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Sacrificial Process For Silicon Microchannel Wafer Enablement

ABSTRACT

Techniques are described for the enhancement of structural integrity of wafers that include microchannels. Silicon wafer microchannels are filled with sacrificial materials that can easily flow and fill the microchannel gaps, maintain their structural integrity during wafer processing, e.g. withstand wafer dicing, survive reflow temperatures, and possess deformation properties sufficient to absorb the stress and strain induced during wafer processing. In one option, a carrier wafer is attached to the bottom surface of the wafer to cap the channels. The microchannels are filled with filler materials, e.g. using a vacuum inducing or compressive process. In another option, the sacrificial molding compound is directly compressed into the microchannels using a compression molding process. Excessive molding compound material is removed by grinding or etching to retain a flat wafer bottom surface. The sacrificial material is removed at the end of the wafer processing.

KEYWORDS

- Microchannel
- Wafer dicing
- Compression molding
- Mold grinding
- Silicon wafer
- Wafer etching
- Negative photoresist material
- Carrier wafer

BACKGROUND

Silicon wafers sometimes have microchannels etched onto the bottom surface of the wafer for electronics cooling or Lab-on-Chip applications. For cooling applications, the microchannels serve as coolant passages and heat transfer surfaces through which heat generated by the semiconductor chip is carried away. This approach of bringing coolant to the heat source directly eliminates the need for thermal interface material (TIM) and hence improves cooling drastically.

However, the presence of microchannels on a silicon wafer poses several challenges, particularly, potential disruption to the wafer process. For example, etching away of silicon from the microchannels can cause structural weakening of the wafer and impact wafer handling. Stress concentration due to the presence of microchannels can cause wafer cracking during wafer dicing. During chip-on-wafer processing, there can be impacts such as pick and placement issues during die-bonding, channel clogging during compression molding, and a risk of die damage during mold grinding.

Solutions that can enable microchannel inclusion in a wafer while mitigating the risk of wafer damage during processing can enable safer adoption of microchannel use in wafers.

DESCRIPTION

This disclosure describes techniques for the enhancement of structural integrity of wafers that include microchannels. Per techniques of this disclosure, silicon wafer microchannels are filled with sacrificial materials that enhance the structural strength of the silicon wafer during wafer processing. The sacrificial materials are then safely removed after completion of the wafer process.

Sacrificial materials are selected that can easily flow and fill the microchannel gaps, maintain their structure during wafer processing, e.g., withstand wafer dicing, survive reflow temperatures, and possess deformation properties sufficient to absorb the stress and strain induced during wafer processing. The sacrificial material should also be safely removable at the end of the wafer processing.

Example sacrificial materials include negative photoresist material(s) that harden upon curing, adhesive materials that can be chemically removed at the end of the wafer process, and molding compounds that can be compressed into the microchannels.

