SPTS
An orbotech Company

APPLICATION
BRIEF

Fan-Out WLP - PVD Processes

Introduction

Fan-Out WLP (FOWLP) technology is an enhancement of standard wafer-level packages (WLPs) developed to provide a solution for semiconductor devices requiring a higher degree of integration and a greater number of external contacts. It provides a smaller package footprint with higher input/output (I/O) along with improved thermal and electrical performance.

In conventional WLP schemes I/O terminals are located over the chip surface area. Using this method, there is a limitation to the number of I/O connections.

FOWLP takes individual die and embeds them in a low cost material such as epoxy mold compound (EMC) with space allocated between each die for additional I/O connection points – avoiding the use of relatively expensive Si real estate. Redistribution Layers (RDL) are formed using PVD seed deposition and subsequent electroplating/patterning to re-route I/O connections on the die to the mold region.

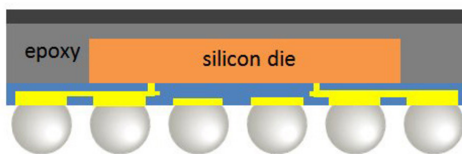

Fig 1 Schematic illustration of FOWLP

Mold compound is a cost-effective material for this application, but readily absorbs moisture when exposed to atmosphere. Outgassing during the PVD process sequence can have detrimental effects on package contact resistance (known as Rc or R_{VIA}) so effective degas is essential. However, the material also has low thermal budget (TMAX typically <120°C) to prevent decomposition and excessive wafer warp.

Consequently an effective degas requires long process times at low temperature. This significantly reduces system throughput for traditional single wafer-based degas systems, impacting CoO and capacity. Figure 2 shows how Rc for FOWLP test vehicle wafers improves with longer degas times.

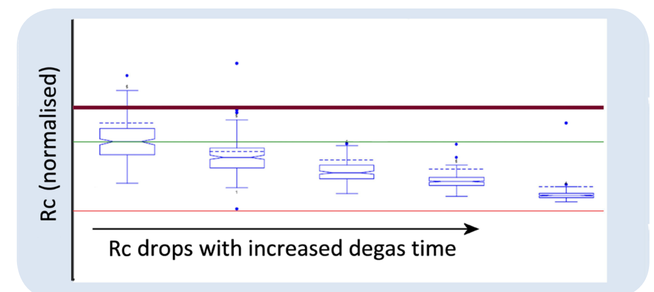

Fig 2 Benefit of increasing degas time - Reduced Rc

Multi-Wafer Degas

Improved Rc and Throughput

To eliminate the degas bottleneck SPTS offers a "Multi-Wafer Degas" solution (MWD) that enables a large number of wafers to be degassed in parallel before continuing to pre-clean and sputter deposition process modules without breaking vacuum. Wafers are dynamically pumped under clean, high vacuum conditions, with direct wafer heating to ensure efficient, effective heat transfer.

A Sigma® fxP PVD system configured with MWD will deliver throughputs >1.5x competitor systems based on single wafer degas processing technology. As materials emerge with lower thermal budgets, longer degas times can be employed with no impact on throughput. The module also offers potential to remove oven pre-bake steps prior to PVD from the FOWLP process flows. Conversely, competitor systems based on single wafer degas will get progressively slower (see Fig 3 overleaf).

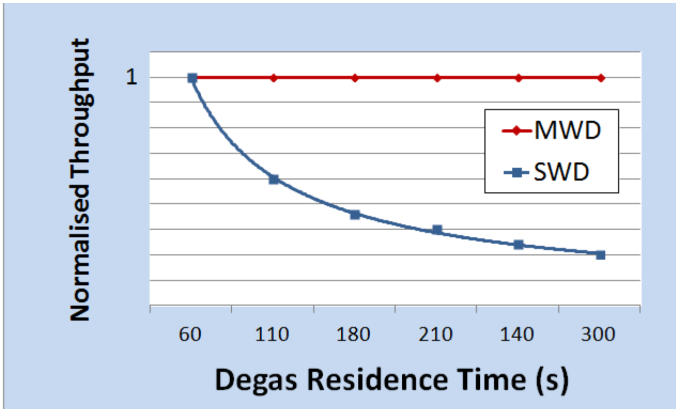

Fig 3 Throughput advantage of MWD versus single wafer degas increases with longer degas time

SE LTX Pre-Clean

Improved MWBC

With I/O counts increasing in FOWLP schemes the amount of exposed metal contacts on the wafer presents challenges for MWBC with ICP-based pre-clean chambers. Metallic contamination from the over-etch disrupts RF coupling through the ceramic chamber wall, leading to process stability issues.

