LASER ABLATION – EMERGING PATTERNING TECHNOLOGY FOR ADVANCED PACKAGING

Ralph Zoberbier, SUSS MicroTec Lithography GmbH, Schleissheimer Str. 90, 85748 Garching, Germany
Matt Souter, TAMARACK Scientific Co., Inc., 220 Klug Circle, Corona, California 92880-5409, USA

INTRODUCTION
Wafer Level Packages have emerged as the fastest growing semiconductor packaging technology. Rather than a single solution, wafer level packaging technologies are a set of different solutions including flip-chip wafer bumping, electroplated gold, solder bumps and recent copper pillar technologies. These chips can be packaged in many different ways, through fan-in WLCSP, fan-out WLP, 3D WLP, interposer and 3D IC interconnections using TSV’s.

One of the most critical process steps of each technology is the patterning of features or interconnects in a most efficient but reliable manner. Nowadays, proximity exposure technologies (mask aligner) or projection lithography (step and repeat or scanning) are the typical choices to create redistribution lines, pads, TSV patterns and others. However, the latest developments and advances in Excimer laser ablation and complementary technologies, offer the promise of further reductions in manufacturing costs as well as enhancements in chip performance. This article provides a general overview of the Excimer laser ablation technology delivered by the equipment set from Tamarack Scientific Inc., recently acquired by SUSS MicroTec in March 2012.

Figure 1. Typical optical set-up of an excimer laser system
WHAT IS LASER ABLECTION?

Excimer Laser ablation is a dry patterning process, utilizing a 248nm or 308nm excimer laser source. The laser light is shaped and homogenized through a series of optics, where it is projected through a reduction lens onto the substrate or wafer, removing the material as desired. This technology is quite similar to a typical UV Stepper, however, instead of exposing a photo imagable material, the substrate is etched directly without the need for a photosensitive material nor any of the post develop and etch processes that accompany a photolithography process. Ablation is a physical and photo chemical removal process, breaking the materials molecular structures and directly etching the circuit patterns to desired depths on the substrate. Only those areas not protected by the mask are ablated, unaffected the areas surrounding. This ‘non-thermal’ laser ablation process produces a very accurate replication of the mask image. Combined with a large field projection lens and high power laser, the system can ablate areas up to 50 x 50mm at one time, resulting in high throughput in comparison to other patterning technologies such as DPSS ablation or LDI (Laser Direct Imaging), where single laser beam is rastered, greatly limiting throughput capability.

Laser ablation offers the ability to directly etch materials, offering a means to significantly reduce manufacturing costs in comparison to a photolithography process. By using Excimer laser ablation, many process steps and costly materials can be eliminated from the manufacturing flow, including resist coating, baking, developing, resist stripping and etching.

Furthermore, laser ablation enables the use of less expensive non-photosensitive materials, which often promote better thermal characteristics. Excimer ablation is suitable for ablating a wide variety of polymeric materials, thin metals (<600nm), epoxies, nitrides and other organic materials. For example, the technology can be applied to pattern conductive films over polymer layers, while not damaging the underlying polymers.

LASER ABLECTION EQUIPMENT

Tamarack Scientific, recently acquired by SUSS MicroTec, has been designing, engineering and manufacturing laser ablation equipment since 1987 and recently introduced its 6th generation laser ablation stepper (ELP300), targeted at the advanced packaging market. While laser ablation is already in use in many other electronic applications, including the medical and display markets, the WLP industry has also begun to embrace this technology as a means to not only lower manufacturing costs, but also achieve requirements for next generation chip packages. The equipment platform is designed to address WLP applications, with standard platforms to
automatically handle wafers up to 300mm and substrates up to 800x800mm. Using a step and repeat approach, similar to a UV stepper, the system can also compensate for substrate run-out. The system allows the patterning of traces to 2μm and vias down to 1μm, with alignment accuracies < +/- 1μm. System throughput is dependent on material type and desired ablation depth.

In addition, the same Excimer laser based system can also be utilized for other WLP applications including laser debonding for 3D TSV’s, RDL/UBM seed layer removal and for resist exposure. This makes it the perfect versatile tool for laser processing in packaging applications.

LASER ABULATION IN WLP APPLICATIONS

Laser ablation, by design, offers a significant potential for manufacturing cost reduction and is currently being investigated by the packaging industry for various applications including patterning of RDL trenches and vias in FOWLP and WLCSP, blind via drilling for 3D TSV and via drilling for PoP applications in EMC for FOWLP.

In 2010, at the IEEE (ESTC conference) hosted in Berlin, AMKOR announced the development of a Fan-Out WLP Technology based on laser ablation patterning, addressing lower cost patterning solutions. The technology used ABF (Ajinomoto build-up film) and laser ablation to generate the RDL interconnect pattern. ABF, which was developed for multi-layer substrate fabrication, allows direct laser drilling of micro vias and traces, where these are filled with Cu using electro-less or electroplating methods. The process flow is shown on the right. In a similar fashion to more standard fan out processes, chips are first attached face down to a laminating tape and compression molded into wafer form. At this point ABF or other EMC materials are laminated on the reconstructed wafer and vias are laser drilled. Thin film processing is used for interconnect and UBM before the solder balls are attached. The parts are then singulated. In this process, laser ablation is used to directly etch the RDL traces and pads to a specific depth in the dielectric material, followed up by the RDL vias down to the Cu or Au pads in two steps. In the first step, the trace/pad pattern is aligned to global or local alignment targets. Following alignment, the system ablates the trenches and pads to the desired depth within the material. Following this step, the laser is used to continue ablation of the vias down to the Cu or Al pads, stopping precisely on this metal layer without damaging the pad.
Ralph Zoberbier graduated in 2001 from the University of Applied Sciences in Nuremberg with a Dipl.-Ing. (FH) degree in Microsystems Engineering. He has started his career at SUSS in May 2001 as R&D engineer and took over the role as R&D project manager for the development of the 300mm mask aligner platform in 2003. In 2006 he earned a degree for Master of Business Administration (Entrepreneurship) from post-graduate studies at the University of Louisville, Kentucky. Since 2010 he works as Director Product Management Aligner within the Lithography Division of SUSS MicroTec.

Matt Souter graduated in 1992 from CSULB in California with a BS in Mechanical Engineering. He joined Tamarack Scientific in 2001 and has been active in the role of VP of Sales and Marketing for both the Laser Ablation and Photolithography product lines. Much of his focus as of late, has been in the research and development of alternative patterning techniques using Excimer laser ablation as a means to not only meet next generation Advanced Packaging requirements, but also address a means to lower manufacturing costs. Matt has recently authored an exciting new laser process for the removal of metal seed layers in lieu of standard processing approaches, addressing both technical limitations as well as a reduction in manufacturing costs. This process is currently patent pending. With the recent acquisition, he currently works as Global Sales Director and Laser System Product Manager for SUSS MicroTec.

**SUMMARY**

The requirement for more functionality and higher performance of electronic devices continues, while also under the continued pressure lower manufacturing costs. This trend will continue, requiring the adoption of innovative technologies in backend semiconductor packaging. Excimer laser ablation is the promising technology that will make and is already making its way into packaging applications to address these future requirements.

With the acquisition of Tamarack Scientific, SUSS MicroTec compliments its patterning technology with projection lithography and laser ablation competence. Laser ablation technology and toolsets are now available by SUSS MicroTec, which have been serving the semiconductor industry for over 60 years, with early adopters within the industry already using this technology in production.

SUSS MicroTec will continue to focus on this promising technology, working in close cooperation with research institutes and industry partners to further increase the application spectrum of laser ablation.