Laser Micro-machining System

A laser micro-machining system is needed to support the Advance Composites Program (ACP). The laser will be used to perform surface preparation experiments on aerospace structural materials. ACP is supporting experiments to test laser ablation as a surface preparation technique for adhesive bonding. The laser shall be able to ablate contaminates and resin from composite panels as well as remove mill scale and tenacious oxide layers from aerospace metal alloys. The laser power, pulse width, wavelengths, pulse repetition rate and other laser parameters are specified based on requirements for surface preparation. Those requirements include but are not limited to an ablation depth of up to 50 microns, an ablation rate of about 1 cm^2/min, and automation for ablating large areas over several hours to days. The motion range and speed (in the x, y, and z directions), power attenuation, focus, automation and software is needed to prepare lab-scale coupons for analysis and mechanical testing. The same hardware is needed to prepare small-scale test articles using realistic joint geometries.

After the ACP project has been completed, the laser micro-machining system will continue to be useful for machining and fabrication services. The system can be used for hi-resolution pattern generation, photo-lithography, and machining of small parts.

<u>CLASS I ENCLOSURE</u>

1. Enclosure:
    i. Class I enclosure with interlocked access doors on all sides. A clear, unobstructed, mechanically actuated viewing access door to view laser processing.
    ii. An interlocked Class I enclosure shall provide safety for operators and others in the room.
    iii. All light paths shall be sealed and interlocked.
    iv. The system shall incorporate an emergency shutdown switch located convenient to the operator's location.
    v. Enclosure shall incorporate all necessary duct work for fume extraction from the process areas to prevent the collection of debris on critical electrical, optical, and mechanical surfaces.
    vi. Provide a stand-alone fume/exhaust extraction device either for filtration and recirculation or exhaust to facility exhaust duct.

2. Frame and Base:
    i. Structure to include a metal skeleton and granite base designed for vibrational stability and ergonomic use.
    ii. The motorized X/Y stage shall rest on a solid granite base for vibrational and thermal stability.
    iii. Most major components of the laser system shall be integrated into the frame including the beam delivery, electronics, safety and motion portions.
    iv. Shall include a standard AC disconnect switch to energize/reenergize complete system.

v. Any cooling equipment needed to operate laser at any power level shall be provided with system.
vi. Any ancillary equipment/subcomponents needed to enable full capability of the laser system shall be included.
vii. System shall be compatible with existing electrical service: 208V, 3 phase, and 30Amps per leg.

LASER and OPTICS

1. A picosecond laser with a minimum of 18W in the fundamental (1064nm), 6W at 532 nm and 4 W at 355 nm wavelengths.
2. The laser shall have the following specifications:
   i. Four wavelengths in same laser source, with computer controlled wavelength switching:
      a. 1064nm
      b. 532nm
      c. 355nm

   ii. Min Pulse energy at maximum pulse repetition rate:

      a. 1064nm: >100 micro Joules
      b. 532nm: >60 micro Joules
      c. 355nm: >30 micro Joules

3. A nominal pulse length of less than 20 ps.
4. Beam shall have a uniform and concentric geometric shape in all wave length deliveries.
5. The laser shall be mounted inside enclosure described in part 1.
6. Optics trains:

   i. The beam delivery shall be composed of optics providing the maximum available durability for each wavelength to enable longest possible lifetime.
   ii. A telescope will be used to expand the beam and fill the input apertures to the lens.
   iii. System shall contain two digital galvanometer heads, one for 355 nm (14 mm aperture) and the other dual coated for both 532 nm and 1064 nm operation (20 mm aperture).
   iv. A nominal 100 mm lens is included for each wavelength (355 nm, 532 nm and 1064 nm).
   v. There shall be an additional lens of about 250 mm = f provided for each wavelength as well.
   vi. The minimum spot size for the 355 nm wavelength shall be less than 25 microns in diameter.
   vii. A lens shall be provided to achieve a spot size of approximately 120 microns or more in diameter at a wavelength of 1064 nm.
   viii. All lens shall be easily interchangeable to their appropriate galvanometers.

ix. All optical paths shall be enclosed and interlocked for safety.
x. Motorized attenuators shall be included for each wavelength that have an attenuation range of 2%-98% or more.
xi. Capable of fixed beam delivery in all wave lengths to incorporate table motion translation processing.
xii. A height sensor shall be incorporated to focus the laser delivery system to the desired processing area.

7. Camera:
    i. A digital color video camera with adjustable focus and zoom.
    ii. Part viewing shall be done on the computer monitor using a video capture and color photos shall be printable using normal computer printers.
    iii. Nominal "on monitor" magnification of 80x.
    iv. Illumination shall be provided through an adjustable light source coupled with fiber optic light guide.
    v. Precision alignment of laser possible with a cross hair reticle viewed on system monitor.
    vi. Capable of positional calibration with software.

Motion Control and Software

1. Motion Control:
    i. The motion system shall consist of 24" by 24" X/Y stage to allow for processing with both galvanometers at any location within the 24" x 24" field.
    ii. Stage position shall have a resolution of 0.1 micron or better.
    iii. Stage repeatability shall be 1 micron 3 sigma or better.
    iv. Computer control chall be used to control the motion axis.
    v. The maximum stage speed shall be a minimum of 10 in/s
    vi. A motorized overhead z-stage shall be provided to carry the optical train and enable precision focus. The travel of the z-stage shall allow for a working height of 4 inches and variable focal lengths from 3 to 8 inches.
    vii. All stages shall have standard crash prevention provisions.
    viii. A nominal 12 inch x 12 inch porous ceramic chuck shall be provided. A vacuum source suitable for chuck shall be included.
2. Software:
    i. The laser machining software shall be Microsoft, Windows compatible.
    ii. The control computer shall come with Microsoft Windows 7 Professional operating system.
    iii. A minimum of one >19" monitor shall be included.
    iv. The monitor and keyboard shall be mounted in a manner to ergonomically aid in the operation of the system.
    v. The main computer shall be the customer interface and will control all functions.

vi. The laser software package shall allow for automation of stage motion and laser processes. Programing shall be possible to automate ablation processes that require ablation, stage motion, laser power adjustment, focus adjustment.

vii. The software shall include drawing capabilities to prepare artwork for the laser processing at the system. The software shall accept standard file types produced by computer aided drafting software such as .dwg files.

Misc.

1. Installation:
    i. All installation expenses and shipping charges shall be included in purchase price.
2. Training:
    i. Training shall occur at the customer's facility immediately following installation.
    ii. All training and related expenses shall be included in purchase price.
3. Warranty:
    i. Warranty shall be a minimum one year on all components with the exception of major components that carry the original manufacturer's warranty.

4. Service and Support:
    i. Company shall be able to provide priority service when requested within 24 hours of a request from the customer on work days.
    ii. Shall be able to provide quarterly visits for maintenance and optical alignment of the laser system.
    iii. Company shall be able to provide same day material processing support and system support via phone and email.
5. Safety:
    i. This laser tool shall conform to all applicable OSHA and CDRH requirements.
    ii. The enclosure shall have all access panels that do not require a tool to open (ie – doors) interlocked so that, if any of these doors are opened in operator mode, all power to the laser will be shut down.
    iii. An interlock bypass shall be included to enable maintenance and service procedures with the safety interlocks in a disabled state.
    iv. System shall provide a connection to safety warning light to alert visitors when the laser system is in operation.