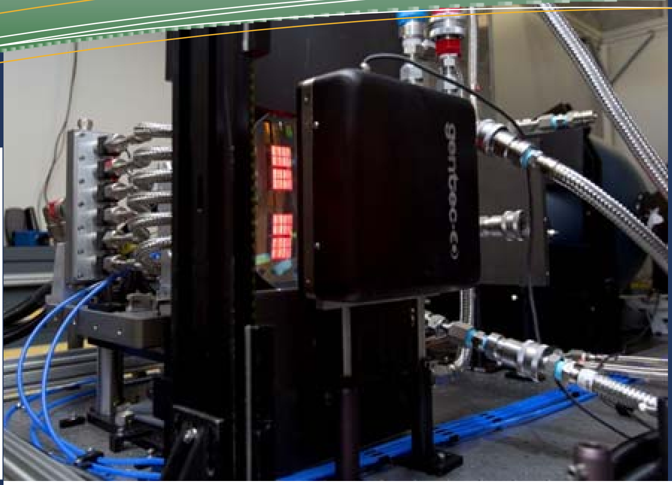
Volume 3
Issue 1

Laser Lessons News Letter



Award Winner!!

This issue

The Newsletter has been awarded a 2014 EFCOG Appreciation Award and was also recognized as a DOE/EFCOG Best Practice!

Introduction

As we begin the third volume of the newsletter, along with continuing to provide useful information on laser safety and lessons learned, we will begin to highlight some of our laser laboratories. The focus will be on how the melding of safety and science creates world class research. This issue will cover "extended source -surface emitters," a spotlight on the "Advanced Diode Application Lab," and a lesson learned from a recent off normal event.

Extended Sources

In the previous issue we discussed a near miss which occurred during the use of laser diode arrays. Laser diodes (LDs) along with Light Emitting Diodes (LEDs) are types of extended source surface emitters. Surface emitters are sources that emit their optical radiation perpendicular to the lasing medium (semiconductor). Where most laser applications today utilize a type of semiconductor, we are going to focus on the LD and LED subcategory.

An extended source is one which has an angular subtense at the cornea larger than α_{min}. Alpha min is the angular subtense of a source below which the source is effectively considered as a point source. This value is 1.5 mrad.

Is an extended source surface emitter a laser? The answer to this is yes *and* no. It is true that they do meet the simple definition of Light Amplification by the Stimulated Emission of Radiation, but do they meet all of the generally accepted characteristics of a laser?

1. They emit "coherent" optical radiation.
2. They can be monochromatic,
3. They are not generally very directional or of low divergence. More important, an extended source can be resolved by the naked eye into a geometrical image.

The last characteristic is "key" to determining the overall hazard of this optical source. Where a laser spot size is infinitely small and highly collimated in comparison, the extended source is generally a larger source size with a relatively extreme divergence. The spot size of the laser beam is viewed by the eye as if at infinity and cannot be imaged on the retina.

Adding magnifying optics to the extended source does not provide much greater hazard with respect to biological effects. The optics are applied outside of the amplifying medium and are thus considered a passive component. This is an example of the "Brightness Theorem." The brightness theorem states that the brightness of "a" light source cannot be increased with passive optical components such as lenses, mirrors, or waveguides.

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A few words from Mr. Obvious:

Choosing the correct Laser Protective Eyewear is not only dependent on the laser, but on physical facial characteristics!

If I am not “AUTHORIZED” I am prohibited from entering!

The aperture is where the laser beam exits. Don’t look into the aperture!

If the laser beam is strong enough to light a cigar it is strong enough to burn your eye!

A Laser Injury is **PERMANENT**… **BE SAFE!**

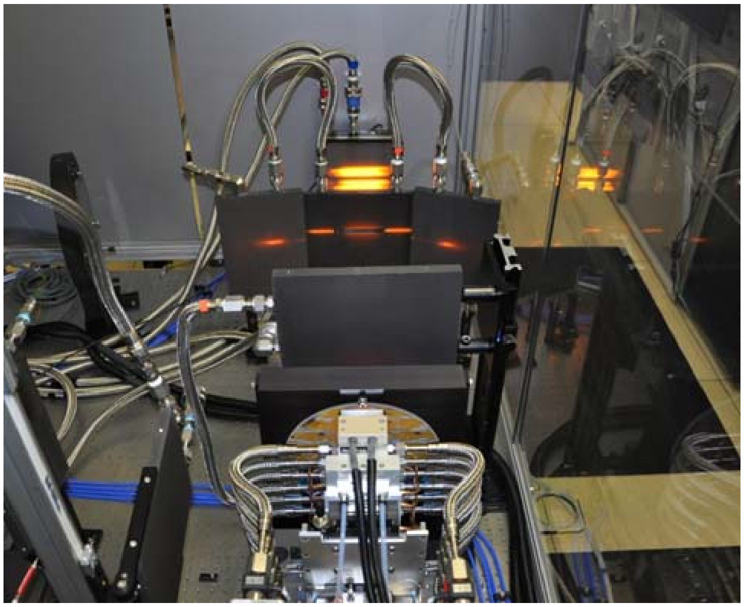
A laser is different because the optical amplifier is considered an active optical component and the brightness theorem does not apply while the light is being modified in the amplifying medium. This is the simple reason why an LD or LED is not in the same caliber as a laser. Let’s dig a little deeper.

