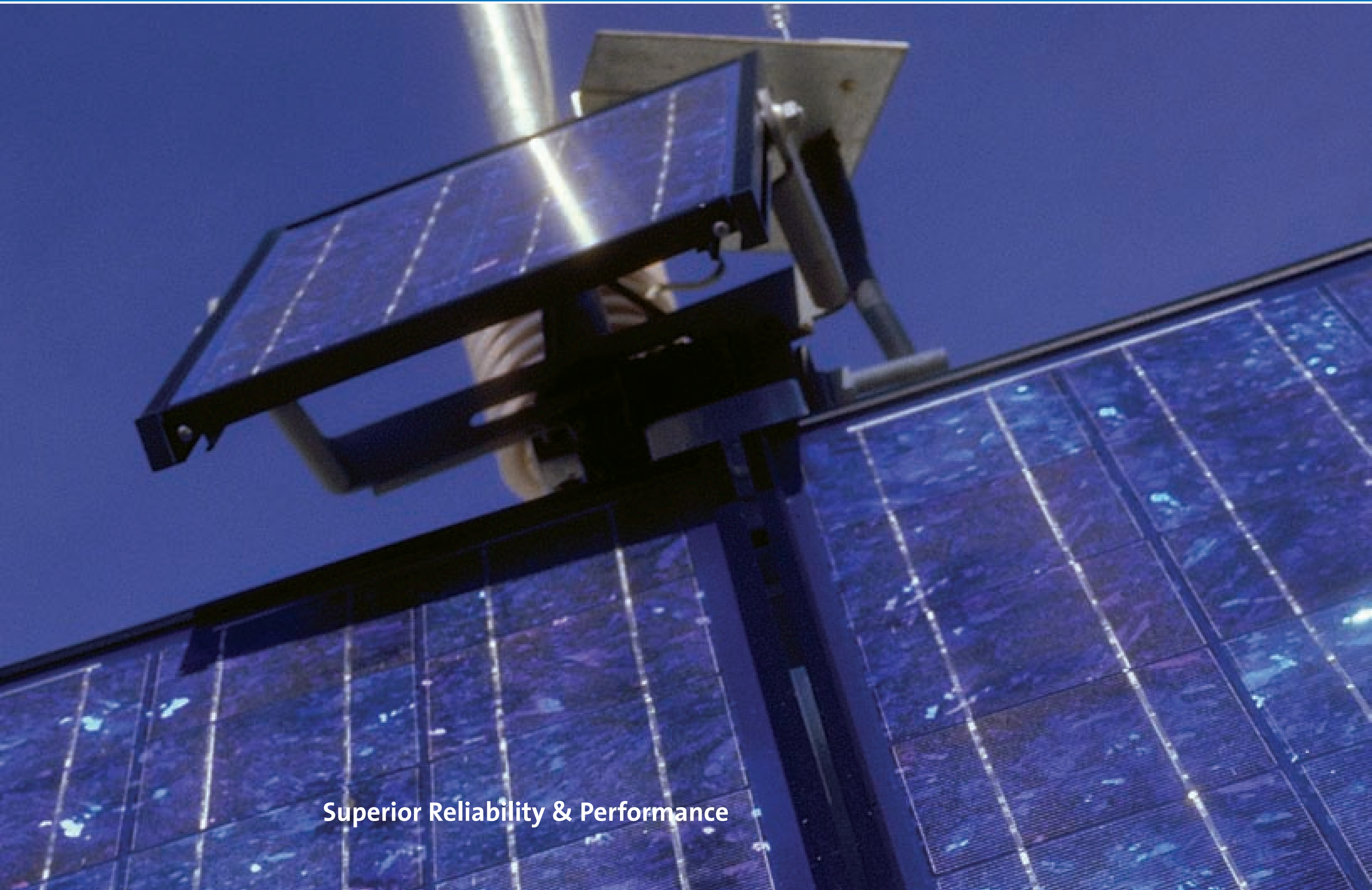
