Special Conference Section Inside

LIA TODAY

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In The News...

Joint Quantum Institute

The National Institute of Standards and Technology (NIST), the University of Maryland (UM) and the National Security Agency (NSA) have announced the creation of a joint research institute designed to advance quantum physics research and to exploit this knowledge to transform quantum technology from an exciting promise to practical reality.

The institute will be located on the University of Maryland campus in College Park. It will have an annual budget of approximately $6 million and a staff of about 20 scientists, half from the university and half from NIST. The staff will include experts in atomic physics, condensed matter and quantum information, including William D. Phillips, the 1997 Nobel laureate in physics, who is both a NIST Fellow and a Distinguished University Professor of Physics at Maryland.

The JQI's three primary scientific disciplines are:

(Cont. on pg.11, see **In The News…**)

Practical Part Repair Using Metal Deposition with Lasers

by Wayne Penn & the Alabama Laser Team

For over 40 years lasers have advanced in design and applications. Initially only scientists were excited about the possibilities for lasers. Soon, the applications that followed the laser were destined to birth new industries that would have a major impact on the manufacturing economy. As the laser grew in power, the beam quality produced a high energy density enabling applications for drilling, cutting, and welding. New industrial markets were created and others transformed by the new tool made of light.

Today, metal deposition with lasers is maturing into practical applications for the economic repair of industrial parts. Here we will cover the basic components of a laser metal deposition system as well as the application conditions and example results.

The Laser Energy Source

The basic components of a laser metal deposition system are comprised of the following: the laser, beam delivery, filler material, and mechanical motion system.

The laser is the energy source for the application, focusing to an energy density at the material that is high enough to produce a molten pool and melt the filler material. This results in an increase in the mass of the part that can be used to fill a defect or shape a new volume onto the part.

Lasers that can be used for metal deposition

(Cont. on pg. 6, see **Deposition**)

OP-TEC

National Center for Optics & Photonics Education

by Dr. Fred P. Seeber

OP-TEC, the National Center for Optics and Photonics, is a recently funded National Science Foundation Advanced Technological Education (ATE) Center with the mission of promoting photonics education by assisting colleges around the country in developing and implementing educational programs that support expansion of this critical technology. By providing information materials and networking opportunities, colleges and universities around the country can take steps in implementing photonics programs that give their students the opportunity to work in this rapidly expanding, high-demand, high-paying field that is expected to grow more than 1,800 per year on average through 2009.

OP-TEC
National Center for Optics and Photonics Education

OP-TEC will develop materials in photonics and create career pathways that will begin at the high school level and extend into post-secondary degrees.

I, an LIA fellow and former board member, am a co-PI (principal investigator) of OP-TEC and will coordinate the partner colleges and

(Cont. on pg. 8 see **OP-TEC**)

13501 Ingenuity Drive, Suite 128; Orlando, FL 32826 Phone: 407.380.1553 Fax: 407.380.5588
http://www.laserinstitute.org

Deposition, cont. from pg. 1

include:

1. Carbon dioxide (CO_2) gas lasers – The carbon dioxide gas laser is the original industrial workhorse. The CO_2 laser generates efficient beam energy at industrial power levels with a broad base of applications in the metal cutting market. The medium infrared wavelengths (10.6 micron region) from CO_2 lasers are safer to the human eye than visible or near infrared lasers, thus allowing simpler enclosures for safer operation on the job shop floor. The CO_2 laser beam is delivered with free space hard optics.

2. Nd:YAG lasers – The older types of Nd:YAG lasers (the second industrial work horse) are pumped with flash lamps. Many of the new Nd:YAG lasers are pumped with laser diodes. The Nd:YAG laser produces energy in near infrared (IR) wavelengths. The Nd:YAG laser can be delivered by free space hard optics or fiber into a Class I work enclosure for eye safety.

3. Fiber lasers – The fiber laser in the past few years has grown to high industrial powers with efficiencies that result in small chiller requirements. The laser beam's wavelength is in the near IR. The fiber laser is pumped by laser diodes. A passive fiber with fiber optic connectors is then often used to carry the beam to a Class I work enclosure for eye safety.

4. Diode lasers – The diode laser uses direct conversion from electricity to produce a laser beam in the near IR typically right outside the red end of the spectrum. The direct diode laser has high efficiency. The beam may be delivered by free space hard optics or by fiber. The diode laser should operate in a Class I enclosure for eye safety.

Beam Delivery

The beam delivery system provides a path for the laser photons to move from the laser to the work piece. Fiber beam delivery offers mechanical flexibility, while free space hard optic beam delivery requires high mechanical stiffness and stability for reliable operation. Both systems require sealing and purging to maintain absolute cleanness in the industrial environment.

