Laser Scribing Thin Film Molybdenum for Photovoltaic cells

Summary
The use of photovoltaic (PV) cells that harness the power of the sun to produce electricity is growing very rapidly. Although the majority of the production currently uses silicon in the range of 0.2-0.4 mm thick, there is a rapid rise in the number of manufacturers of thin film solar cells. Of the major types of thin film solar cells, one of the most widely exploited to date is based on a CIGS (Copper Indium Gallium diSelenide) active layer. These cells typically use a thin layer of molybdenum as a back contact layer deposited directly onto the glass. Laser scribing or 'cutting' of this layer for electrical isolation, known as a P1 scribe, is a very important early step in the manufacture of these cells. Fiber lasers have proven to be well suited to this application.

Introduction
The rising cost of oil, awareness of global warming and an increasing awareness of the real costs of fossil fuel usage (carbon footprint) has led to growing acceptance of PV technology. Many countries and many US states are now providing financial incentives to stimulate solar energy adoption. This has accelerated technical improvements in PV cells and industrial lasers are playing an important role in many of these. This in turn has led to increased sales and increasing competition, as a consequence manufacturing costs are becoming critical.

CIGS thin film PV cells
A number of companies are already offering CIGS PV products and many more are developing the technology.

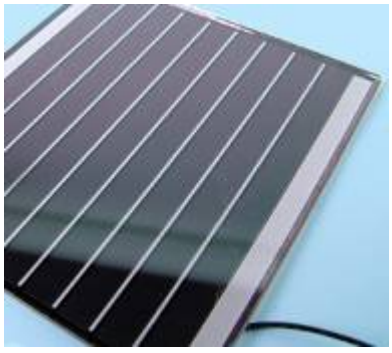

Figure 1: Thin Film Solar Cell module

They have the advantage of being efficient in converting solar energy and relatively easy to manufacture using an automated process. All manufacturers currently use a very thin (<1um) sputter deposited layer of molybdenum as the back contact layer. This highly reflective layer requires excellent adhesion to the substrate, usually glass.

Laser processing for thin film PV technology
Typically, diode pumped Vanadate lasers have been used for this process. The laser system deployed (typically less than 20W) will suffer from the standard physics-based limitations of rod or disc lasers which can lead to time-based fluctuations in output power, focal position and beam quality.

In many industries, the ongoing maintenance costs of lasers can be expensive. Fiber lasers on the other hand offer a low cost of ownership.

Laser processing details
There are a number of issues with the laser processing of these films:

1) If pulse energy or heat input per unit length is too high then lifting of the edge of the film occurs causing problems when the next coat is deposited.
2) The combination of peak power, pulse energy and repetition rate of the DM MOPA fiber laser allow use of higher repetition rates. At >125 kHz and for a fixed scanning speed smaller edge corrugations are produced on the film.
3) As molybdenum is a high melting point refractory metal, it is difficult to deposit this film without some residual stresses. A poorly controlled laser process can therefore lead to cracking of the film. As this is a thermal process, some minor cracking is inevitable and hence the objective of laser process optimisation is to minimise this to achieve "fit for purpose". The point of intersection of the overlapping spots is usually the origin of this thermally induced cracking. These cracks may propagate into the film or into the glass. Both of these can be minimised

using the additional level of parameter control available from the DM MOPA laser.

Results:
Clean scribing of Molybdenum thin-film on glass can be achieved using the SPI 20W Fiber Laser. Line widths of 50µm required for this application are easily achieved with fiber lasers.

SPI's directly modulated MOPA fiber laser, figure 2, has produced excellent results when employed to ablate these molybdenum layers at high speed, figures 3 & 4.

Due to the direct modulation of the seed diodes, these lasers are able to maintain 20W average power up to 500 kHz. This repetition rate is far above that of any other comparable laser leading to much faster scanning speeds. These speeds are in excess of those currently used, due to the speed limitations of current direct drive motion systems. The benefit of this is that a lower power more cost effective laser pulsing at a higher repetition rate can be employed.

Figure 2: Pulsed MOPA laser

Set-up:
Laser: SPI 20 W Fiber
Scanlabs Hurryscan 2 scan head
Focal length: 163 mm, 6.2 mm beam diameter

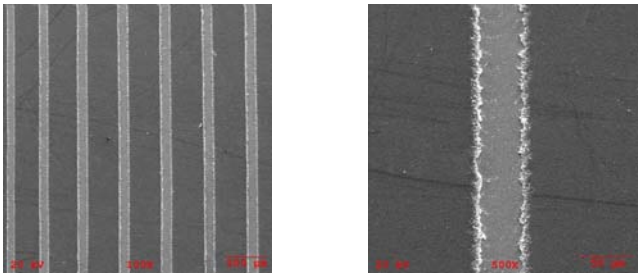

Figure 3 & 4: Fiber Laser Scribing of Mo on glass at 250 kHz WF3, 4m/s

Process Advantages of Fiber Lasers
The advantages of such a system are as follows:

- The laser gives fiber delivery via a small BDO (beam delivery optic) that can readily be configured to give appropriate beam diameters into the focussing optics of the head.
- SPI's PulseTune waveforms allow greater parametric control and optimisation of the processing parameters.
- Low maintenance requirements and high system uptimes particularly in 24/7 operations.
- Fiber delivery allows the laser to be totally isolated from vibration and particulate contamination
- The lack of optical parts ensures no alignment drift with time or due to vibration.

Conclusions:
PV technology is developing rapidly and the timely arrival of pulsed fiber lasers is now able assist in reducing costs of PV manufacturing.

The high repetition rate capability of directly modulated MOPA fiber lasers allows ablation of thin molybdenum films at increased processing speeds up to 4 m/s depending on film thickness.

For further information & to register for your FREE 30-day SPI Fiber laser evaluation unit, go to www.spilasers.com

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