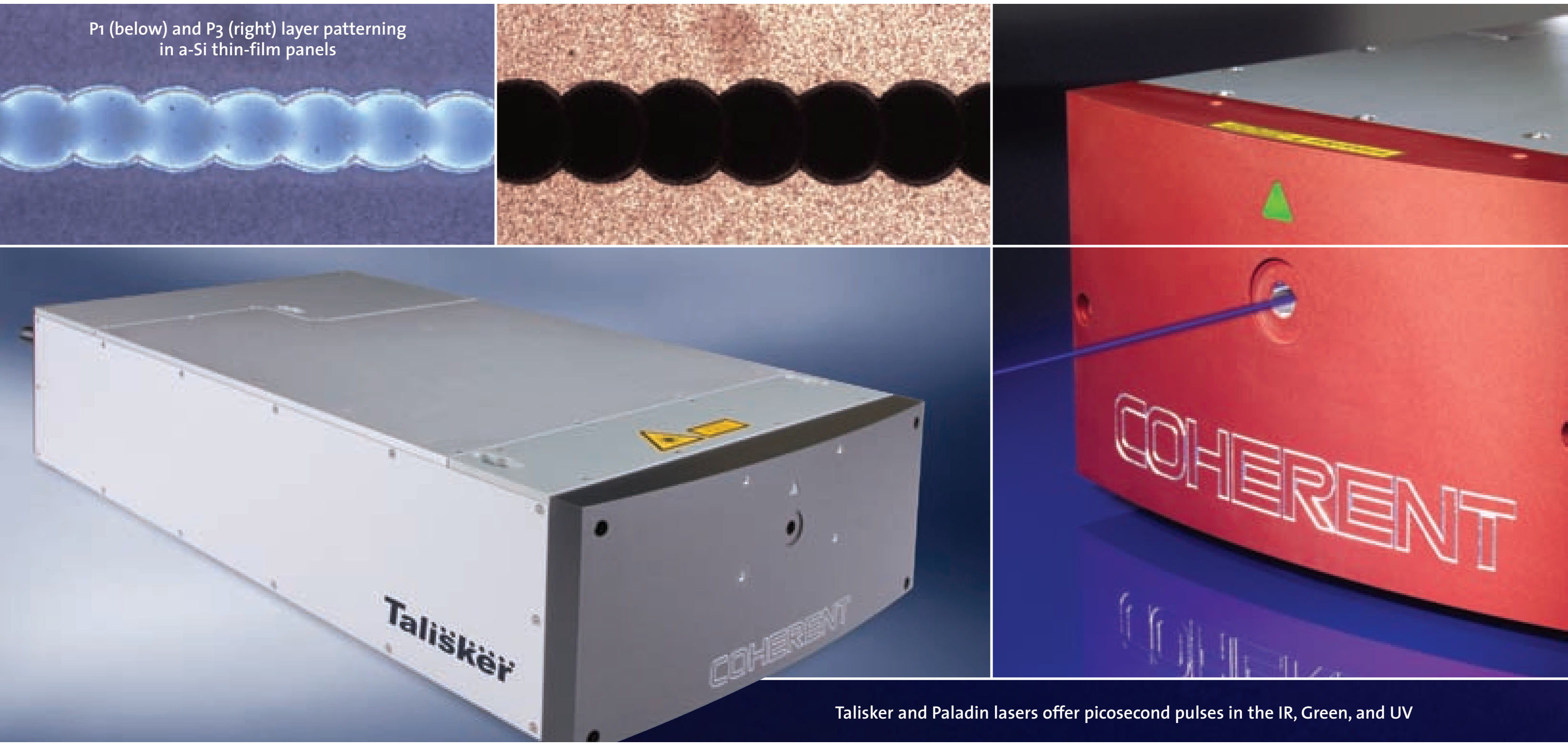
COHERENT®

