Through-Glass-Via Enabling Low Loss High-Linearity RF Components

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Summary

Successful fabrication of metalized through glass vias (TGVs), using glass wafers for low-loss high-linearity 3D wafer-level packages (WLP). Characterization of the TGVs shows significantly better performance than today´s commercial TSV MEMS technology. Using two sets of TGVs and a 1.1 mm long transmission line, ***excellent non-linearity performance of 78 dBm was demonstrated*** and a DC resistance of 28mOhm/TGV was measured.

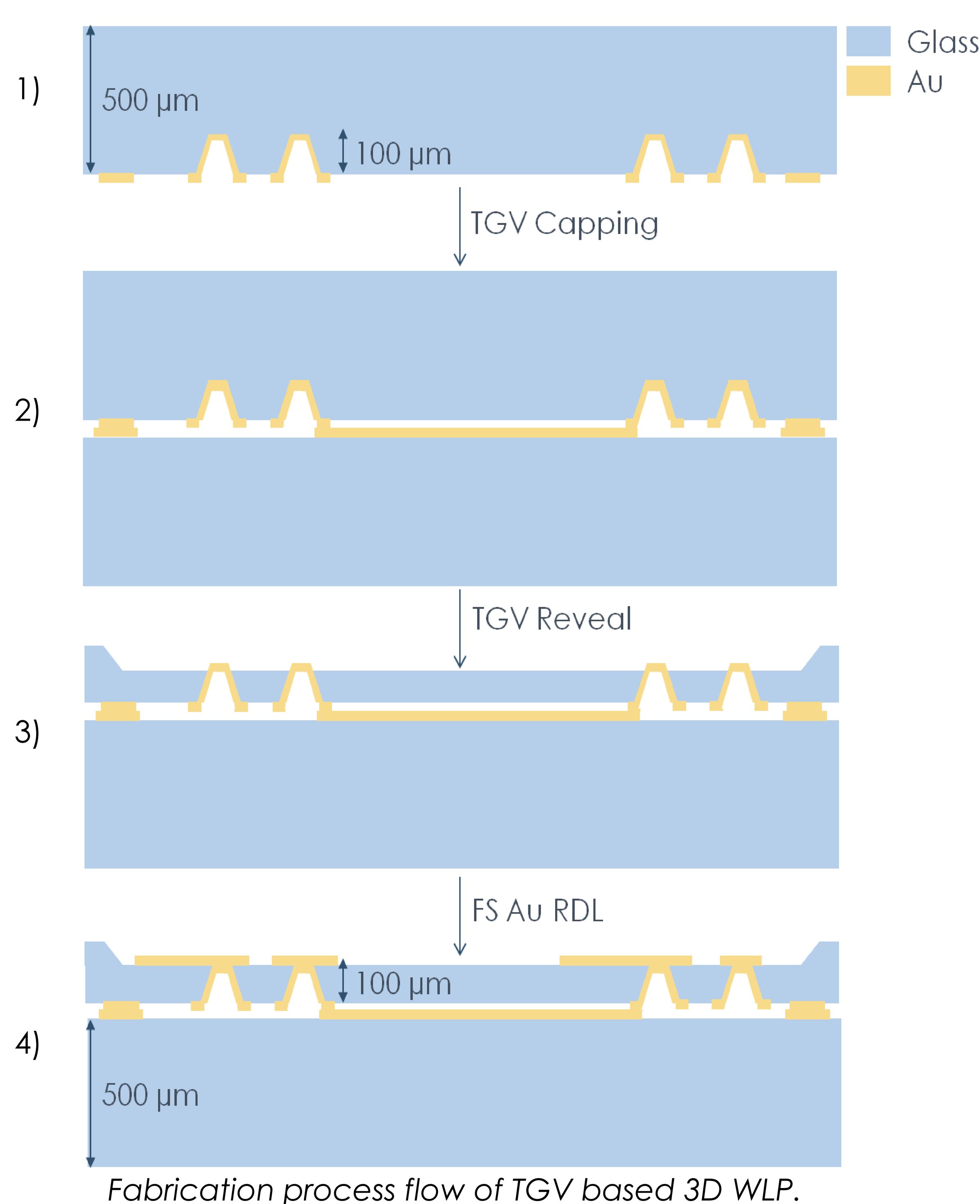
Why Through Glass Vias (TGVs)?

