PROJECT RESULTS

CAT801 | Promising outlook for advanced packaging products thanks to improved production yield in high volume manufacturing [TSV-Handy]

The TSV-Handy project met its key objectives: the brightfield inspection of heterogeneous 300mm wafers; development of metrology and new logistical concepts for wafers on 380mm frames; and improvements to temporary bonding and debonding processes. Key achievements included innovative frame-handling and a flexible metrology platform equipped with multiple sensors.

Through silicon via (TSV) is a more-than-Moore (MtM) chip technology which improves the density of a device by stacking dices (3D) onto an interposer, or arranging them horizontally side-by-side (2.5D). This technology is also applied to reconstituted epoxy/mould compound wafers with through polymer VIA (TPV) in fan-out wafer-level packaging (FO-WLP) technology, an enhancement of standard wafer-level packages developed to provide a solution for semiconductor devices requiring a higher integration level and a greater number of external contacts. In addition, this technology provides a smaller package footprint with higher input/output (I/O), along with an improved thermal and electrical performance. Consequently, it has become the preferred technology for system design and the focus of attention.

Boosting high-volume TSV manufacturing and improving production yield

TSV-Handy's focus was on supporting a high-volume manufacturing (HVM) ramp-up and on improving the yield for manufacturing advanced packaging products. In particular, it addressed challenges posed by 3D TSV and FO-WLP technologies, and by the increase in substrate types which typically have different mechanical behaviours and physical properties.

Key project activities and resulting benefits were:

- Heterogeneous handling development of 300mm wafers with brightfield inspection (a technology that uses light sources to find defects during the transistor fabrication process in a fab). This resulting innovative way of handling glass and recon will improve European competitiveness because heterogeneous handling is not generally available on the European EFEM market, especially the mid-end part;
- Developing metrology and new logistical concepts for wafers on 380mm frames, which resulted in an innovative frame-handling and a flexible metrology platform with multiple sensors. This should improve the position of European suppliers in a very competitive metrology market where the key players are the USA, Israel and Asia, and where there are only two known European suppliers with frame-handling capabilities, and no frame EFEM suppliers which can service the production area;
- Frame logistics development for HVM, which resulted in a front-opening unified pod (FOUP) frame, shipper and a frame with radio-frequency identification (RFID) prototypes compatible with an automated HVM environment. This should increase the position of European suppliers of products for handling in-process wafers mounted to frames (typically open style cassettes that are multi-piece, custom-fabricated carriers often made of metal which are high-cost, with low particle-control, and part-to-part variation due to low-volume and a custom fabrication technique);
- Improving temporary bonding and debonding processes for the 3D integration market and HVM, resulting in key reproducible processes using novel adhesive materials transferable to major IC makers. This should give European bonding and debonding vendors a competitive edge.

Adopting a modular approach called SMART platform (a common robotics and software core interfaced with several loading stages and end-effectors), this project delivered modular equipment capable of manipulating several types of wafers, without any hardware reconfiguration. In addition, smart software-management was developed to help end-users improve equipment flexibility and up-time.

PROJECT CONTRIBUTES TO

- Communication
- Automotive and transport
- Health and aging society
- Digital lifestyle
- Design technology
- Process development
- Manufacturing science
- More than Moore

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KEY PROJECT DATES

1 April 2015 - 31 March 2019

In particular, TSV-Handy delivered two equipment front-end modules (EFEMs):

- A platform capable of handling frames, on which a metrology tool with lithium indium diselenide (LISe) and Spiro sensors was adapted, and a load-port designed for a FOUP;
- An atmospheric EFEM to handle silicon and recon wafers with an integrated brightfield inspection module.

Importantly, this project was also able to demonstrate that the heterogeneous inspection and frame metrology equipment could respond to the wafer handling and inspection/ metrology requirements for mid-end manufacturing. In addition, the resulting prototypes were successfully installed and evaluated according to their usage in terms of automation, cleanliness, and stability.

How TSV-Handy will impact business and markets

TSV-Handy could impact business in several ways. Firstly, it could raise productivity levels, but also generate new products. This will drive business and in turn increase employment. It will also promote and maintain high-tech European companies and semiconductor centres.

Crucially, this project also secures competitiveness in several European industry sectors. The FO-WLP packaging market is starting to grow as this new technology platform begins implementation. According to YOLE, a French research institute, in 2016 90% of the FO-WLP market was driven by eWLB, a breakthrough technology which provides a more space-efficient package design, enabling a smaller footprint, and higher density input/ output. Furthermore, since tapes can no longer be used for ultra-thin wafers, new wafer-handling technologies have to be developed, which means that the use of temporary bonding technology is also growing. Along with standard approaches, we now have temporary bonding with reconstituted wafers for FO-WLP.

The production of TSV chips and wafers is forecast to have a significant average continuous growth rate in the coming years (107% throughout 2013-2018), given that industry can address the challenges related to technology and manufacturing cost. By 2016, the temporary bonding tool market-value for TSV and FO-WLP was forecast at US$222m. The TSV Handy project will also help boost and stabilise this position for novel applications targeted in the TSV-Handy project. This is particularly important for Europe, considering the major competition is in Asia and US.

Europe offers more flexible and versatile solutions in metrology inspection over its competitors, given that it is the only solution-provider capable of measuring moulding compounds before thinning (required for advanced-packaging solutions). Furthermore, TSV-Handy is expected to improve equipment to satisfy current and upcoming demands. Potential sales for a key European supplier were put at somewhere between €5m and €10m by 2019.

Finally, new business generated by automated wafer-handling equipment is expected to increase an important European supplier's volume by 30%. Estimated revenue generated from this segment should be at least €5m per year by 2020. Furthermore, for another key European automated shipping-carrier supplier (which already has some 40% of the worldwide market and where Europe represents 20% of its business), project deliverables are expected to generate a worldwide share of 40-60%, with 40% of that business in Europe. In addition, this same supplier also expects more than a 60% market share in in-fab 3D wafer-handling products worldwide, with 30-40% of that business in Europe.

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