Table 1 shows the different lasers and summarizes some of the basic properties of each.

Filler Material

The filler material adds mass to the part. Either powder or wire can be used. Wire is a cleaner process, not leaving behind the residue produced when using powder.

Wire requires precise alignment with the melt pool. Also the wire must be available in the alloy desired.

Powder is fed in with a powder delivery system through a nozzle that is located about a centimeter from the molten pool. Careful alignment is necessary for proper deposition control with a balance between the geometry of the deposit and the time the powder spends in the beam before hitting the molten pool. If too much powder is used and or the powder spends too much time in the beam then the beam spot on the base material is distorted with a reduction in energy density. If the energy density is too low, then the molten pool will become unstable or nonexistent. Parameters to balance include:

- Laser power
- Deposition rate
- Deposition alignment and intersection with the molten pool
- Deposition mass delivery rate
- Spot size
- Energy density
- Speed of deposit (motion system)

Mechanical Motion System

The motion system for metal deposition includes accommodation of the part fixtures and management of the powder waste if the system uses powder.

The motion system and beam delivery are housed in a Class I enclosure such as the system shown in Photo 1.

Application Conditions

Before repairing a part using metal deposition, one must first make sure that the part is clean – free of oxides and contamination. Many parts to be repaired have been used in the field and often are exposed to contaminating conditions. Pre-machining a surface may be necessary to expose clean metal for proper metallurgical bonding with the deposited material.

Photo 1 – Example of a laser metal deposition system.

Once the surface is clean, you will need to determine the proper starting parameters for the metal deposition process. A basic technique is to first establish a "bead on plate" diffusion type of weld. This weld is accomplished by using the laser to create a molten pool on the base material, and then moving the pool across the surface without depositing any additional metal. A solidified track is created on the part and must then be analyzed for:

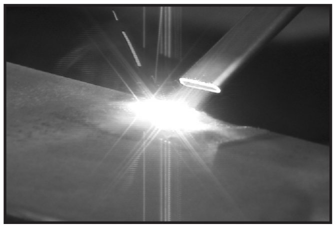
- Bead width
- Bead penetration
- Welding speed
- Stable pool solidification
- Stable wetting of the material (clean interface between the molten pool and base material)

Once the starting parameters are established then add the powder or wire and increase the laser power or slow the process speed for the additional energy needed to melt the material being deposited. The amount of power or process speed reduction needed will be a function of the delivery rate.

Four regions will be present after the deposition is

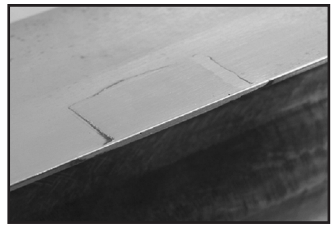
Table 1

Laser	Technology	Emission	Beam Delivery	Beam quality
Carbon Dioxide	Gas discharge	Medium IR	Free Space (FS)	High
Nd:YAG	Rod or disc	Near IR	FS or fiber	Medium to high
Fiber	Active fiber	Near IR	Fiber or FS	High
Direct Diode	PN junction	Very Near IR	FS or fiber	Low



Laser metal deposition process running.

Repaired part ready for grinding.



Repaired part after grinding.

made. The first region is the deposit with a small grain structure that results from the laser metal deposition. The second region is a base material dilution zone with the deposited material. The third region is a heat-affected zone (HAZ) and the final region is the original base material. Each region has its on specific metallurgical properties depending on the materials used and the deposition parameters.

High hardness (HRC60 plus) can be achieved in the deposition with a narrow dilution zone. The heat-affected zone can transform the base material in this region.

Example Results

The repair of commercial parts can be accomplished at high speeds with laser metal deposition technology. For example, a laser deposited repair made on a sheet metal folding die used the following:

- Direct diode laser with maximum power of 4kW running at 2250 watts
- Beam shape 1 millimeter wide by 12 millimeters length
- Robotic motion system for part manipulation process speed 5 millimeters per second
- Powder feeder distributing alloy powder at 17 grams per minute
- Argon shield gas
- Four layers deposited - total process time approximately two minutes

The laser metal deposition system can deposit a strip of metal approximately 12 millimeters wide and .5 millimeters thick at a speed on the order of five millimeters in length per second. The photos show the metal folding machine die repaired with the conditions given above.

Conclusion

Laser metal deposition technology has exciting possibilities for the future. The feasibility of commercial part repair is now available. Applications for this technology will broaden as lasers become less expensive. Various hybrid technologies coupled with the laser also holds potential for future applications. ✱

Wayne Penn (256-358-9055), president of Alabama Laser Systems, (www.alabamalaser.com) Munford, AL, has over 30 years of experience with lasers.