MEMS technology market is now aiming at the miniaturization of high performance applications, in particular radio-frequency (RF MEMS). By using 3D WLP with TGVs, shorter low loss electrical connections and smaller foot prints can be achieved. Compared to commercially available silicon based vias (TSVs), glass substrates provide superior electrical insulation and low capacitive coupling, which are critical parameters for RF signal handling.

How to fabricate TGVs?

The fabrication of the TGVs were executed on 150 mm Eagle glass substrates, which are alkaline earth boro-aluminosilicate and contain no heavy metals.

1) The via holes were fabricated, then a redistribution layer (RDL), W-2-W bond pads, and via metallization layer was realized by conformal Au-plating (7 µm thick);
2) then by thermo compression bond, the TGV-Cap™ wafer was bonded to a test device wafer,
3) then a thinning and reveal process was executed in order to
4) contact the TGVs from the front side with a 7 µm thick Au-RDL.

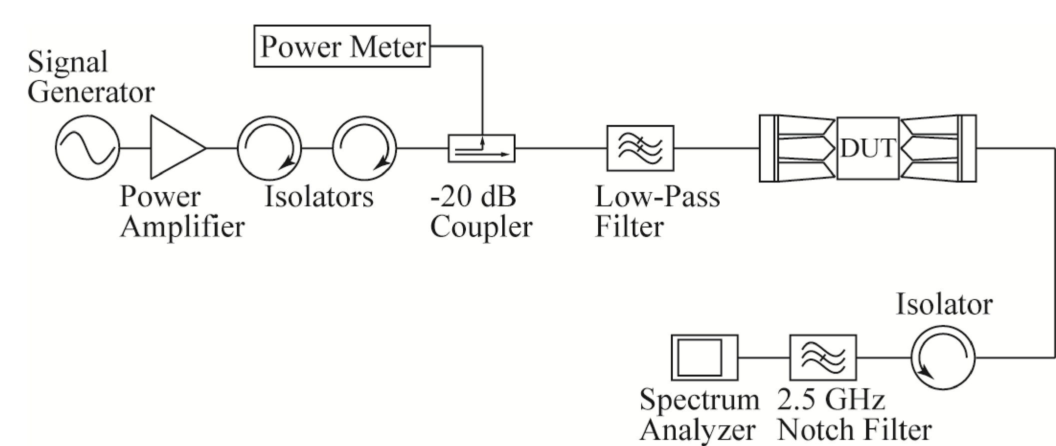


Fabrication process flow of TGV based 3D WLP.

Successful full wafer fabrication process of the TGVs was achieved, resulting in a DC via resistance of 28 mOhm/via; including RDL and bond interfaces, measured on dedicated DC daisy chain test structures.

RF – Characterization Set-up

The linearity of the TGVs were characterized by measuring the output power of the 2nd and the 3rd harmonics in relation to the input power at the center frequency of 2.5 GHz using a coplanar waveguide transmission line (with and without TGVs). This testing was conducted using a very broadband measurement set-up (up to the 3rd harmonics).

