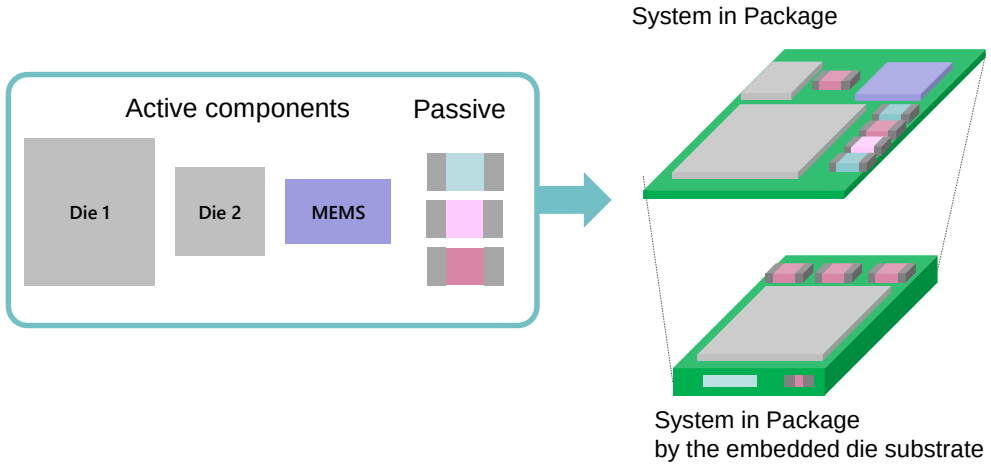
Stress Reduced Embedded Die Substrate Structure Fabricated for Heterogeneous Integration Using Selective Laser Ablation,

[Device Packaging Conference 2021, April 12-15, 2021]

Masamitsu Matsuura*, Tanemasa Asano, Haruichi Kanaya

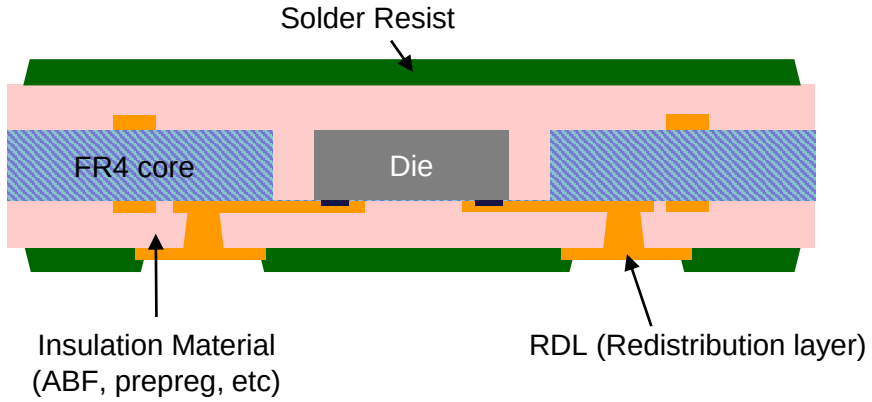
Background

The demand for high-speed, multi-functionality, and miniaturization of devices increases with a general acceptance of mobile communication devices such as smartphones and smartwatches in the next-generation 5G and IoT era. Undoubtedly, the semiconductor package of the mobile communication devices needs to be downsized with keeping function. One of the solutions is embedded die substrate technology, which is able to integrate passive components and active components with the minimum volume in the same body to implement heterogeneous integration.



The embedded die substrate technology has high potential to meet the demand on electronics packaging in the next-generation mobile communication and the IoT era

The structure of conventional embedded die substrate



However, in the conventional embedded die substrate, the embedded die is fully covered by the substrate materials. This fact results in the generation of significant residual stress in the embedded components. Accordingly, the stress-sensitive components such as micro electro mechanical systems (MEMS) sensor, bulk acoustic wave (BAW) resonator, and surface acoustic wave (SAW) filter are regarded unsuitable for embedding.

Objective

Develop the embedded die substrate structure for MEMS devices whose performance is highly sensitive to the mechanical stress.