Lasers in Solar Manufacturing

The Cutting-Edge of Green Solar Panel Production





P1 (below) and P3 (right) layer patterning in a-Si thin-film panels

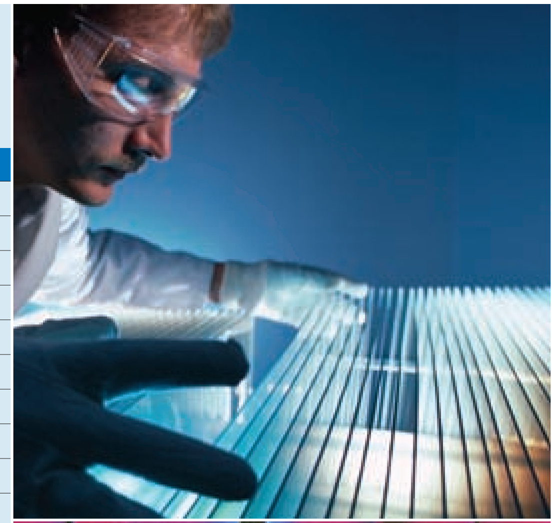
Talisker and Paladin lasers offer picosecond pulses in the IR, Green, and UV

Key Requirements of a Laser Supplier for Solar Manufacturing

- Optimized laser sources for solar cell & panel manufacturing
- Turn-key diode-pumped solid-state lasers
- Industrial qualified from semiconductor & flat-panel industry heritage
- Worldwide service & support network
- Range of wavelengths from IR to UV for different material absorptions
- High peak powers for scribing, ablating, & melting applications
- High average powers for high production throughput
- High quality beam parameters for narrow lines & feature sizes
- Optimized models for all c-Si & thin-film applications
- Enabling novel cell concepts in R&D and pilot-lines

Coherent Lasers in Solar Cell Applications

	AVIA	LAMBDA SX	Talisker	Paladin	PRISMA	FAP System	MATRIX
Crystalline-Silicon							
Edge Isolation	•						
Laser Grooved Buried Contacts	•						
Texturing	•	•	•				
Selective Ablation	•		•				
Wrap-Through	•		•				
Dopant Diffusion				•			
Laser Fired Contacts					•		
Interconnection						•	
Thin Film							
a:Si Patterning	•				•		•
CIGS Pattering			•		•		•
CdTe Patterning					•		•



Laser edge isolation of c-Si cell

Solar Cell Applications

- c-Si Edge Isolation
- c-Si Laser Fired Contacts
- c-Si Wafer Marking
- c-Si Laser Grooved Buried Contacts
- c-Si Selective Dielectric Removal
- c-Si Laser Doping
- c-Si Wrap-Through
- c-Si Texturing
- c-Si Singulation
- a-Si & a-Si/mc-Si Patterning
- CIGS Patterning
- CdTe Patterning
- Border Deletion
- Glass Cutting

Lasers as a solution to decreasing manufacturing costs and increasing product efficiency

As in most manufacturing processes, controlling the production costs is the first step toward profitability. Although investments in research and development remain critical, in the solar energy business, how to make the product is less of a concern than how to make them quickly in volume production at low cost and with a higher degree of efficiency.

As the efficiency of each cell produced increases, and the cost of producing these cells decreases, the closer solar energy comes to matching the cost of existing energy sources. At that point – when a kilowatt of solar power costs the same or less than traditional energy sources – the challenge will be how quickly the solar industry can grow rather than how successful it is projected to be.

With this "grid parity" condition being the initial goal of the solar industry, lasers are already one of the most important components in reaching that level.