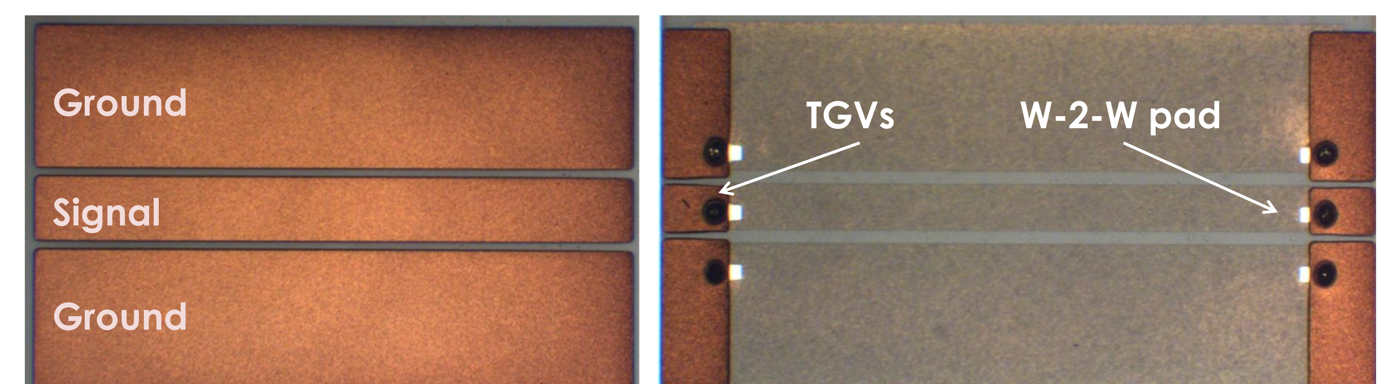


Harmonics measurement set-up.

Measurements were performed at several input power levels ranging from 11.5 to 36.5 dBm. The 2nd harmonic level with and without TGVs was roughly the same, while the 3rd harmonic level with TGVs was about 2 dBm lower as compared with the transmission line without TGVs.

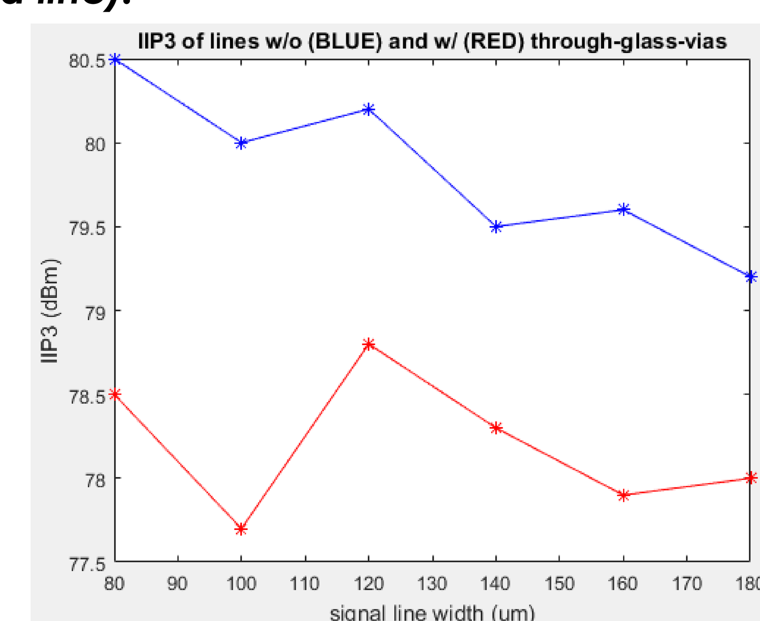
RF – Characterization Results

RF characterization was performed on a full 150 mm wafer, using 1.1 mm long transmission lines and a signal width ranging from 80-180 µm; without (a) and with (b) TGVs.