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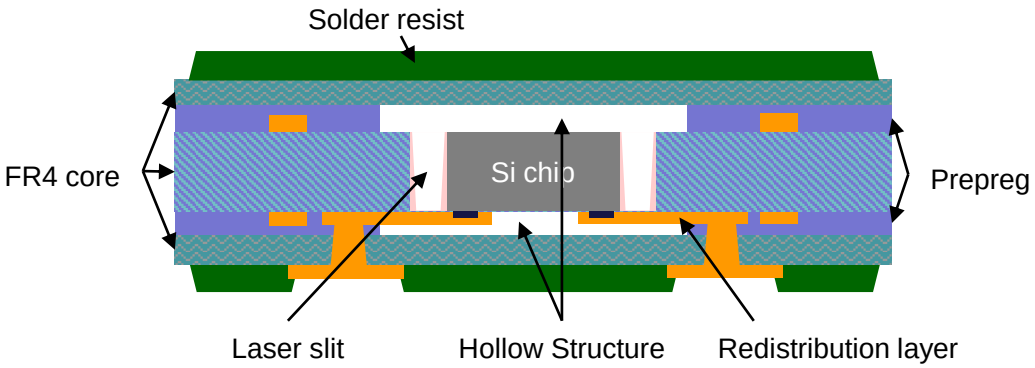
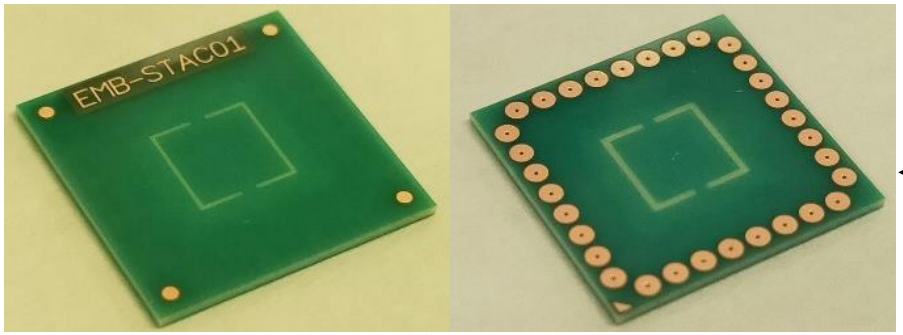
Proposed Package Structure

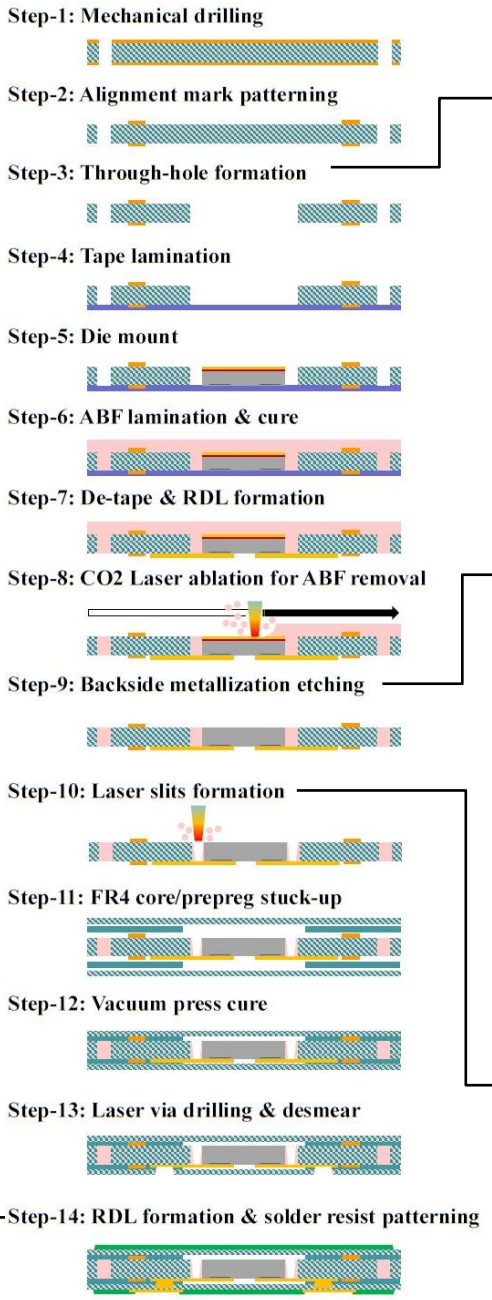


	Material Sets	Supplier	Model	Thickness
1	FR4 frame	Hitachi Chemical Co., Ltd	MCL-M-679FG	150umt
2	Insulation Material*	Ajinomoto Fine-Techno Co., Inc.	ABF GX-T31	50umt
3	Prepreg	Hitachi Chemical Co., Ltd	GEA-679FG	30umt
4	Solder Resist	Taiyo Ink MFG Co., Ltd	AUS410	25umt

