LIGHT UP YOUR WORLD

SOLAR POWER ■ LASER ■ ROFIN

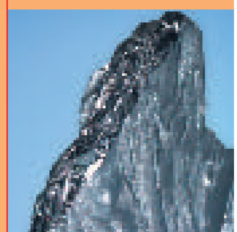
WE
THINK
LASER

FOCUS ON FINE SOLUTIONS

Solar Power

The future today

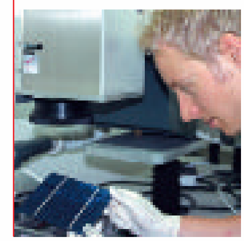
Silicon – the source of power



ROFIN / Baasel Lasertech – the headquarter for micro applications

Innovative solutions are the result of working closely with our clients

Competence in customized solutions



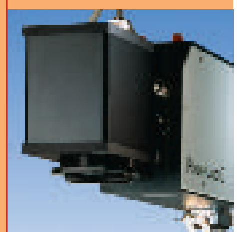
The future today

Driven by the shortage of fossil fuels and increasing environmental pollution, photovoltaics is significantly gaining importance in energy generation. Extensive government subsidies in great industrial nations have triggered its growth. Also, more and more producers of solar cells appear on the market investing into modern, large scale production plants. In order to reduce production costs per Wp, intensive efforts have been made to increase efficiency in fully-automated fabrication lines with high throughput.

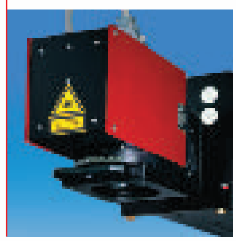
Independent of the solar cell concept, lasers have always been taken into account in the development of new production processes. In some cases, there is a strong competitive situation with one or two alternative technologies, but in many cases no other tool can compete with the speed and precision of the laser.

With a variety of CO_2, Nd:YAG, disc, diode and q-switch lasers, ROFIN provides the world's widest range of lasers for almost every application. With headquarters in Hamburg (Germany) and Plymouth/Detroit and 25 subsidiaries worldwide, ROFIN is always close to their customers – we are where you are.....

From IR to UV with high beam quality



Laser with galvo head for high flexibility



Disc laser for glass cutting

High power q-switched laser for highest ablation rates

Q-switched Disc Laser

The solution for high-speed processing

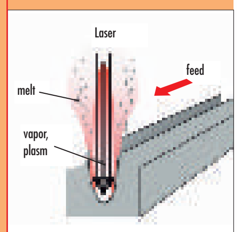
Laser concepts

The dominating sources used for PV-related processes are solid state lasers. This is due to the demand of simultaneously delivering high power, top beam quality, and maximum repetition rates, all of which are needed to realize high processing speeds together with high resolution.

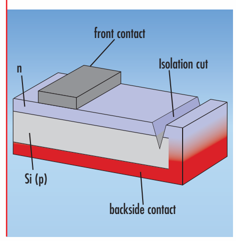
Regarding solid state lasers, there are four concepts competing with each other. Up to now, the laser equipment of research institutes as well as of solar cell producers mainly consists of diode-sidepumped and diode-endpumped solid state lasers, containing a neodymium-doped rod made of YAG or Vanadate. Recently, two other geometries of the laser active medium have been challenging the established concepts: fiber and disc. But none of them is capable of occupying the solar market alone. The diversity of various processes leads to the necessity to constantly develop tailored laser solutions.

Due to its exceptional material processing properties, especially the disc laser concept is gaining more and more acceptance in solar cell production. As a result of the comparatively low volume of the active laser medium, diode pumping takes place via a parabolic mirror, leading to a multi-pass reflection. The laser crystal is water-cooled from the rear side, causing only a one-dimensional temperature gradient. Therefore, compared to a rod, a disc laser offers significant higher beam quality or, in other words, much higher average power of best beam quality.

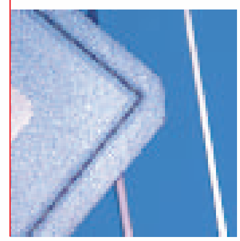
Laser engraving by vapor pressure-induced melt ejection



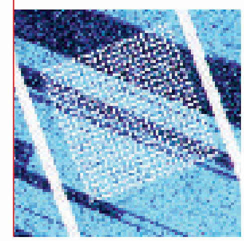
Edge isolation



Laser edge isolation — flexible and fast



Microglyph — most robust and highly flexible direct part marking



Laser Edge Isolation

Inline processing improves material flow

Laser applications on mono and polycrystalline solar cells

Ablation rates

Processing mono and polycrystalline silicon wafers with high intensity, nano-second laser pulses, absorption always takes place on the surface.The material is ablated by vapor pressure-induced melt ejection. One of the most decisive parameters for the ablation depth is pulse duration. Tests have shown that for power densities well above ablation threshold (typ. 10^8 W/cm^2) scribing depth is nearly a linear function of pulse duration.