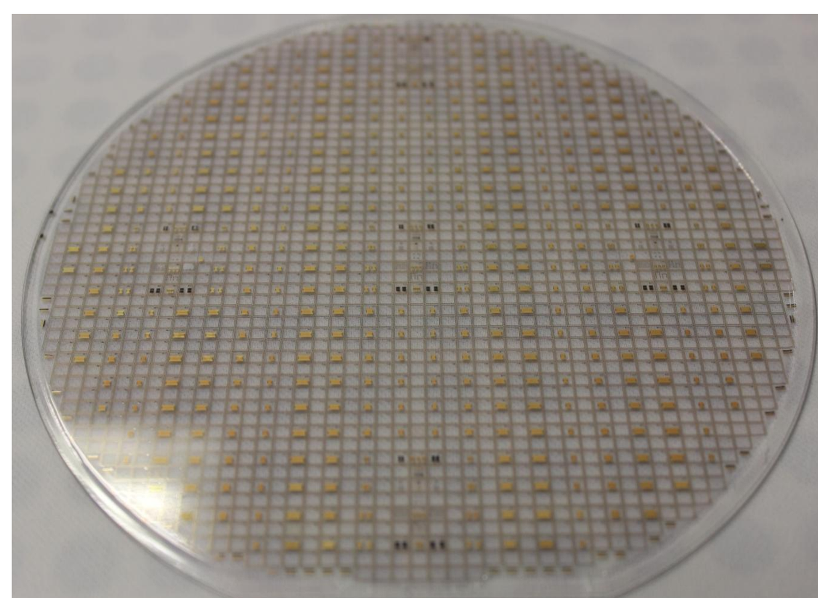


a) 50-Ohm transmission line. *b) Transmission line with two sets of TGVs.*

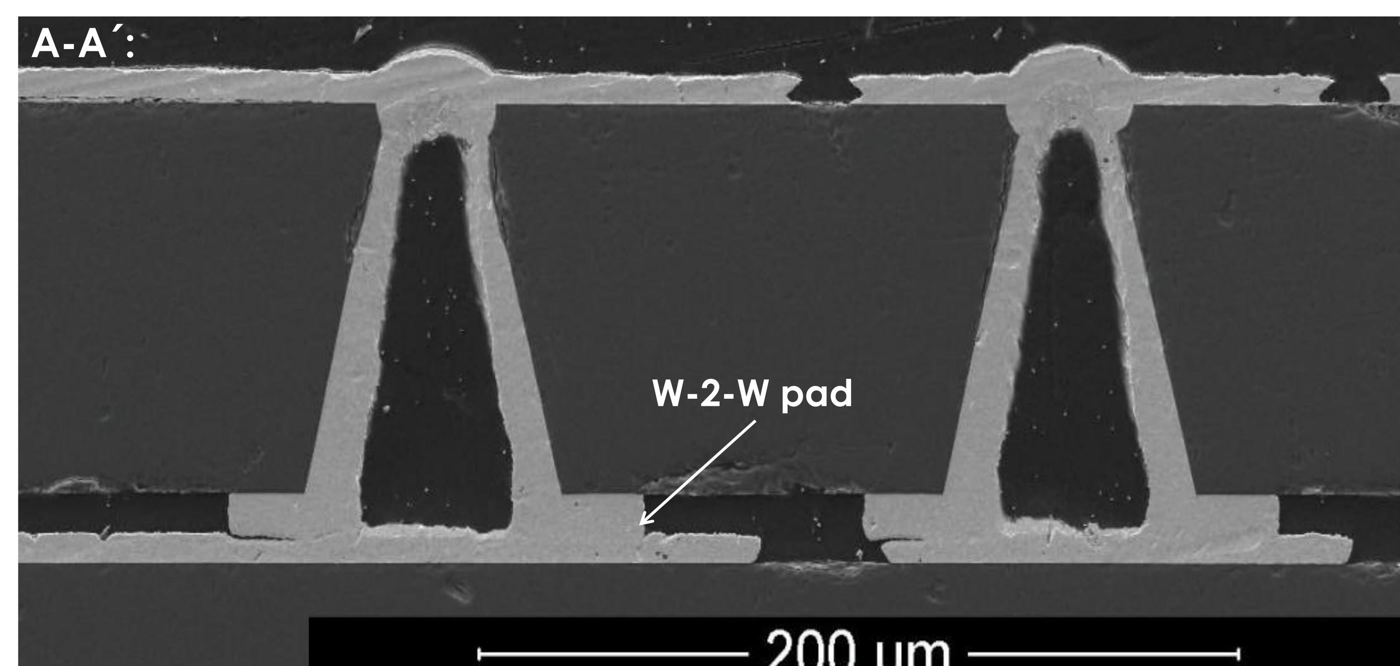
The non-linearity (IIP3) of the (non-TGV) 50-Ohm transmission line and a signal line width ranging from 80 to180 µm resulted in values between 80.5 and 79.2 dBm (blue line). While, the ***IIP3 measurement with two G-S-G sets of TGVs ranged from 78.8 to 77.7 dBm (red line).***