Coherent lasers in solar manufacturing processes

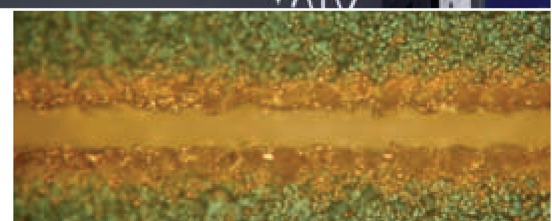
Coherent lasers form an integral part of the solar industry's roadmap today. Here, they increase the yield (or throughput) levels, improve the efficiency of solar cells, allow non-contact processing on larger and thinner wafers, and enable the implementation of low cost-of-ownership production line equipment.

There are two competing types of solar cells produced today in high volume – silicon wafers and thin-film substrates.

In both silicon wafer manufacturing – whose end products are crystalline-silicon (c-Si) solar cells – or in the production of thin-film solar panels incorporating materials such as amorphous silicon (a-Si), cadmium telluride, or copper indium gallium selenide, Coherent lasers create precise and repeatable pulses of energy to scribe, ablate or melt specific material-groups used in the different manufacturing processes.

AVIA and MATRIX lasers offer nanosecond pulses in the IR, Green, and UV

c-Si edge isolation method



Laser grooved buried contact on a c-Si cell

By performing the necessary material removal or scribing of surfaces by a non-contact method, lasers produce the highest efficiencies in the individual cells, while also reducing micro-cracking, and increasing the overall cell efficiencies. Coherent lasers also produce results more quickly than any other technology, as well as faster and more efficiently than any other type or brand of laser.

Crystalline-silicon (c-Si) cell manufacturing

In the crystalline-silicon cell production method, thin silicon wafers are transformed into functional solar cells.

Coherent's pulsed diode-pumped solid-state lasers, operating in the infrared, green or ultraviolet spectral regions, are routinely integrated within the most efficient and productive tools to enable novel high-efficiency concepts to be realized. This includes a range of front and rear surface processes, in addition to through via hole drilling.

How our AVIA lasers eliminate the doping "pathways" problem

Within each solar cell the p-n junction that creates the electrical current requires that the front of the positive-conducting boron-doped silicon wafer be exposed to a phosphorous gas in order to dope an n-type conducting film on the top surface of the cell. However, this doping process has a detrimental effect on the cell performance; it coats not only the front surface of the wafer, but the sides, as well. This side coating creates a shunt path between the front and rear surfaces, which prevents the cell from operating efficiently.

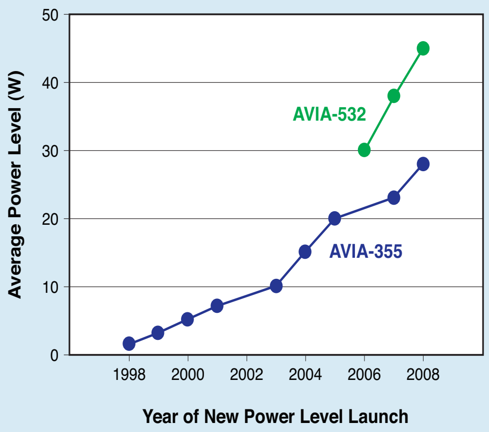
To fix this problem, our AVIA lasers – operating in the green or ultraviolet wavelength regions at 532 nm or 355 nm – scribe a continuous groove completely through the n-type layer of the p-n junction and around the entire perimeter of the front surface. This scribed groove isolates the front and the back surfaces of the cell, eliminating the shunt path and increasing cell efficiency.

By using a laser, this non-contact process is faster and cleaner than other methods which involve hazardous chemicals and waste produce.

The high power – up to 38W – of our AVIA lasers allow processing of greater than 3,000 wafers per hour. Due to the strong absorption of silicon in the visible and ultraviolet spectral regions, the short-wavelength output from AVIA lasers reduce any micro-cracking within the silicon wafer: a problem often reported with lasers which operate in the infrared. High power and short wavelength output of AVIA lasers combine to allow both faster production line capacities and higher material yields.