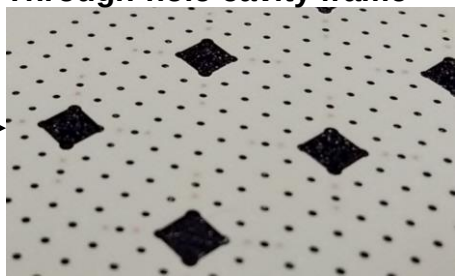
The die is embedded into hollow chamber in substrate and it is held by re-distribution layer (RDL)

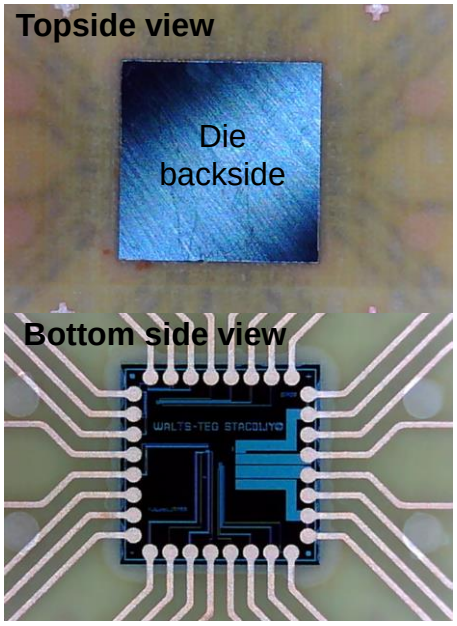


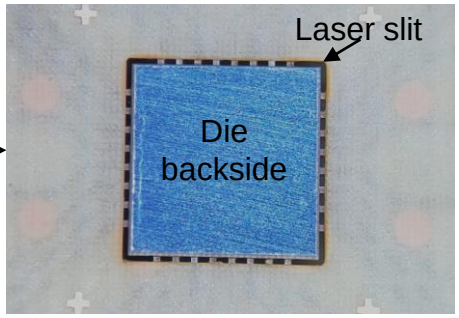
Process Flow



Through-hole cavity frame







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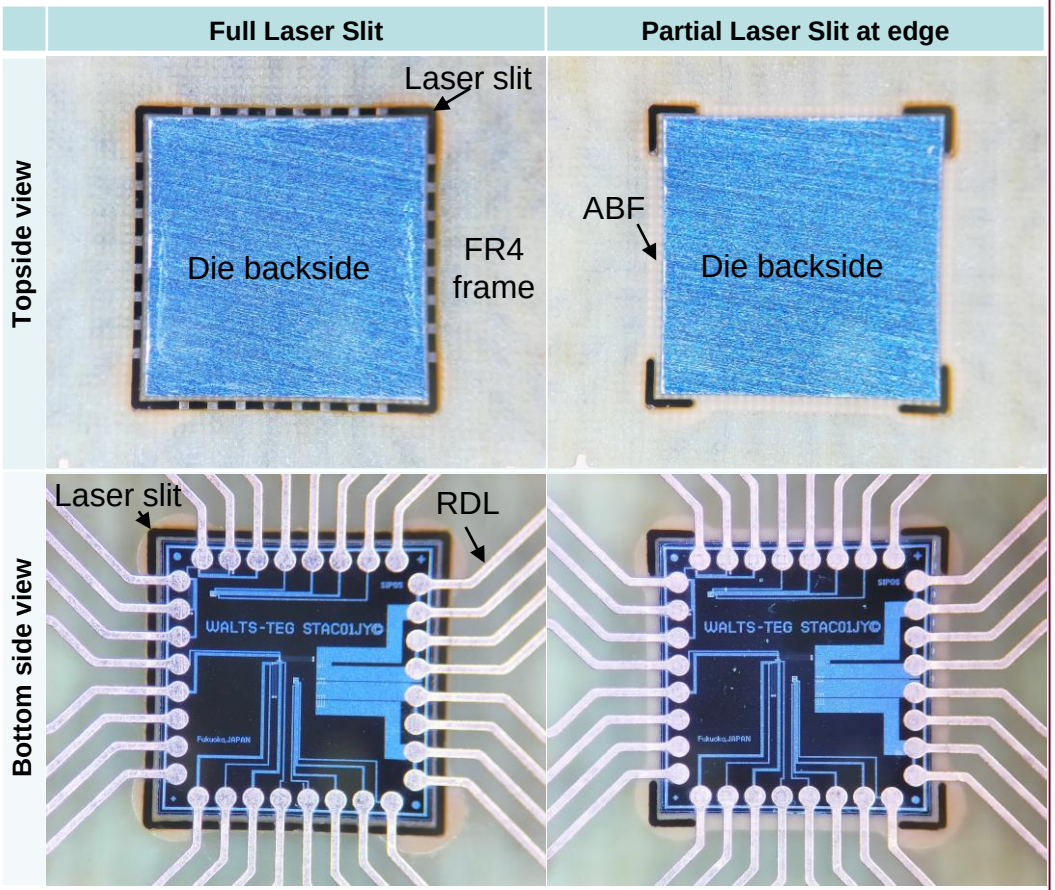
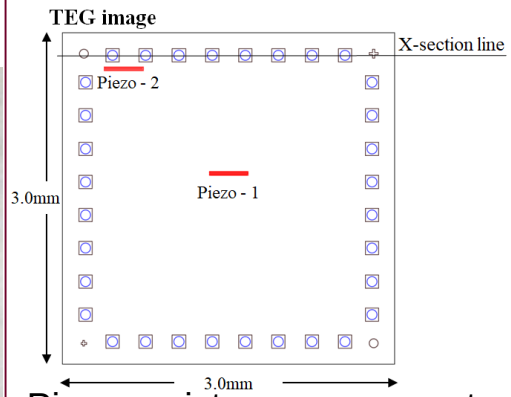
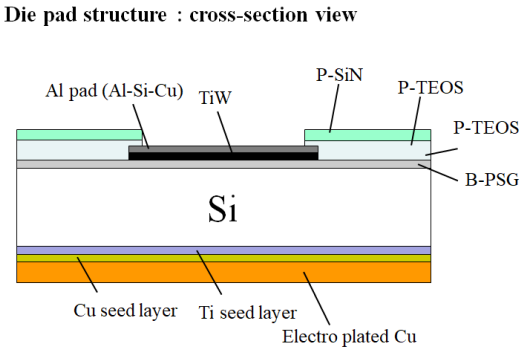
Experimental and Stress Measurement – Laser Slit