The SE LTX pre-clean module is specifically designed to overcome this challenge. Specialized hardware prevents continuous build-up of metal on chamber walls while providing good adhesion for organic passivation materials sputtered onto the sidewalls as a by-product of the pre-clean process, resulting in a typical particle performance with > 5000 wafers MWBC.

Inspira™ PVD

Cost-effective Cu Seed

With degas and pre-clean stages completed the final stage of the PVD RDL process is the deposition of pre-plate seed layer. Typically Ti or TiW adhesion/barrier followed by Cu seed, this stage of the process requires relatively uniform, repeatable metal films over low topography. Inspira™ PVD technology designed specifically for BEOL processing with the emphasis on low CoO is used.

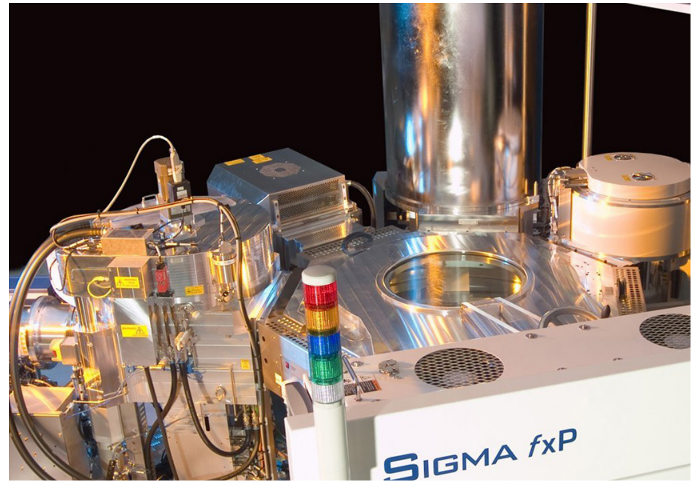

Fig 4 300mm Sigma® fxP with MWD

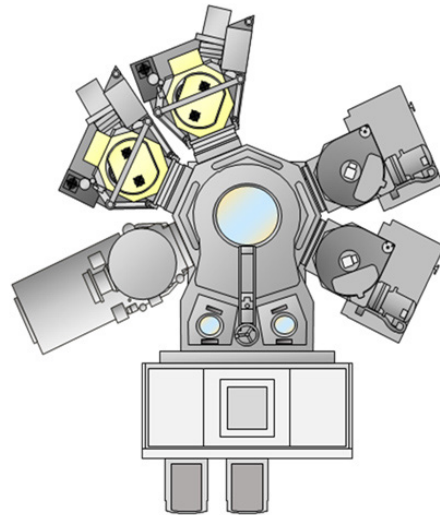

Fig 5 Plan view of Sigma® fxP with (clockwise) MWD, 2 SE LTX & 2 Inspira process modules

Cost Reduction Trends

Processing reconstituted wafers means wafer sizes are not necessarily limited to Si diameters and this presents opportunities for cost reduction. The Sigma® fxP PVD solution has been designed to run substrates up to 330 mm in diameter, giving a 20% increase in surface area for additional die to be processed in the same pass, reducing overall cost per die. Mold thickness can also be reduced, saving material cost. Wafer bows can increase as a result of either modification. Consequently the Sigma® fxP has been designed to accommodate wafers with up to 10 mm bow.

The combination of batch degas, high productivity pre-clean and Inspira hardware tailored for BEOL, results in Sigma® fxP being the most productive FOWLP PVD RDL system in the industry.