Thin-film solar panel manufacturing

In the thin-film solar manufacturing process, our nanosecond diode-pumped solid-state lasers are used typically at the cell isolation and interconnection stage, commonly referred to as "patterning". This is a 3-step process in which our lasers perform material removal after each layer deposition stage.



Solar Industry roadmap trends for crystalline-silicon production

	Current 'Typical'	5-Year Trends
Cell Efficiency	14 to 18%	Increase by 2 to 3%
Wafer Size	125 or 156 mm	Move to 210 mm
Wafer Thickness	~220 µm	Transition to sub-200 µm
'Green' Production Equipment	Varies per production line	Cleaner production tools
Yield Levels	85 to 90%	Increase to >95%

Thin-film patterning process on a-Si panels

In the case of amorphous silicon panels, the first patterning stage (P1) involves material ablation of the front-contact transparent conducting oxide (TCO) layer. Here, an infrared laser operating at 1064 nm provides an ideal match in terms of output power, repetition rate and material absorption. Next, in the P2 step, a laser emitting in the green region at 532 nm creates a pattern on the amorphous silicon absorber layer. Lastly, following the same process as used at the P2 stage, a 532 nm laser is again used to pattern the back-contact layer of the cell – the P3 stage.

PRISMA diode-pumped solid-state lasers are ideal for thin-film panel production because they provide excellent pulse-to-pulse stability, accurate beam positioning on the panels, and a combination of short pulse-width and high repetition rates greater than 100 kilohertz. These unique characteristics of our high-performance infrared and green lasers combine to produce the demanding performance required in large solar panel manufacturing.

Future growth and increasing benefits of using lasers in the manufacture of solar cells and panels

The use of lasers in the growing solar manufacturing market will become more important as we move into the future.

With thinner wafers below 200 microns in thickness being implemented over the next few years, new demands are being placed on the type of equipment used within the manufacturing process. At the same time, there is a requirement to increase production yield levels to microelectronics industry standards. To address these roadmap objectives, the "non-contact" nature of laser systems allows processing on brittle wafers while minimizing breakage rates associated with more traditional technology types.

In addition, solar cell manufacturers are increasingly under pressure to utilize production equipment which itself provides very low 'global warming potential'. Here, an ideal - or 'green' - manufacturing process uses laser equipment to minimize both water consumption and hazardous chemical waste. Coherent's diode-pumped solid-state lasers are ideal equipment types, with turn-key operation, single-phase electrical input, and very long component lifetimes.

Through availability of industry-qualified diode-pumped solid-state lasers operating at high power from the infrared to ultraviolet spectral regions, and with the choice of both nanosecond and picosecond pulse-width operation, Coherent's lasers are poised to play an increasingly important role with solar manufacturing worldwide. Benefiting from our lasers' alignment historically within complementary semiconductor and displays technology roadmaps, and utilizing our existing worldwide service and support network, Coherent is uniquely placed to drive high laser adoption with key technical benefits for the solar industry.

Coherent as your partner.
To compete and succeed in today's fast-paced research and manufacturing environments, you need a laser partner who understands your needs. A partner who can provide a wide range of technology solutions, and the support that goes with them.

Since 1966, Coherent has been helping customers by providing complete laser-based solutions for a wide range of commercial and scientific applications.

With a heritage of innovation and an uncompromising position on quality, Coherent is the most forward-thinking and diversified manufacturer of solid-state, gas, excimer and semiconductor lasers in the industry.

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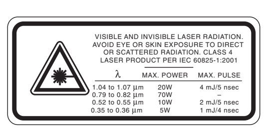
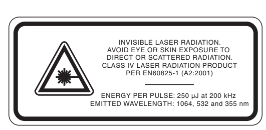
Coherent's scientific and industrial lasers are certified to comply with the Federal Regulations (21 CFR Subchapter J) as administered by the Center for Devices and Radiological Health on all systems ordered for shipment after August 2, 1976.





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Printed in the U.S.A. MC-037-08-0M1008