Laser Diodes are configured from individual tiles or “bars.” Currently the highest commercially available output bars range from 100-500 watts. These can then be put together into a Laser Bar (10 -50 side-by- side) and then stacked on top of each other to create “arrays” or “stacks.” Commercially available stacks are now offered into the tens of kilowatts.

Remember that as the output power of these devices goes up, so does image size. LDs emit within the infrared portion of the spectrum, so the tissue of concern is the retina. All of the light must pass through the aperture of the eye (pupil) which is generally 7mm in diameter. It is literally impossible for a 30kW diode array to have all of its energy deposited onto the retina efficiently. The same cannot be said of a 30kW laser with 1mm bean size.

Microlens conditioned arrays are becoming ever more prevalent, being deployed as pump systems for diode-pumped lasers as well as stand-alone diode arrays for material processing applications. Because such arrays contain microlenses that act at the individual bar or even the individual emitting aperture level, they require special consideration when evaluating their effective brightness or radiance. A good rule of thumb for the purpose of the eye safety calculations within is to always use the beam divergences measured after the microlenses, i.e., after the diode light has traversed the microlenses. Using this post microlens divergence along with aperture area as normally defined then properly accounts for the impact of the microlens-conditioning on the output of the laser diode array.

Like LDs, LEDs are becoming more and more prevalent and their use is rapidly expanding. Unlike the LDs, LEDs run the gamut of the spectrum from the UV to the IR. The major concern here is the UV and visible wavelengths. UV LEDs are used in curing lamps and care must be taken to protect both the skin and eyes (cornea and lens) from overexposure. The effects here are erythema and melanoma to the skin, ~~and~~ corneal burns and cataracts to the eyes.



A power transmission measurement being made on a multi-kilowatt backplane. The main lobes can be seen on the water-cooled calorimeter behind the aperture which is also water cooled. Water-cooled beam dumps are used to terminate the residual high-angle scatter left and right of center.

For those in the visible wavelengths, you need to ensure that you do not get overexposure both from acute (short term) and chronic (long term) contact. The effects can range from flash-blindness and afterimages from the former to degradation of color vision from the latter.

LDs are manufactured and sold as laser products. Because of the output of these devices, they are generally sold as Class 4 lasers. LEDs on the other hand are not regulated within the U.S., but internationally (EU) they are classified much like lasers. Due to international commerce, these will generally be sold with a classification.

To assure your safety and the safety of others, it is best that you involve your laser safety officer in the purchase of these products. This will ensure that any required work control documents are in place and approved prior to beginning work.

Special Thanks to Ray Beach for input

BE SAFE!

Highlighted-Laser Lab

Courtesy of Mike Runkel

A huge effort has been underway for a number of years in the NIF&PS directorate to develop a large scale diode pumped alkali laser (DPAL). Over the past months, successive laser runs have yielded world-record power levels. Reaching these power levels requires a pump source of significant stature. Such a source requires facilities dedicated to characterizing and optimizing the laser diode arrays that are used as the DPAL pump source. This research is being performed under the watchful eyes of Mike Runkel and Matt Boiselle.

During a recent laser safety inspection, this operation was awarded an "Outstanding Audit." An outstanding audit is indicative of safety and science melding into world class research. All aspects of the operation must be top notch. This includes engineered safety, housekeeping, and administrative aspects to name a few.

The LLNL strategy to reach ever-higher diode brightness involves procuring batches of small laser diode stacks (known as unit cells containing many hundreds of individual emitters), characterizing and optimizing each unit and then choosing an ensemble of unit cells based on the required various operation requirements for a specific laser run.