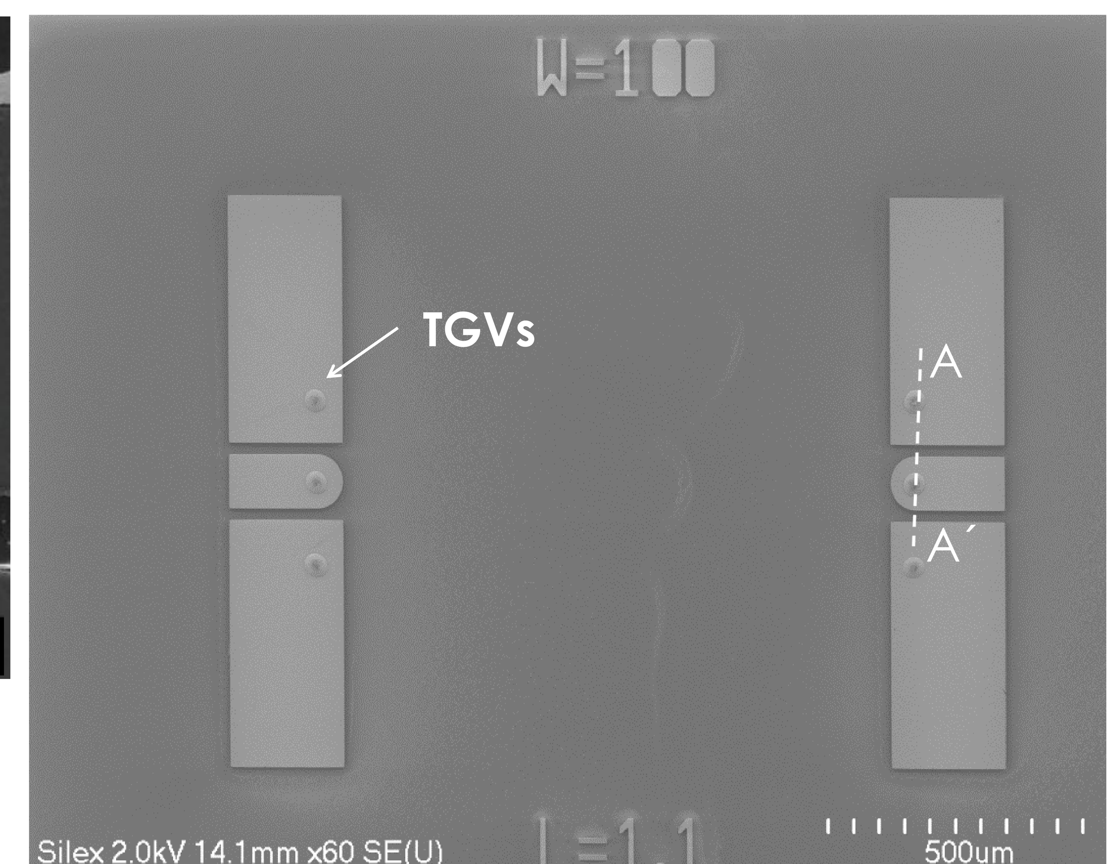
IIP3 results over signal line width for all devices using transmission lines without vias (top blue line) and transmission lines with two sets of vias each (bottom red line).



Full 150 mm 3D WLP bonded TGV glass wafer pair using Au-Au thermo compression bond.



Cross-section of the TGVs showing the conformal Au-plating and the wafer to wafer (W-2-W) bond interface.



Top view SEM image of G-S-G TGV RF test structure.

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