CO_2 laser ablation with 100 μm diameter is applied to make a Laser slit in filling material before the formation of hollow structure in the embedded die substrate. Two kinds of Laser slit design are evaluated. One is full laser slit design which is completely removed the filling material around die. Another one is partial laser slit design. The filling material at die edge area is removed. For full laser slit design, the die is only held by RDL after laser slit formation.

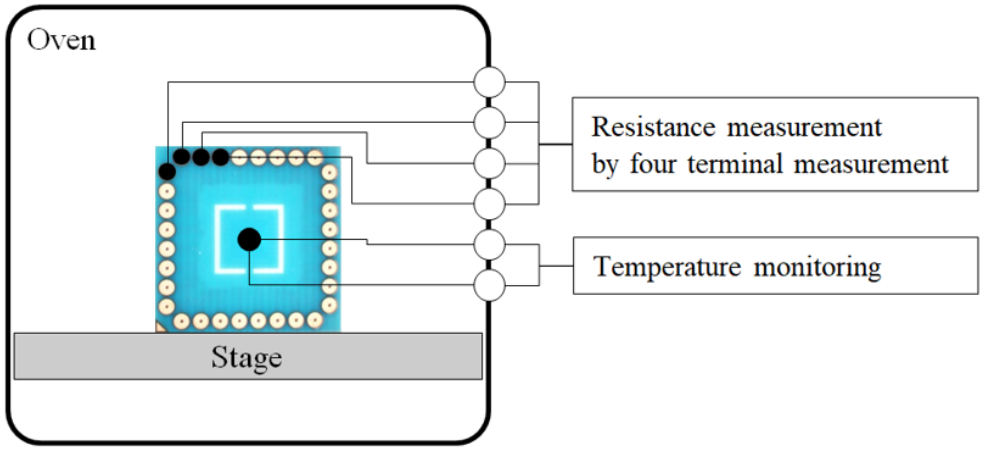
Experimental and Stress Measurement – Test chip





Piezo-resistance gauge at near die edge and at near the center was used for stress measurement. The residual stress on the die surface is calculated by the change of resistance compared with the initial resistance at wafer level.