DPAL diode team members Mike Runkel (l) and Matt Boisselle (r) in front of the backplane test

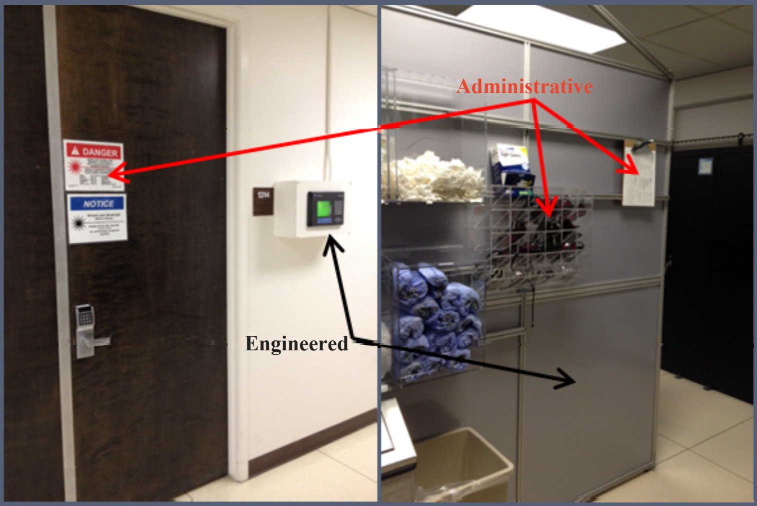
Once characterized and chosen, the ensemble is built onto a custom, LLNL-designed backplane and characterized in the same way as the individual unit cells. Characterization involves measuring the total laser power, power in spatial and spectral buckets, near and far field spatial profiles, degree of polarization all as a function of applied voltage, coolant flow and temperature and gas flow. Optimization involves finding the highest power in the spatial and spectral buckets for a given set of operational conditions. This will ensure that the maximum amount of usable pump light is able to pass into the laser cell in the correct spectral band for maximum laser output.

A backplane populated with several unit cells can produce several kilowatts of continuous power and managing the high divergence of the arrays (~100 milliradians) requires equipment and optics with large apertures. At these power levels, operator and equipment safety is of paramount concern. Beam dumps, calorimeters and integrating spheres are water cooled.

This great science along with their approach of seamlessly melding in safety equates to nothing less than "World Class Research." Great Job!

Engineering and Administrative Controls

This laboratory utilizes a PLC based defeatable Safety Interlock System (SIS). When the correct code is entered the SIS is bypassed for a short period allowing ingress and egress, Because of the bypass, a portal entry is required, This prevents stray laser beams from exiting the space, A solid wall made of 80/20 is used, This is considered an engineered control because the wall does not easily move out of position (requires a tool). It is a much cleaner and user-friendly install than a curtain. The Administrative Controls (Laser Protective Eyewear and Sign in Sheet with daily hazards), can be easily mounted on the wall. Laser Warning Signs can be seen posted on the outer door.



Light Emitting Diodes (LEDs)

- An LED lights up by using a small semiconductor crystal. When the crystal is energized with electrical current, the semiconductor emits light.
- The LED semiconductor has n-type (negative) and p-type (positive) material. These two materials give the LED the ability to light up. When current is allowed to flow from the p-type material to the n-type material, the LED emits light.
- A small reflector (like the reflector surrounding a car headlight lamp) surrounds the semiconductor crystal, making the LED brighter.
- An epoxy case surrounds the LED circuit, providing a defined color and protection of the circuit.
- An LED has two legs that are used to connect it into a circuit. The legs, called leads, also help pull heat away from the LED circuit.
- The legs of the LED are not the same. One leg is longer than the other. The longer LED leg is known as the anode. The shorter LED leg is known as the cathode.
- The anode leg helps direct current from the p-type material to the cathode. The anode leg is connected in a circuit toward the positive terminal of the battery. If the LED is connected backward it will not light up.
- All LEDs are made with a maximum voltage they can connect to without being destroyed. This voltage is typically between 1.5 volts and 3.6 volts. Voltages higher than labeled on the LED packaging will result in a LED that is destroyed.
- Natural white LEDs are not available. Instead, light bulb makers mix several different LED bulbs which results in light we see as white.
- The first patent for LEDs was issued to James Biard and Gary Pittman while working at Texas Instrument in 1961.

