Who is LIA?

Founded not long after the laser was invented in 1968, LIA, as the Laser Institute of America, has been the number one source of quality Content, Standards, Training, and Membership worldwide with regard to Laser Safety.
LIA’s future as the Institute for Photonic Materials Processing Innovation is a result of our geographic reach and expanded focus to all applications of Light-Based material interaction.
LIA serves our membership by acting as a bridge to:

- Advanced materials processing (nanomanufacturing)
- Medical sciences applications
- Semiconductor and electronics
- Laser safety incorporated into a manufacturing process
- System integrator implementation of Industry 4.0
### List of ANSI Z136 Standards

LIA is the Secretariat to the Accredited Standards Committee (ASC) Z136 whose volunteers develop and maintain the Z136 series of laser safety standards. To further our mission, we also publish this series of ANSI-approved standards.

<table>
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<th>ANSI Standard</th>
<th>Latest Publication Date</th>
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<tr>
<td>ANSI Z136.8, <em>for Safe Use of Lasers in Research, Development, or Testing</em></td>
<td>2012</td>
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<tr>
<td>ANSI Z136.9, <em>for Safe Use of Lasers in Manufacturing Environments</em></td>
<td>2013</td>
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<td>In development, Z136.10, which will pertain to safe use of lasers in entertainment</td>
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Industrial Laser Market Overview

2017 Was a Standout Year for Lasers ($12.5B Total)

- +19.5% Total Laser Revenue 2016 to 2017
- +48.6% Revenue KW Material Processing
- +23.5% Revenue Micro Material Processing (OLED Annealing)
- +43.8% Revenue Displays (Cinema, TV & Projection)
- +30.4% Sensors (Smartphone Sensors)
- +18.1% Communications (But now headed DOWN)
- +10.1% Medical (Especially Aesthetics)
Laser Advantages

- Wide array of available parameters across the spectrum of light ensures that there is a laser for every application
  - Output power up to kW
  - Wavelengths from Infrared (IR) to Ultra Violet (UV)
  - Pulse lengths from fs to cw
  - Repetition rates from 1 to 100 MHz
- Increased precision and intricacy over other manufacturing methods
- Autonomous programing allows for high levels of productivity increasing production and reducing costs
- No physical contact with workpiece
- New lasers constantly being developed
Laser Characteristics: Power Levels

- **0.005 watts** = Laser pointer
- **5 - 100 watts** = Typical Power level for Marking and Micromachining
- **100 - 1,000 watts** = Typical Powers for most machining applications including welding
- **1,000 – 10,000 watts** = High power applications like heavy steel cutting, welding and cladding
- **100,000 Watts** = Current highest available power
- **1,000,000 Watts** = Directed Energy for strategic targets (ballistic missiles)
Laser Characteristics: Wavelength

Short Wavelength: UV Lasers

- Short (λ) wavelength light: <400 nm
- Short Pulse Duration: <100 ns
- High Peak Power (Pulse Energy per Pulse Duration): >1 kW
- Photon/Material Interaction within shallow absorption depth
- Small feature sizes – High Intricacy
- Clean or “Cold” Ablation - UV bond breaking, rather than thermal material removal
Laser Characteristics: Wavelength

Long Wavelength: IR Lasers

- Long (λ) wavelength light: >1 μm
- Long Pulse Duration: > μs
- High Powers commercially available (kW)
- Photon/Material Interaction with high absorption depth
- Large feature sizes – Lower Intricacy
- Thermal material removal, joining, and deposition
Laser Characteristics: Pulse Length

Long Pulse [ns]
- Heating of material
- Melting
- Interaction with plasma
- Absorption strongly wavelength dependent

Ultra Short Pulse [ps/fs]
- Hardly any heating of material
- Ionization and sublimation
  - (direct change from solid to gas)
- Pulse and plasma separated in time
- Non linear absorption – also in transparent materials
Carbon Dioxide (CO₂) Lasers

- Most common laser in industry
- Inexpensive ($/photon)
- Wide range of power output
- Emission wavelength of 9.4 - 11.0 μm (infrared)
- High penetration depth (10 – 100 μm or more)
- Inert gas used to limit oxidation in process area
- Flexibility allows for multiple manufacturing applications
Solid State Nd\textsuperscript{3+} Lasers

- Very common laser in industry
- Fairly Inexpensive ($/photon)
- Wide range of power output
- Fundamental Emission frequency of 1.064 \(\mu\text{m}\) (infrared) Can be frequency shifted to 532 nm, 355 nm and 266 nm
- High penetration depth (10 – 100 \(\mu\text{m}\) or more)
- Fundamental Wavelength still used for majority of welding applications, although fiber lasers have surpassed for cutting
Fiber Lasers

- Incredibly long lifetime
- Highly reliable
- Reduced maintenance
- Low cost of ownership and operation
- Outstanding beam quality
- No thermal lensing
- Dominant in metal cutting
- Gaining market share in welding
Laser Cutting
Laser Welding
Laser Cleaning

Photos courtesy of TRUMPF Inc.
Laser Additive / 3D Printing
Microvia Drilling for Electronic Packaging

Laser beam shaping and thermal modeling for better microvias to enable high density packaging and high speed interconnects

Gaussian beam with diffraction ring: Bad for microvias in nanoelectronics

Pitchfork beam: Good for microvias in nanoelectronics

Comparison between the beam shaping calculation and experimental pitchfork profile

Top view of a microvia showing the embedded copper layer

The thermal model results for microvia profile compares well with the experimental profile
High Pressure Laser Implantation

High pressure laser doping direct write

Emitting primarily green and UV
For wide area processing

Photos courtesy of Applicate Associates, LLC
Direct Write

High Pressure Laser Implantation

Fractal antennas on and in insulators (glass) and silicon carbide (semiconductors).

Typical process parameters 532 nm, 25-50 cm/s, 6000 kHz beam diameter 20 um and less.

Photos courtesy of Applicote Associates, LLC
Conclusion

• Advancements in laser technology are changing the landscape of what is possible during the manufacturing process
• Lasers are no longer only considered a Research and Development technology, but an extremely effective and efficient tool useable across many manufacturing applications
How can you get involved?

• Sign up at lia.org to receive our Bi-Monthly Newsletter LIA TODAY
• Become an Individual or Corporate Member of LIA
• Start down your career path as a Laser Safety Officer by taking one of our many specialized courses
• Make sure your facility is up to date and within compliance by having a copy of the appropriate Z136 Standards on hand
• Attend one of our conferences to learn and network with the industry’s top minds

SEE YOU AT ICALEO 2018
International Congress on Applications of Lasers and Electro-Optics
OCTOBER 14-18, 2018
ROSEN CENTE HOTEL
9840 International Drive
Orlando, Florida USA 32819
THANK YOU
and Thanks to the LIA Staff

QUESTIONS?

For questions about LIA please contact:
lia@lia.org | 1.800.34LASER | www.lia.org