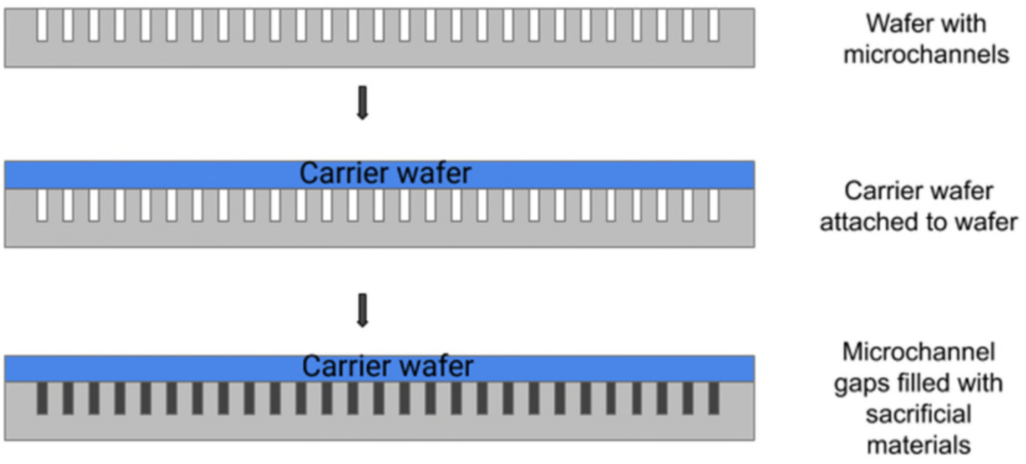

Fig. 1: A carrier wafer is attached to a wafer before filling microchannel gaps

Fig. 1 depicts a first option for the filling of microchannels with sacrificial material during wafer processing, per techniques of this disclosure. As depicted in Fig. 1, a carrier wafer is attached to the bottom surface of the wafer to cap the channels; the carrier wafer also acts as an interface for all subsequent wafer handling and processes. The microchannels are filled with filler materials, e.g., using a vacuum inducing or compressive process. In situations where a sacrificial material is selected that has adhesive properties, the same material can be used as a filler as well as an adhesive for the carrier wafer attachment. The presence of the carrier wafer prevents any direct contact of the microchannel surface(s) during wafer processing.

In some implementations, the carrier wafer is permanently attached to the wafer and functions as a fluid distribution layer. In such situations, the carrier wafer is pre-patterned with coolant passages prior to bonding to the microchannel wafer.

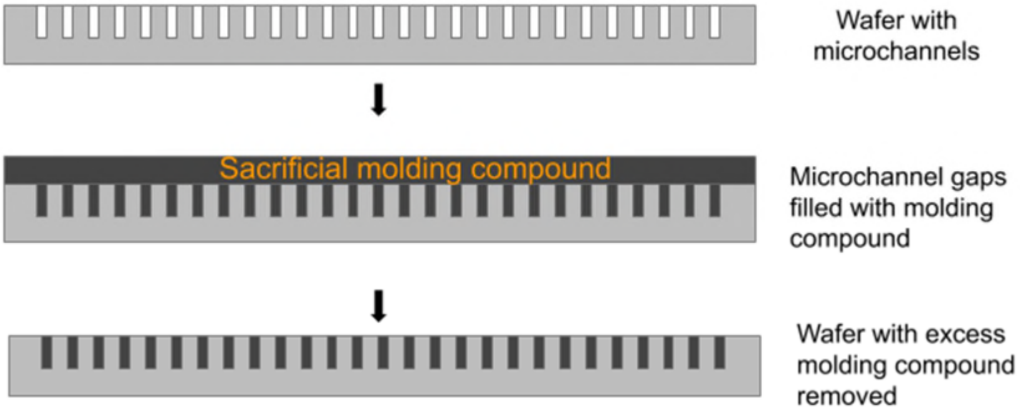

Fig. 2: Sacrificial molding material is utilized to fill microchannel gaps

Fig. 2 depicts a second option for the filling of microchannels with sacrificial material during wafer processing, per techniques of this disclosure. In this option, the sacrificial molding compound is directly compressed into the microchannels using a compression molding process. Excessive molding compound material is removed by grinding or etching to retain a flat wafer bottom surface. Presence of the sacrificial material within the microchannels protects the microchannel surfaces from external exposure during wafer processing.

