite with a high percentage of carbon fibers (over 25%). It will significantly increase the cost because carbon fiber dominantly decides the cost of the composite material. The other is that these packages are developed in the application with a transmission rate not higher than 2.5 Gb/s. With the trend of high-speed optical communication, it is essential to develop a low-cost plastic package with high SE and EMS performance at a frequency range of 10 GHz or above.

This paper presents a high electromagnetic immunity and low-cost plastic composite package for the optical transceiver module operating at 10 Gb/s by employing the woven carbon-fiber epoxy composite (WCEC). By weaving the continuous carbon fiber in a balanced twist structure (BTS) with excellent conductive networks, the SE of the package housing can be significantly increased while keeping a very low weight percentage of carbon fiber at 10 GHz. The main difference of the BTS-based WCEC from those previous composites is the use of long carbon fiber with multiple contacts to weave the fiber-conducting networks. It provides more continuous path of the conducting current induced by the electromagnetic wave inside the WCEC and thus enhances the SE performance.

The succeeding sections of this paper are organized as follows. Section II describes the fabrications of plastic composites and plastic optical transceiver modules with transmission rates of 10 Gb/s. The measurement results of the SE for the plastic
case C with the package housing, it is clearly seen that the BER performance is significantly improved. The optical power is approximately $-12.9$ dBm for a BER of $10^{-12}$. Comparing between cases B and C, it is found that the proposed WCEC package significantly increases the electromagnetic immunity to the radiated interference with an optical power gain of approximately $4.1$ dB at BER $10^{-12}$.

V. CONCLUSION

Based on the WCEC, this paper proposes a high EMS performance (or high electromagnetic immunity) and low-cost plastic composite package for the 10-Gb/s optical transceiver module. By weaving the continuous carbon fiber in a BTS with excellent conductive networks, the package housing performs excellent shielding and electromagnetic immunity while keeping a very low weight percentage of carbon fiber at 10 GHz. It is found that the WCEC package with a thickness of 1.0 mm and 4.8% carbon fiber can have an SE performance of approximately 60 dB at 10 GHz as the package is grounded to the system ground. The SE can also reach approximately 38 dB for the realistic packaged module operated at 10 Gb/s. In addition, the excellent electromagnetic immunity or EMS performance of the package is demonstrated by the eye diagrams and the BER test. Under the strongly radiated interference, the package housing significantly improves the jitter and mask margin of the 10-Gb/s eye diagrams. Compared with the unpackaged module, it is also found that an optical power over 4 dB can be gained to keep the BER at $10^{-12}$. To the best of our knowledge, it is the first plastic composite package developed for a 10-Gb/s optical communication module with low-cost and high EMS performance.

REFERENCES


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Photographs and biographies of co-authors Cheng-Wei Lin and Wern-Shiang Jou not available at the time of publication.