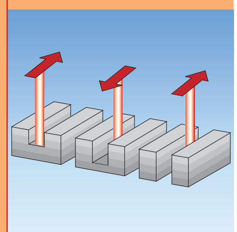
Edge isolation

The decisive factor for solar cell performance is the minimization of recombination possibilities. In order to obtain high efficiency, front and rear side must be electrically isolated on the edges. The separation of p-type layers is done by cutting trenches with qs-Nd:YAG or qs-Nd:Vanadate lasers. Compared to plasma etching, the productive advantages of laser scribing are better in-line processing and improved material flow. Apart from that, there is no need for costly etching gases and their disposal. High power density is necessary in order to effectively eject the melt out of the kerf and to avoid re-deposition of the molten material. Typical scribing speeds are in the range of 400 to 800 mm/s.

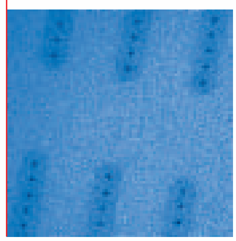
Marking

When it comes to encoding solar cells with the laser, demands on the marking result are high. Microglyph codes are innovative 2 dimensional codes. Other than any conventional matrix or barcode, the basic principle of this technology uses tiny, 45 degree diagonal lines (the micro-"glyphs") for encoding binary data on the solar cell surface without impairing its electrical conductivity. The encoding is fully readable in spite of the reflection properties of polycrystalline silicon.

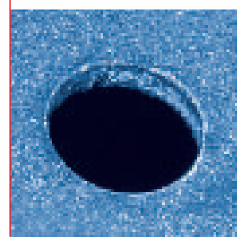
Multi-pass processing



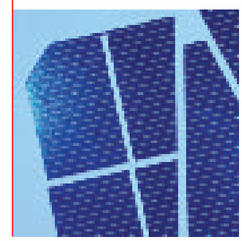
Percussion drilling – extremly high removal rates with processing speeds of up to 5000 holes / second

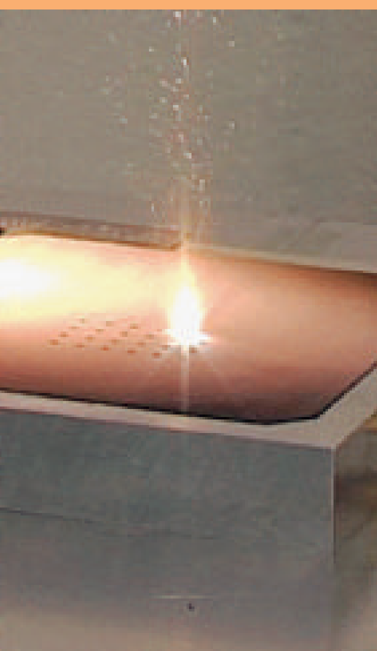


Whenever reverse contacting is needed, the laser drills the hole



The flexible way – cutting with the laser





Laser Drilling

Larger hole diameters require a relative movement between laser beam and wafer

Drilling of wafers

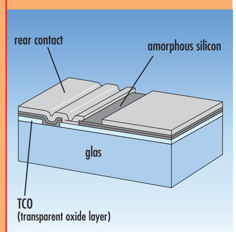
The efficiency of solar cells can be increased by eliminating the front side contact grids and bus bars, which would otherwise block quite a substantial amount of light. By means of EWT and MWT, electrical contacts of the front side are transferred to the reverse of the wafer. The realization of this process requires to drill holes of different sizes and numbers. Hole diameters from 30-100 µm are produced by percussion drilling. Larger hole diameters require a relative movement between laser beam and wafer (trepanning, cutting). Extremely high removal rates can be achieved with qs-disc lasers with very high TEM00-average power. These lasers realize processing speeds of up to 5000 holes/second for percussion drilling and up to 25 holes/second for trepanning.

Cutting of wafers

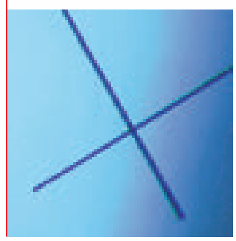
Fast cutting of mono and polycrystalline silicon wafers can be conducted with very high precision and low heat input by using the same ablation process as for edge isolation and drilling. In the past, flash-lamp pumped Nd:YAG lasers were used to melt cut silicon in a single pass with a coaxial gas jet. Due to rapid cooling of the melt layer at the cut edge, micro cracks were formed. New approaches indicate that a multi-pass cutting process without assist gas gives a better surface quality at the edge. With a qs-disc laser, users can expect typical cutting speeds of up to 150 mm/s for a wafer thickness of 0.2 mm.

With wafer thicknesses above 400 µm and in production areas with a low degree of automation, silicon wafers are not cut completely, but scribed to a depth of 30-50% of the cross section. To separate the wafer, a subsequent snapping, either manual or fully-automated, is required. Typical scribing speeds are in the range of 50-300 mm/s.

