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Optoelectronic Package using Optical Waveguide Hole for Chip-to-chip interconnection

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Abstract

We have proposed an optoelectronic package structure having optical waveguide holes through a package for chip-to-chip interconnections. This can be coupled optical device to a fiber array by passive alignment from LSI mounting plane.

Introduction

Today fiber optic interconnections have been extending their field to the short reach region within computer systems because it is said that it has become the bottleneck of electrical transmission due to increase LSI performance. So, optical interconnection modules that can be coupled to optical fiber array within servers or routers have been studied and progressed at many organizations [1,2], but the optical interconnection within computer systems such as CPU(Central Processing Unit) to memory, the so-called chip-to-chip interconnection, has not been enough studied thus far.

Therefore, we have been studying an optoelectronic package for chip-to-chip interconnections, which can be coupled to an optical fiber array. Unlike long-haul optical transmission, a package used in consumer-computer is required to be the low-cost optical coupling structure that can be used the established assembly process in the very short region such as chip-to-chip interconnections. Additionally, it needs to design the optimal electrical transmission lines for higher bandwidth. We have been considering taking following steps against above issues, as follows:

1. Using a fiber array as an optical transmission media at the portion of higher data transmission, and utilizing MT coupling techniques between media and package.
2. The package having optical waveguide holes to transmit optical signals between the flip chip optical device and the optical fiber connector.
3. The package having optimal electrical transmission structure for higher bandwidth because a processor, a controller IC and an optical device are located to be near on the same plane to ease the impedance matching.

Concepts of Optoelectronic Package

Our proposed package has the shortest possible electrical paths that utilize only surface lines and standard Flip Chip bonding pads without difficult impedance matching such as wire bondings, through holes and vias. Fig.1 shows the conceptual image of optoelectronic package structure. The established socket is connected to the motherboard, and then the LSI (Large Scale Integration) package is set in the socket with the PGA (Pin Grid Array). In this structure, electrical power or low-speed signals are supplied through the PGA socket. However, high-speed data signals can be transmitted through the optical paths and not the PGA socket. The processor, controller IC and optical device are mounted on the same surface plane of the package by flip chip connection. The package with guide holes [3] can be simply coupled to the passive optical connector with guide pins on the backside. The passive optical connector has the 45degree mirror for picking up optical signals.

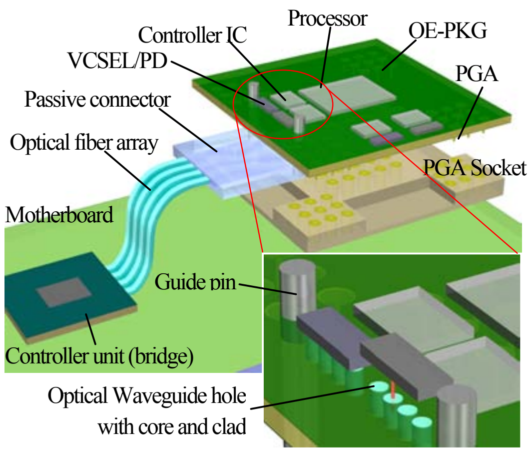


Fig. 1: Optoelectronic Package structure

Proposed package can be assembled by all passive alignment, because flip chip mounting of active devices and fabrication of guide holes to incorporate guide pins are handled with respect to the same alignment patterns on the surface plane. Optical devices have active faces and electrodes on the same plane. So when optical devices are mounted by flip chip in common use, these work forward package. Therefore, the optical through holes that are fabricated with guide holes at the same time are required for transmission through the package. Consequently, we have developed the simple and efficient optical transmissions through the package.

Optical waveguide Hole

If output beam from a VCSEL (Vertical Cavity Surface Emitting Laser) is transmitted in free space, optical receiving power significantly decreases due to the beam divergence. Additionally, if it is transmitted in the drilled holes, this will lead to lower transmission quality due to the diffuse reflection at the rough sidewall. To get sufficient quality of optical signals cannot be expected by both ways. In order to overcome these issues, it is reported that optical paths by a filling transparent resin into the prepared holes availed against power loss and low transmission quality [4]. We would like to propose the optical waveguide hole with core and clad structure for more efficient transmission.

Table.1 shows ray-trace simulation results of free space and optical waveguide hole transmission, respectively. In spite of only 0.4mm free space transmission, the optical coupling loss was -13.3dB. Therefore, it is difficult to establish the optical transmission system for transmitting and receiving by free space transmission. However the optical waveguide hole with the same size as an optical fiber can get sufficiently low loss for optical transmission systems.

Fig.2 shows the experimental field patterns of 0.4mm free space and optical waveguide hole transmission, respectively. Due to the optical waveguide hole, we can now have the higher optical power and the smaller spot size to be able to combine with the optical fiber rather than free space transmission.

Table.1 Simulation result of optical coupling loss

Transmission media	Simulation result
Free space transmission	-13.3dB
Optical waveguide hole	-0.7dB

a) Free space transmission

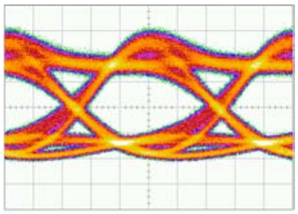
b) optical waveguide hole

Fig.2 Field patterns

Transmission Characteristics of Optical waveguide hole

Fig.3 shows the 10Gbps eye pattern of the optical output signals through the optical waveguide hole. This measurement has been monitored by connecting GI50-MMF (Grated index Multi-Mode Fiber) to MT connector.

Table.2 shows transmission characteristics of the optical waveguide hole. The optical waveguide hole has -1.7dB insertion loss including coupling loss. And the results of transmission characteristics showed the difference in jitter of less than 2ps against input optical signals.



V ; 60uW/div

H ; 20ps/div

Fig.3 Eye pattern of output signals

Table.2 Properties of optical waveguide hole

Material properties	Specification
Difference in reflective index	8.3%
Transmission characteristics	Specification
Insertion loss	-1.7dB
Jitter (p-p)	25ps(Δ:＜2ps)

Conclusions

We have proposed the optoelectronic package that can couple the optical fiber array to LSIs for chip-to-chip optical signal transmission. We have demonstrated that the optical waveguide holes through a package have excellent optical transmission against insertion loss and jitter characteristics. We will verify the usefulness of our proposed package with guide holes for passive alignment and the optical waveguide holes for optical paths, which can be coupled to an optical fiber connector.

References

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