Thin Glass Based Packaging Technologies for Optoelectronic Modules

L. Brusberg, H. Schröder, M. Töpper, N. Arndt-Staufenbiel, J. Röder, M. Lutz, H. Reichl

Fraunhofer IZM, Gustav-Meyer-Allee 25, 13355 Berlin/Germany, Lars.Brusberg@izm.fraunhofer.de

Abstract

As a result of its beneficial properties like chemical resistance, optical transparency over a wide range of wavelengths, bondability to silicon, feasibility of metal deposition and thermal resistance, glass is widely used for sensing and MEMS packaging. Thin glass foils of large dimension and a thickness of some tens of microns, high purity and low surface roughness are used for flat panel display manufacturing. Another area of interest is laminating of thin glass into PCBs for optical interconnects on board level (EOCB) featuring a higher bandwidth × length product, more power efficiency and a higher bandwidth density than electrical interconnects. Borosilicate glass (Schott D263T) with a thickness of 300µm was used for an ion-exchange waveguide and PCB laminating process [1]. The combination of commercial availability in standardized wafer or square sizes for wafer level processing and the optical, mechanical and electrical properties make thin glass interesting as substrate and interconnection material for packaging of optoelectronic modules. A comprehensive all-glass based packaging approach was not yet been reported.

In this paper we introduce the novel packaging approach glassPack for optoelectronic modules. Commercially available thin glass foils get electro, optical and fluidic structures before being stacked for vertical integration. The main ideas of the glassPack concept are: selection of suitable glass foils as substrate material, realization of microsystem compatible structuring technologies like cutting, drilling and etching, integration of optical waveguides by ion-exchange for single-mode (SM) and multi-mode (MM) applications, implementation of optical interconnects between fibers and integrated waveguides by laser fusion, integration of electrical wires and through-vias, assembly of electronic and optoelectronic components, and bonding of the thin glass foils to 3D-stacks [2, 3].

The new approach demonstrates the beneficial electrical properties of glass which make it suitable as carrier material instead of silicon, ceramic or FR4. Substrates made of thin glass foils can decrease the substrate thickness, reduce the pitch of wiring, increase the density of solder pads and increase the performance of electrical through-vias for high-frequency applications. As a result, highly integrated electronic systems with a high thermal reliability are possible. Electro-plated Cu lines of 100µm width and through hole interconnects of less than 300µm diameter are presented. Different fabrication methods for through holes like laser drilling (Nd:YNO_4 & TiSa-Laser) and etching photosensitive glass (Schott FOTURAN) are compared. A glassPack demonstrator designed as refractive sensor having Cu wiring, through-vias and flip-chip mounted silicon chips will be presented.

The most important advantage of glassPack is the transparency of the substrate material. To establish the new concept we researched into the silver ion-exchange technology to realize optical waveguides for single mode SM and MM applications. Using a two-step processing buried waveguides for low-loss fiber and optical device coupling results. The ion-exchanged waveguides in Schott D263T have a low loss of less than 0.1 dB/cm for MM and less than 0.32 dB/cm for SM. On the other hand the ion-exchange process is used for implementation of planar GRIN-lenses. Optical coupling in-plane or out-of-plane is performed by position the electro-optical device or fiber in front of the waveguide or using a 45°-polished mirror [4]. Optical fibers are laser fused to thin glass foils for reliable optical interconnection [5].

A huge benefit of the presented approach is the possibility of stacking glass foils having electrical or optical interconnects. Above the stacked glass layers components are mounted for vertical integration. For example mounted VCSELs can illuminate through the transparent substrate and couple light into waveguide layers below using planar integrated lenses. Bonding technologies like soldering, adhesive and fusion bonding are presented.

It is necessary that materials and technology processes are compatible with each other to establish this novel concept. To show the potential of glassPack an optoelectronic sensor module was designed and manufactured. The main issues are focused on optical design, thermal management and packaging

technologies. A wafer level packaging process was performed using 4” glass wafers (Schott D236T) as substrate material for electrical circuits and optical waveguides. Fluidic cavities were etched in 4” glass wafers (Schott FOTURAN) and fusion bonded to the waveguide integrated glass wafers. Horizontal and vertical electrical wiring were manufactured using laser drilling and Cu-plating. An FP-Laser was flip-chip mounted on a solder ball bonded glass stack for light coupling into the waveguide structure. An adhesive mounted PD detects the light signal at the end of the waveguide. Flip-chip mounted silicon chips show the successful realization of optoelectronic multichip module packaging. Thermal management is realized by thermal-vias and heat sinks.

References

[1] Schröder, H.; Arndt-Staufenbiel, N.; Beier, Axel; et al: „Thin Glass Based Electrical-Optical Circuit Boards (EOCB) Using Ion-Exchange Technology for Graded-Index Multimode Waveguides”. Proc. of ECTC, Lake Buena Vista, 27-30 May 2008, pp. 268-275

[2] Brusberg, L; Schröder, H; Arndt-Staufenbiel, N.; Wiemer, M: “glassPack: A novel photonic packaging and integration technology using thin glass foils”. Proc. of SPIE, Vol. 6992, 2008, pp. 699206-699206-9

[3] Schröder, H; Arndt-Staufenbiel, N; Brusberg, L.: "glassPack – Photonic Packaging using thin glass foils for Electrical-Optical Circuit Boards (EOCB) and sensor modules” Proc. of ESTC, Greenwich, 2008, pp. 1245-1250

[4] Schröder, H; Arndt-Staufenbiel, N; Brusberg, L; Tekin, T.: “Optical coupling using thin glass based arrayed waveguide components”. Proc. of MOC, Brussels, 25-27 September 2008, pp. 56-57

[5] Arndt-Staufenbiel, N; Lang, G; Krissler, J; Schröder, H; Scheel, W.: „Specific glass fiber technologies: Lensing and laser fusion“. Proc. of SPIE, Vol. 5445, 2004, pp. 83-86