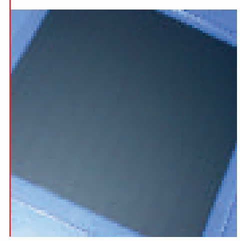
Structure of a thin film cell

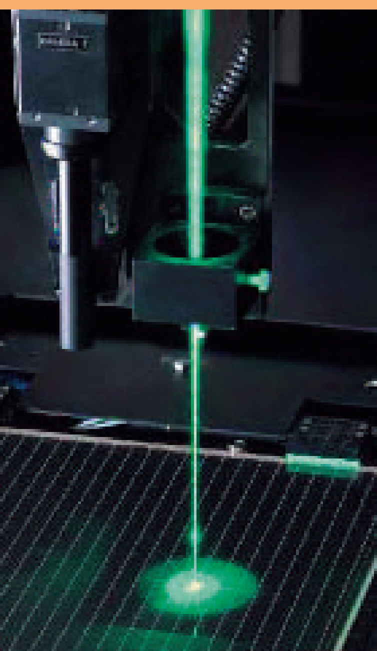


Thin film scribing –
flexible and fast



Edge deletion





Selective Ablation

Thin film ablation at
research center Jülich

Laser applications on thin film solar cells

Selective ablation

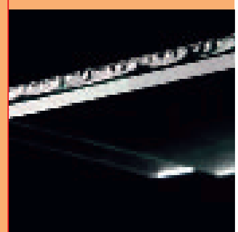
Thin film solar cells are produced through a sequence of vapor deposition and scribing processes. The integrated circuits are generated between the different deposition steps by selective ablation of single layers to achieve electrical isolation. Best beam quality lasers (TEM00) with very high repetition rates of up to 200 kHz are used to ablate 20-50 µm wide lines at scribing speeds of up to 2000 mm/s, without damaging the glass substrate or layers underneath. Thus, Nd:Vanadate lasers with short ns-pulse duration (up to 100 ns) are the standard laser type for this kind of application. The optimum wavelength for the various processes depends on the type of layer. Fundamental (1064nm) and second-harmonic (532nm) wavelength are commonly used in the production of a-Si, CIS and CdS/CdTe solar cells.

Edge deletion

For electrical isolation and hermetic sealing of the module, the complete removal of all layers from the edges of fully processed thin film solar cells on glass substrates is required. In order to meet production requirements, removal rates have to be in the range of 10-20 cm^2/s. Here, the laser challenges conventional techniques, like sand blasting and grinding.

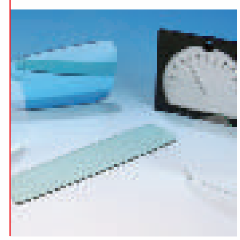
Since standard TEM00-lasers (like Nd:Vanadate lasers used for scribing) do not provide sufficient ablation rates for this application, especially developed high-power qs-lasers are applied. Those diode-pumped Nd:YAG lasers generate an average power of up to 850 Watt at 30 kHz which is guided through a 600µm step-index fiber, in order to produce a homogenous, flat-top intensity profile. Typical ablation widths are between 0.7 and 1.5 mm at processing speeds of up to 4000 mm/s.

Two methods in comparison: the upper glass with a rough edge and micro cracks, was scribed and broken. The lower was laser cut and has a smooth and crackfree edge



Even double layers can be cut. After lamination the laser provides perfect quality

Both straight and curved cuts are possible – the range of applications is wide



Glass Cutting

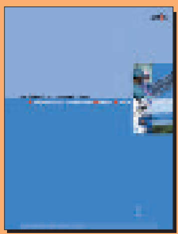
Contact-free seperating of glass in a single pass

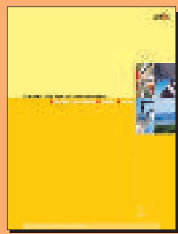
Glass cutting

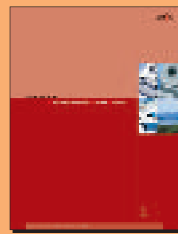
Flat glass is predominantly cut by scribing and breaking. However, this process produces splinters of glass fragments and micro-cracks along the separation line, which reduce the bending strength of glass substrates significantly.

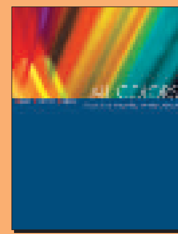
The patented MLBA process is based on the volume absorption through multiple reflection of laser radiation in the glass, using diode-pumped cw-YAG-lasers at the fundamental wavelength. By heating the glass using laser radiation, a defined tension profile can be induced in the glass. On the basis of a starting crack, the glass is separated by guiding the crack through product. This non-contact procedure produces premium quality edges, which provides increased firmness of the product. This procedure is applicable for coated glass, too, and several glasses can be separated in one processing step, without breaking. Thus, MLBA offers a worldwide singular advantage.

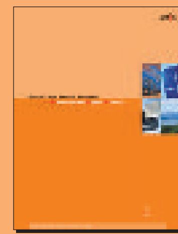
rofin


Medical Device Technology


Flexible Packaging


Deposit Welding


Polymer Welding


Solar Power

SOLUTIONS FROM A SINGLE SOURCE

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