Thin Film Solar Panel Laser Scribing System

Production Machine Design Concept
Laser Scribing System

Structure and Concept – Highest Efficiency Finished panel

- Granite Structure
- Split Axis XY Design
  -Eliminates Table Cantilever
  -No weight stack-up
  -Each stage rides on stable granite base
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Granite Structure

- Superior flatness and stability
- Flat to within 0.001 inch (25 microns) over entire surface.
- Cross axis flat to within 0.001 inch and parallel to base within 0.001 inch.
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- Granite sized to fully support stages.
- Thickness determined by weight load.
- Feet sized for floor load.
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Granite versus Steel Structure

- Lower co-efficient of thermal expansion.
- Lower thermal conductivity.
- Higher damping co-efficient.
- Higher inherent dimensional stability.
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Linear Motors

- Superior acceleration and velocity; lower vibration.
- Contactless motor and encoder technology (no wear points).
- Motors sized for mass, desired acceleration and maximum velocity.

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Linear Motors

- Bearing rails, encoder, hydraulic crash stops and motor magnets mounted on granite base.

- Motor stator and bearings mounted on bottom of vacuum chuck.

- Motors are air-cooled.
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Panel travels on X-axis

- Pitch and Yaw determine straightness and travel flatness - critical parameters – measured with in-house laser interferometer.
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X-axis Characteristics

- Acceleration and velocity important. Determined by size of motor selected – Velocity to 80 cm/sec
- Accuracy important for placement of isolation scribe.
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Lasers / Beam Delivery Optics Travel on Y-Axis

- Pitch and Yaw critical.
- Accuracy critical.
- Velocity and acceleration less important.
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Multiple Systems Integration

- Interferometer stage matching insures precise placement of three scribe lines.
- System design insures highest possible finished panel efficiency.
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Vacuum Chuck Design

- Cast, ground and stress relieved aluminum tool and jig plate structure flat to within +/- 0.005 inch.
- Teflon coated surface – minimal contact area.
- Integral vacuum hold down and debris scavenge.
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Vacuum Chuck Design

- Three point panel alignment system for manual loading.
- Extends fully from under bridge for accurate automated loading. Panels loaded within 0.005 inch.
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Panel Loading System

- Feed conveyor locates panel in two axes.
- Loader places within 0.005 inch.
- Loader contacts panel at edges and bottom, uncoated side.
- Dual mechanism loader for faster load / unload.
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Factors that affect panel efficiency

- Accuracy of panel placement.
- X-axis pitch and yaw.
- Y-axis accuracy, pitch and yaw.
- Vacuum chuck flatness.
- Laser / optics spot size and depth of field
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PC Control

- Velocity & Feedback control loop
- Windows Environment
- U.S. Laser software front end – Friendly Motion ANSI compatible CNC control package.
- Control of laser, shutters, vacuum and loader.
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Typical Vanadate Laser

- 17 watt 1064 nm power @ 50 kHz
- 11 watt 532 nm power @ 50 kHz
- 15 nsec pulse width
- Fiber & Other lasers are available
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- Nd:YVO$_4$ (Vanadate) Laser
- Capable of rep rates to >100 kHz
- Supports scribing speeds to 60 cm per second with 50 micron spot and 80% spot overlap at 60kHz.
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Beam Delivery Optics

- Series of 50/50 beam splitters and dichroic optics to delivery four equal power beams.
- Variable power attenuators to balance power and provide stable operation over entire output power range.
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Beam Delivery Optics

- Four individually controllable beam dump / gating shutter.
- Apochromat objective lens provides superior reduction of spherical aberrations and color correction for superior CCTV image.
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Beam Delivery Optics

- Easily replaceable lens protector.
- Combination gas assist / vacuum scavenge nozzle for debris collection and to protect optics.
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Beam Delivery Optics

- CCTV viewing co-axial and par-focal with first laser beam delivery module.
- Power meter accessible by all beam delivery modules.
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System Throughput

- Isolation Scribe
  - One beam module makes four scribes including across full width of panel
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Typical System Throughput

- Panel scribe time approximately 60 seconds.
- Isolation scribe time approximately 20 seconds.
- Panel load / unload approximately 5 seconds.
- Total <90 seconds.
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Service and Support

- Designed for years of maintenance free use.
- No consumable items except lens protectors.
- Periodic lubrication of bearings (>10,000 hours).

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