SPTS Technologies, an Orbotech company, designs, manufactures, sells, and supports etch, PVD, CVD and MVD® wafer processing solutions for the MEMS, advanced packaging, LED, high speed RF on GaAs, and power management device markets. For more information about SPTS Technologies, email enquiries@spts.com or visit www.orbotech.com/spts

© 2018 SPTS Technologies Ltd. All rights reserved. Ref FO-WLP-Q2/18

Cautionary Statement Regarding Forward-Looking Statements

Except for historical information, the matters discussed in this press release are forward-looking statements within the meaning of the U.S. Private Securities Litigation Reform Act of 1995. These statements relate to, among other things, future prospects, developments and business strategies and involve certain risks and uncertainties. The words "anticipate," "believe," "could," "will," "plan," "expect" and "would" and similar terms and phrases, including references to assumptions, have been used in this press release to identify forward-looking statements. These forward-looking statements are made based on management's expectations and beliefs concerning future events affecting Orbotech and are subject to uncertainties and factors relating to Orbotech's operations and business environment, the previously announced acquisition of Orbotech by KLA, the manner in which the parties plan to effect the transaction, including the share repurchase program, the ability to raise additional capital necessary to complete the repurchase program within the time frame expected, the expected benefits, synergies and costs of the transaction, management plans relating to the transaction, including with respect to the Company's ownership interest in Frontline, the expected timing of the completion of the transaction, the parties' ability to complete the transaction considering the various closing conditions, including conditions related to regulatory and Orbotech shareholder approvals, the plans, strategies and objectives of management for future operations, product development, product extensions, product integration, complementary product offerings and growth opportunities in certain business areas, the potential future financial impact of the transaction, and any assumptions underlying any of the foregoing. Actual results may differ materially from those referred to in the forward-looking statements due to a number of important factors, including but not limited to the possibility that expected benefits of the transaction may not materialize as expected, that the transaction may not be timely completed, if at all, that KLA-Tencor may not be able to successfully integrate the solutions and employees of the two companies or ensure the continued performance or growth of Orbotech's products or solutions, the risk that the Company may not achieve its revenue expectations within and for 2018 (including, without limitation, due to shifting move-in dates); cyclicality in the industries in which the Company operates, the Company's supply chain management and production capacity, order cancelation (often without penalty), timing and occurrence of product acceptance (the Company defines 'bookings' and 'backlog' as purchase arrangements with customers that are based on mutually agreed terms, which, in some cases for bookings and backlog, may still be subject to completion of written documentation and may be changed or cancelled by the customer, often without penalty), fluctuations in product mix within and among divisions, worldwide economic conditions generally, especially in the industries in which the Company operates, the timing and strength of product and service offerings by the Company and its competitors, changes in business or pricing strategies, changes in the prevailing political and regulatory framework in which the relevant parties operate, including as a result of the United Kingdom's prospective withdrawal from the European Union (known as "Brexit") and political uncertainty in the United States, or in economic or technological trends or conditions, including currency fluctuations, inflation and consumer confidence, on a global, regional or national basis, the level of consumer demand for sophisticated devices such as smart mobile devices, automotive electronics, flexible applications and devices, augmented reality/virtual reality and wearable devices, high-performance computing, liquid crystal display and organic light emitting diode screens and other sophisticated devices, the Company's global operations and its ability to comply with varying legal, regulatory, exchange, tax and customs regimes, the timing and outcome of tax audits, including the best judgment tax assessment issued by the Israel Tax Authority with respect to the audit of tax years 2012-2014 in Israel and the related criminal investigation, the Company's ability to achieve strategic initiatives, including related to its acquisition strategy, the Company's debt and corporate financing activities; the timing, final outcome and impact of the criminal matter and ongoing investigation in Korea, including any impact on existing or future business opportunities in Korea and elsewhere, any civil actions related to the Korean matter brought by third parties, including the Company's customers, which may result in monetary judgments or settlements, expenses associated with the Korean matter, and ongoing or increased hostilities in Israel and the surrounding areas.

The foregoing information should be read in connection with the Company's Annual Report on Form 20-F for the year ended December 31, 2017, and subsequent SEC filings. The Company is subject to the foregoing and other risks detailed in those reports. The Company assumes no obligation to update the information in this press release to reflect new information, future events or otherwise, except as required by law.