Extended Abstracts of the 1999 International Conference on Solid State Devices and Materials, Tokyo, 1999, pp. 456–457 **E-10-2**

Hybridly Integrated PLC LD Modules Using Pedestal Structure Reach-through Bonding

Terukazu Naruse, Hidehiko Nakata, Haruhiko Tabuchi
and Kazuhiro Tanaka

FUJITSU LABORATORIES LTD.
10-1 Morinosato-Wakamiya, Atsugi 243-0197, Japan
Phone: +81-462-50-8218 FAX: +81-462-48-5194 e-mail: tnaruse@flab.fujitsu.co.jp

1. Introduction

Hybrid integration of optical waveguide devices and optical semiconductor device such as semiconductor laser diodes (LDs) on PLC (Planar Lightwave Circuit) platform [1] have been extensively studied for cost-effective and highly-functional optical modules. One of the issues in the scheme is the vertical and lateral adjustment of the core of a waveguide and active layer of a LD within about 1 μm, which is required for highly efficient optical coupling between them. We have demonstrated vertical and horizontal adjustment using pedestal structure of plastic waveguide PLC platform [2]. However, The solder bump prohibited precise assembly of the LDs. In this paper, we report a new structure of solder bump suitable for die-bonding on pedestal using deformation of solder bump with its surface tension.

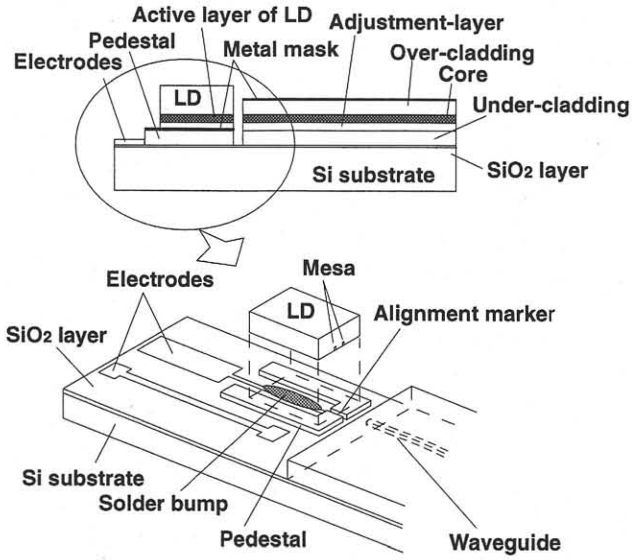

Fig. 1 Schematic structure of PLC Platform

2. Structure of PLC platform and solder bump

Figure 1 shows the schematic structure of a PLC platform we developed [3]. We use upper-surface of the under-cladding of the waveguide as a reference plane. A pedestal to mount a LD is formed with the same layer of the under cladding. By forming metal mask such as Ti on the layer, we obtained pedestal easily by O_2-RIE. Only controlling the thickness of the adjustment layer, we can align the height between LD's active layer and core of the waveguide. Horizontal adjustment is carried out with mechanical alignment between marker on the LD (mesa) and alignment marker formed on the pedestal. To fix the LD on the pedestal and to connect the LD to the electrode on the Silicon substrate, solder bump is adopted.

In conventional assembly process, the solder bump needs higher thickness than that of the pedestal to connect the LD and solder bump. In this case, although horizontal alignment was carried out before heating, displacement tends to occur during heating process as shown in Fig. 2.

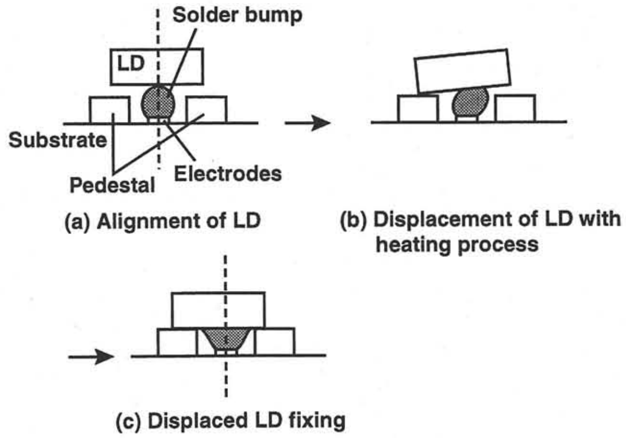

Fig. 2 Conventional bonding on a pedestal

This prohibits the precise alignment horizontally.

To overcome this we adopt new solder bump as shown in Fig. 3(a). The solder is formed over the electrode on the

SiO_2 layer formed on the substrate. The width of solder is made wide than that of the electrode. The thickness of the solder bumps formed lower than pedestal surface plane.

