Laser Experts in Semiconductor Manufacturing

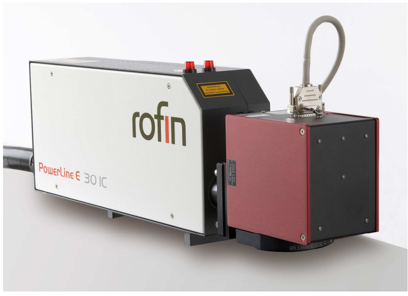
Backed by more than three decades of experience in laser material processing, ROFIN is one of the best established companies in this field. The company has supported the semiconductor industry from the very beginning of laser application and nowadays is a leader in laser marking and material processing in this field, particularly for complex and demanding tasks.

Laser Sources for Any Type of Application

Application fields for the laser in semiconductor manufacturing are manifold. From wafer marking and scribing to marking and singulation of finished chips to failure analysis. A wide choice of laser beam sources is very helpful to find optimum solutions for the variety of materials processed, like silicon, metals and polymers, in particular resins and mold compounds.

Robust Technology for Industrial Manufacturing

Today, diode pumped solid state lasers in fundamental (1064 nm), second and third harmonic wavelength are used for the majority of applications. ROFIN‘s end pumped PowerLine E IC series offers these wavelengths and features a resonator design, beam parameters and pulse lengths which have been optimized for semiconductor manufacturing. With air-cooled technology, they are especially easy to integrate and guarantee low operational costs.



ROFIN’s PowerLine E 30 IC

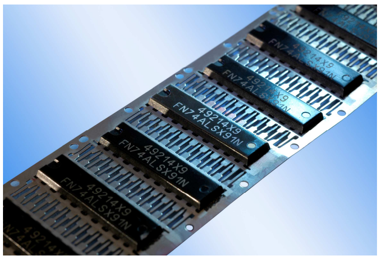
Due to highly specialized processes with in some cases extreme requirements, fiber lasers with comparatively long pulse lengths and low pulse peak powers only captured few applications so far.

Leading-edge Galvoscanner Technology

Besides the laser source the galvoscanner technology has the biggest impact on precision and performance of high-speed marking applications. When marking 1000 characters / second, the laser beam travels a distance of some 100 mm changing direction several thousand times within this period. As an electro-mechanical unit, the deflection head has to work reliably with extraordinary high speed and precision. For this reason ROFIN develops its scanner heads in close cooperation with specialized, leading manufacturers in Germany. To give an example, the new ASC (Auto Scan Control) technology compensates unavoidable position drifts of the deflection units and improves long term repeat accuracy to +/- 30 µm.

Marking with 1600 Characters / Second

Lasers mark all materials commonly used in semiconductor housings: silicon, metals, plastics and ceramics. Standard semiconductor components show a continuous fall in prices which rises the cost pressure on marking applications. One answer to that is further



laser marking of leadframes

production performance increase. Today, when marking plastic or metal semiconductor housings, maximum speed is what counts. Double-head marking systems from ROFIN achieve markings speed up to 1600 characters/second. Even at a character height of 0.2 mm and line widths of less than 30 µm they still ensure best readability. Precise laser control and high pulse frequencies allow high-contrast markings with controlled material penetration depths of less than 25 µm/1 mil.

Traceability of High-Power LEDs

LED technology is currently changing the way road traffic looks like. Besides their striking appearance in dimmed headlights and stoplights of upper class cars, LEDs have been silently displacing light bulbs in traffic lights for quite some time now. Advantages are striking: lower energy costs, longer lifetime and better visibility due to the abandonment of color filters. Even if no one cares about energy efficiency of his car lighting today, this will change due to battery-based hybrid or fully electrical car concepts.

No only the automotive industry asks for complete traceability of every single high-power LED today. Since recently, PowerLine 12 SHG IC lasers are marking the leadframes during the LED production process with miniscule 2D matrix codes, made up of spots which are just 43 µm small. ROFIN got the tender after an evaluation of all suitable laser manufacturers.

Soft and Hard Marking of Wafers

The marking of silicon wafers facilitates traceability of the manufacturing process for fault analysis of semiconductor devices. A laser system designed for wafer marking must meet the most stringent requirements. Thus, the marking must be machine-readable, miniaturized and have no negative influence on the further manufacturing steps and still permit clear identification at the end of the process chain.

With the deep marking method, which produces a durable marking even after a large number of etching and polishing steps, the dots have a depth of up to 90 micrometers and are created through material ablation. The debris-free marking, which is set for clean-room environments, can be as much as approximately 2.5 µm deep, which is achieved solely by melting of the silicon.

Flip-Chips and Micro Ball Grid Arrays

Highly integrated packages like Flip-Chips or Micro Ball Grid Arrays (µBGA) give a good example for the variety of applications for laser material processing and marking.

As the entire surface of the die is used for contacting via bumps, the packages shows its uncovered backside when mounted. Lasers, mostly frequency-doubled types like the PowerLine E 12 IC SHG, mark the wafer backside before singulation. On polished, grinded or coated wafers, they clearly mark a 16 character data matrix code on an area of just 0.7 x 0.7 mm or fonts with just 0.2 mm line height.

Wafer level bumping requires the forming of an under-bump-metallurgy (UBM) on the bonding pad that hat provides a seed layer on top of a diffusion barrier and adhesion layer. Solder-ball bumps are fixed on the UBM via laser-based, localized fusing or screen printing of soldering paste with laser-cut stencils.