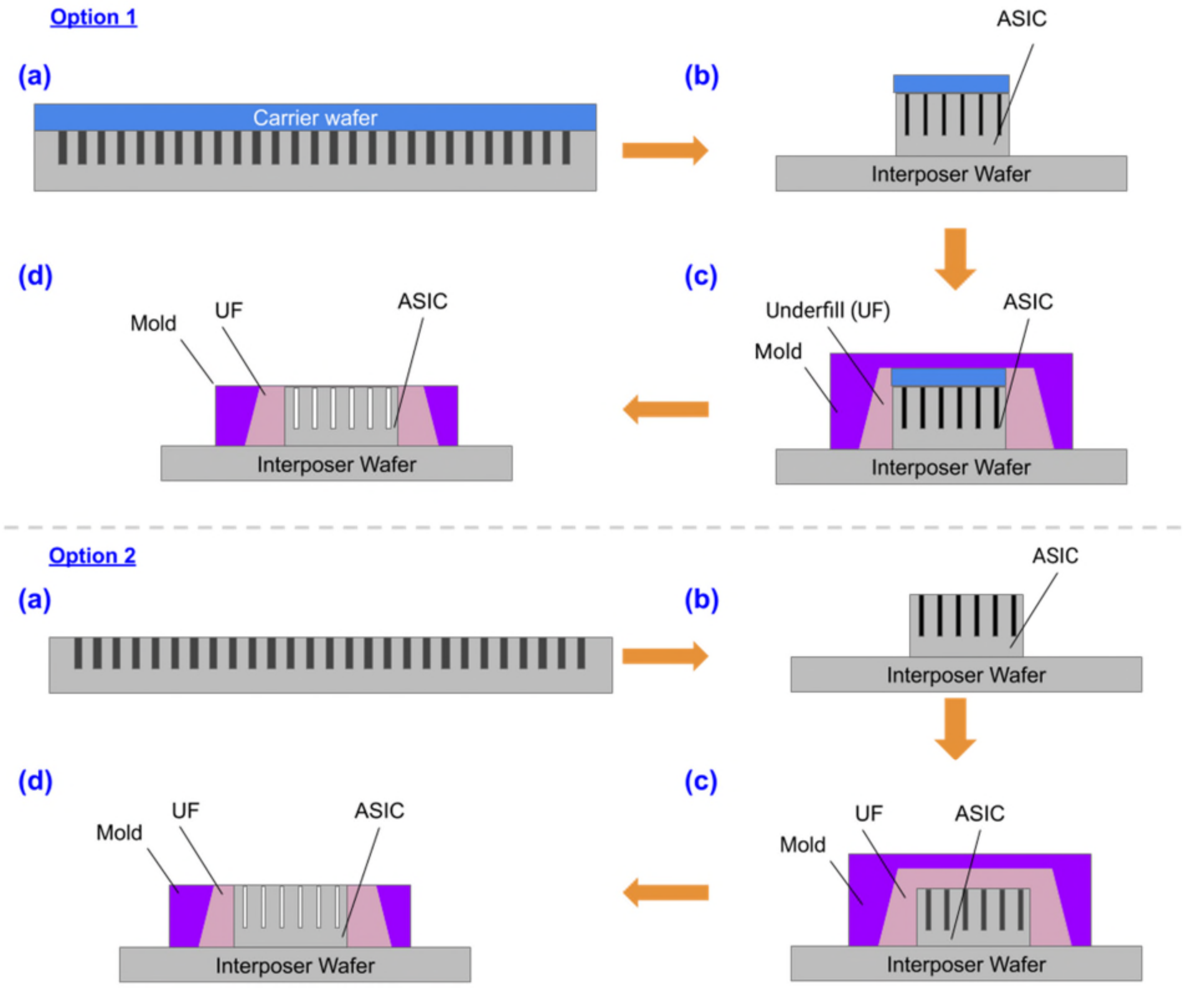

Fig. 3: Wafers are protected during wafer processes

Fig. 3 depicts various steps in wafer processing and the protection offered to the microchannels during wafer handling and processing. Fig. 3(a) options 1 and 2 each depict example wafers with filled microchannels based on the options described earlier. In option 1, a carrier wafer is attached to the wafer prior to the filling of the microchannels, while in option 2, the microchannels are directly filled with a sacrificial material.

Fig. 3(b) options 1 and 2 each depict wafer dicing, wherein the wafers are diced into singular dies using a mechanical/laser/plasma dicing process. The singular dies are then bonded to an interposer wafer. The filled microchannels are protected during wafer dicing by the sacrificial material. Fig. 3(c) options 1 and 2 each depict underfilling and compression processes, during which any risks of channel clogging is mitigated by the presence of the sacrificial material in the microchannels.

Fig. 3(d) options 1 and 2 each depict a mold grinding process that removes the mold material at a bottom surface of the wafer. The microchannels remain protected during mold grinding since they are not exposed. During mold grinding, in some implementations, the carrier wafer is removed thereby exposing the channels whereas in others, it is left in place.

The sacrificial filler materials are then chemically dissolved to expose the microchannels at the end of wafer processing.

CONCLUSION

Techniques are described for the enhancement of structural integrity of wafers that include microchannels. Silicon wafer microchannels are filled with sacrificial materials that can easily flow and fill the microchannel gaps, maintain their structure during wafer processing, e.g. withstand wafer dicing, survive reflow temperatures, and possess deformation properties sufficient to absorb the stress and strain induced during wafer processing. In one option, a carrier wafer is attached to the bottom surface of the wafer to cap the channels. The microchannels are filled with filler materials, e.g. using a vacuum inducing or compressive process. In another option, the sacrificial molding compound is directly compressed into the microchannels using a compression molding process. Excessive molding compound material is removed by grinding or etching to retain a flat wafer bottom surface. The sacrificial material is removed at the end of the wafer processing.