Experimental and Stress Measurement – Temperature dependence



The residual stress on the embedded die surface was measured by four terminal measurement at -60 ºC to 120 ºC in the oven

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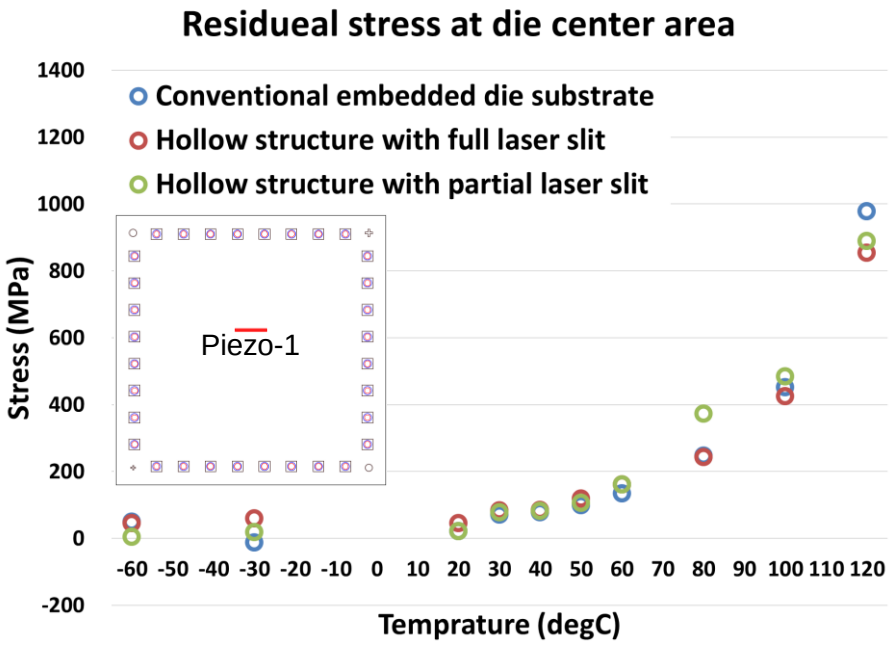
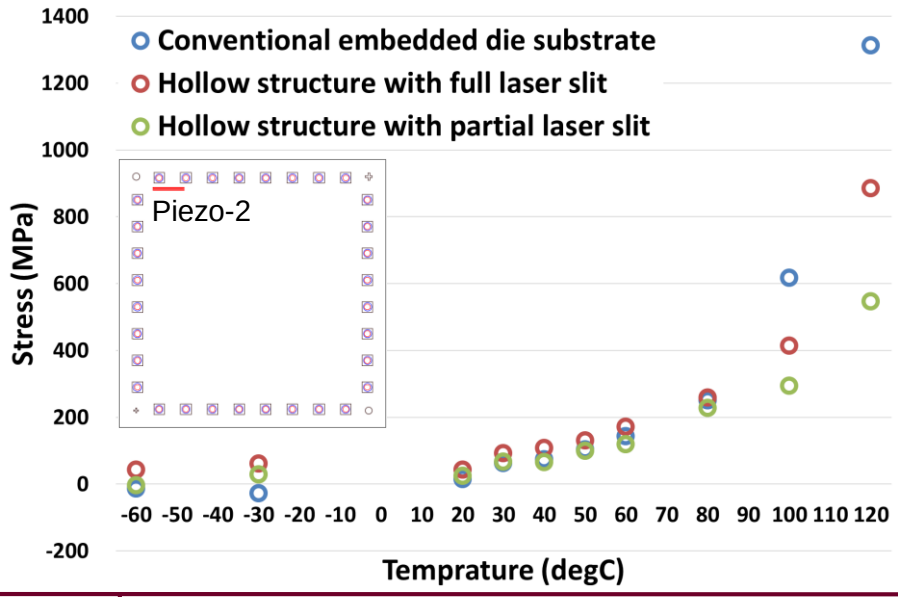
Results of Temperature Dependence and Discussion





The residual stress of three kinds of embedded die substrate structure were investigated at -60 ºC to 120 ºC temperature environment. One is the conventional embedded die substrate structure that the die is fully covered by filling material (ABF GX-T31). Other is the proposed embedded die substrate structure which has hollow chamber with laser slit around the die.

The residual stress of the conventional embedded die substrate at center area is showing 977 MPa at 120 ºC, the edge area is 1312 MPa. The die edge is having much higher residual stress due to stress concentration. On the other hand, partial laser slit design, the stress at edge is significant reduced as 546 MPa at 120 ºC. However, the center area is higher as 888 MPa, the stress deformation can be seen. In contrast, the full laser slit design, the stress value at center and edge are similar value as 853 MPa and 884 MPa at 120 ºC by removing the filling material around die. It is resulted that the stress deformation between center and edge is released by hollow structure with full laser slit design.

Acknowledgements

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References

1. M. Matsuura, T. Asano, H. Kanaya, “Evaluation of Residual Stress of Embedded Die Substrate with Hollow Structure for Heterogeneous Integration”, 22nd Electronics Packaging Technology Conference (EPTC) 2020, 2-4 Dec., pp. 399-402.

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