Wafer Dicing

As wafer thicknesses decrease, laser-based dicing methods gain more and more advantages over mechanical methods. Contact-free laser scribing is more flexible and avoids chipped edges. Edge quality, which is crucial for breaking resistance, can be further improved by various automatized post-processing methods. This means less production wastage and lower overall costs. Recent studies suggest that multi-pass scribing without process gas provides better edge quality than one-pass scribing with coaxial process gas.

Separation of QFN Packages

Compact QFN (Quad Flat Pack No-leads) housings are currently gaining wide acceptance in semiconductor industry. But separation of the finished parts is a weak point in the production process so far. Sawing solder-plated copper lead frame QFN has been a challenge due to the need to cut a combination of soft and hard material. Chipping, burr, copper smearing and solder bridging are typical issues which reduce production output. Beyond that, sawing is comparatively slow and prone to wear.

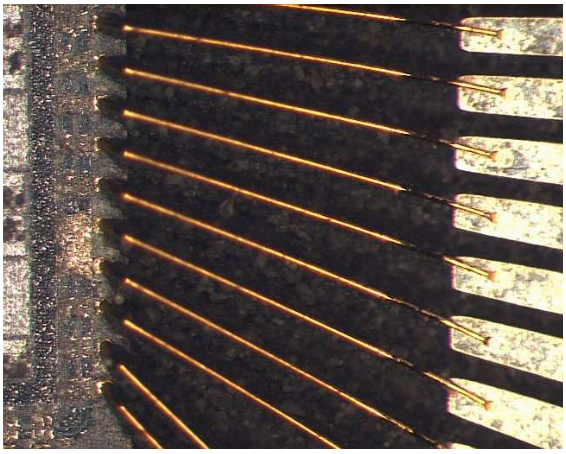
ROFIN‘s patent pending hybrid cutting technology uses the disc laser StarDisc, which is perfectly suited for this task, to cut the leadframe and prepare a perfect kerf for the saw blade to cut the mold compound. All problems mentioned above are safely eliminated and the production output is significantly higher. The process is twice as fast and saw blade lifetime is quintupled. A vision systems coordinates the whole process, it identifies the leadframe position and calculates the correct cutting paths. Integration of laser scribing and sawing process is easy.

Cutting of Multi Media Cards

New production methods for µSD- oder M2 cards entirely recast the leadframe instead of using separate housings. In this way production is cheaper and the cards are significantly more robust and humidity insensitive. Separation of the irregular shaped cards can be done with mechanical sawing, water jet cutting and laser cutting. Laser technology used for isolating of MMC cards is in particular beneficial as to environmental and cost aspects. Water jet cutting, commonly used for cutting compound plastic materials, requires substantial ecological efforts of purifiying cutting water which is polluted with abrasive particles. In addition, there are maintenance and repair cost caused by wear. In comparison, laser cutting with the StarDisc is three times more cost-effective at comparable performance.

Deflashing und Decapping

In both cases the laser selectively ablates mold compound, but the intention behind is entirely different. Excess encapsulation material on unmolded surfaces, can have serious negative impact on proper functioning. Mold flash between individual leads can be hazardous to safe contacting. Excess mold compound around heat sinks prevents accurate mounting for optimum thermal conduction. Laser deflashing systems use integrated pattern recognition to identify crucial areas and remove excess mold with a diode pumped solid state laser.



Decapping with the laser

Decapping is a precisely controlled laser process which ablates layers of the molding compound and reveals the inner structures for failure analysis. Compared to chemical cauterizing or other procedures, the laser allows selective ablation of certain areas and removing of the compound underneath the wiring.

Flexprint Cutting

Highly integrated, miniaturized consumer products like digital cameras, video cameras or mobile phones frequently include flexprint circuits made from polyimide. Flexible connections in most inkjet printers, which are continuously stressed, are made of polyimide as well. The absorption properties of this high performance polymer make UV lasers like the frequency tripled PowerLine E 30 THG IC the perfect tool for cutting.

Picosecond Lasers for Manufacturing LEDs and MEMs

Conventional solid state lasers utilize nanosecond pulses for locally controlled heat input which causes thermally induced material changes like melting or evaporation. One side effect is some heat-affected zone around the laser spot. In contrast, pulses in picosecond scale are short enough to avoid thermal diffusion of energy between electrons. Instead an avalanche ionization effect is produced which causes a nonlinear absorption with direct transition of material to the vapor or plasma. There is no heat transfer to surrounding material.

Today, picosecond laser technology is used for micro material processing of delicate materials, e.g. scribing and cutting of glass, sapphire or quartz. With kerf widths below 5 µm and material penetration depths of less than 10 nm laser sources like the X-LASE series from Corelase, a ROFIN company, are setting standards. Manufacturing of white high-power LEDs is among the new application fields, as gallium-nitride can only be produced on sapphire substrate so far. As picosecond lasers show very prospecting results on certain polymers, ceramics and other materials as well, this laser source finds more an more acceptance for laser cutting, drilling and structuring.

This review of laser applications in semiconductor manufacturing is by no means exhaustive but it should give an impression of the dynamics of this application area.

Contact

ROFIN-SINAR Laser GmbH

Gabriele Fischer, Management Semicon Industry / Europe

Dieselstr. 15

85232 Bergkirchen

Germany

Tel: +49 (0)8131 – 704 -0

Fax: +49 (0)8131 – 704 -4100

E-Mail: info@rofin.com