In the mechanical alignment of a LD, the alignment is carried out easily because solder bump is lower than pedestal surface plane. In heating process, the solder bump melts and moves. Solder bump outside the electrode gather toward the electrode due to the surface tension and difference of wettability between electrodes and SiO_2. At the same time, The height of the solder bump increases [3]. By designing solder bump structure, the solder bump extends through the gap and reaches the LD after heating. Figure 4 shows an example of the increase of the height of the solder bump. About 5 μm increase was realized. By reaching solder bump to LD, fixing of LD is attained. Thus, this reach-through bonding in Fig. 3 is promising for precise adjustment and fixing of optical semiconductor devices such as LDs using pedestal. Moreover, the evaporation thickness decreases with this structure. This makes fabrication process easier and shorter.

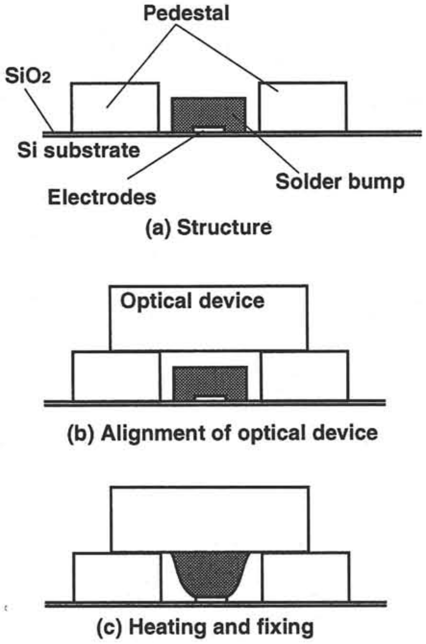

Fig. 3 Reach-through bonding

3. Fabrication and characteristics

We carried out bonding experiments using this structure. Electrode 50 μm wide with Ti/Au layer was formed on SiO_2 layer. After forming plastic layer such as pedestal, Sn solder layer 100 μm wide was evaporated. The height of the pedestal was chosen 10 μm. Thus, cross section of $50 \times 10 = 500\ \mu m^2$ is need to make the solder bump reach to the LD during heating process. We chose the height of the solder bump 7 μm. By heating the fabricated solder bump at 305℃, 10s, 12 μm height was obtained.

To investigate bonding strength we carried out die shear test. We obtained similar strength as that for conventional flat bump bonding on flat surface.

With this bonding alignment accuracy within 1 μm were obtained, which is comparable for that on flat surface bonding. High optical coupling between LD and waveguide was obtained with 3.9dB.

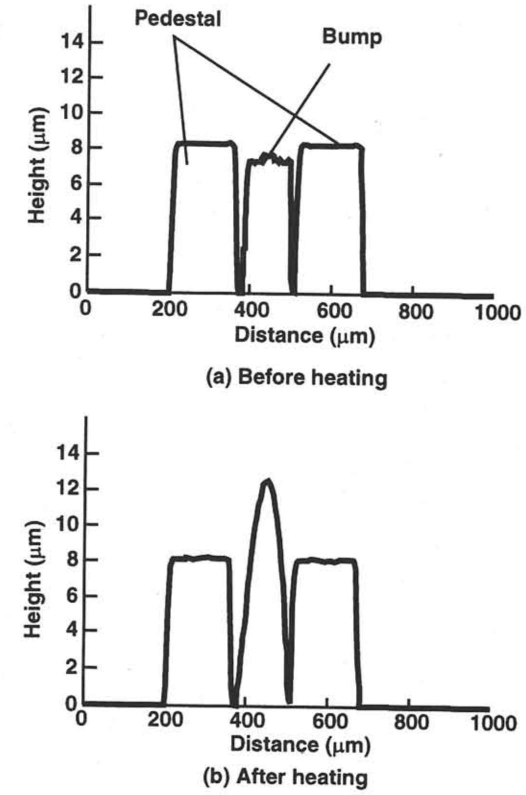

Fig. 4 Increase of the height of solder bump after heating

4. Conclusion

We developed a new structure of solder bump for LD bonding with pedestal. We confirmed effectivity of the bump we developed in respect to bonding alignment accuracy.

References

[1] Y. Yamada et al., Electron. Lett. Vol.29 no.5, p.144, 1993

[2] T. Naruse et al., Technical digest of OECC'98, 15C2-3, p.372, 1998

[3] Y. Akahori et al., Proceedings of ECTC'97, p.632, 1997