Science with Kids
http://sciencewithkids.com/science-facts/facts-about-LEDs.html

Lesson Learned

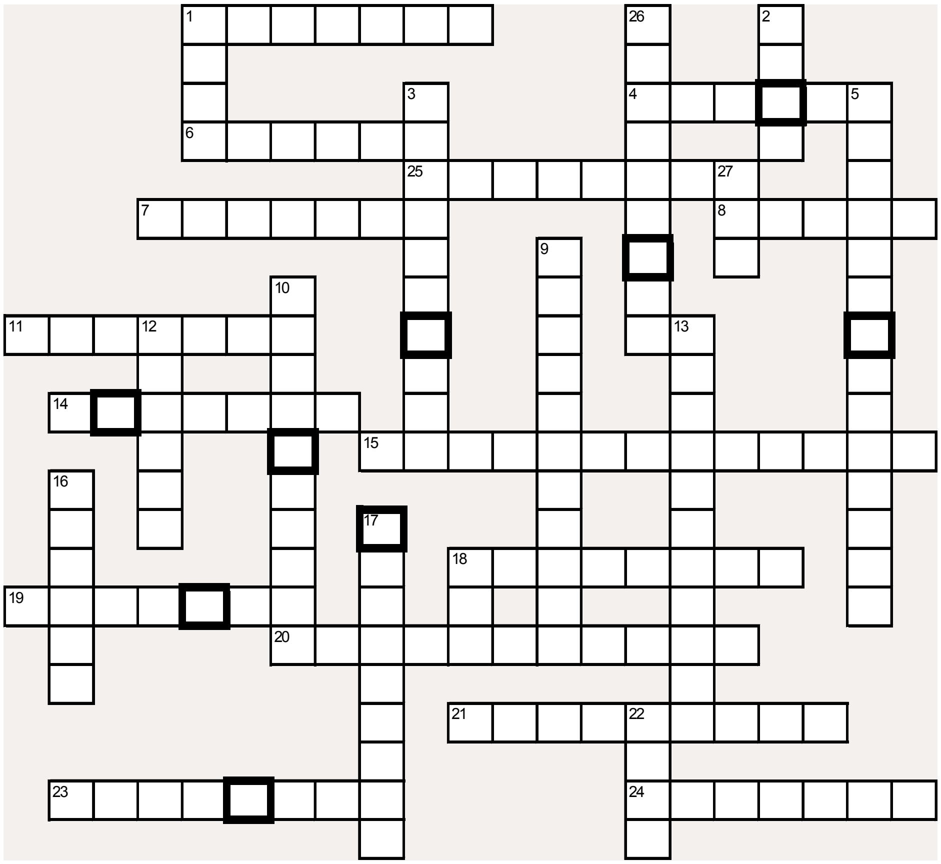
A near miss occurred recently where three workers observed diffuse green laser light when opening a chamber. This work involved two different organizations where one group was responsible for the overall operations (chamber) and the other for the laser aspect. Because of this, there were two different procedures. Both safety plans were quite detailed and contained all of the necessary steps. Though the securing of the laser was the responsibility of the laser workers, and was missed, the chamber procedures had a section to ensure that the laser was secured prior to opening the chamber. Unfortunately, this was contained in the prerequisites rather than in the very first step in the checklist procedures.

Three workers approached the chamber and one opened the door. They saw diffusely scattered green light and immediately closed the door. They paused work and reported to management. They were all subsequently sent out for laser eye exams which indicated that no overexposure had occurred. The laser in use was a Class 3B (300mw) previously downgraded to a Class 3a/3R via neutral density filters to <5mW. Because they were not getting a high enough signal, they upped the output to 30mW (Class 3B). The laser light was sent down 2 separate fiber optics, splitting the output, to an open top metal block where the beam traveled ~5 inches from the fiber output to the receiver. It is physically impossible for an individual to get their eye into the area of the open beam at this location within the block.

A hazard analysis was performed and nominal ocular hazard distance (NOHD) for diffuse reflection was calculated to be <3cm. This is far less than the distance ~~that~~ the workers were located when seeing the scattered light. One might ask why not interlock the chamber door? For the initial operations (<5mW) it is simply not a requirement. Moving up to 30mW pushes it into the "should" level. With the configuration being used, administrative controls are quite adequate as the hazard analysis indicated by the small NOHD (<3cm).

The lessons learned here are that very strict coordination (communication) is required when more than one group is involved in an operation and you should never bury important safety verifications in the prerequisites section. BE SAFE!

Crossword Puzzle



Put the letters, that you find in the outlined boxes, together to form the name of a past laser program pioneer at the lab

☐☐☐☐☐☐☐☐☐

Across

1. Type of lens used in lighthouses.
4. Living tissue in constant contact with the environment.
6. Contains rods and cones.
7. 400-700nm wavelength band.
8. Normal size in humans is 2-7mm.
11. Scattered reflection.
14. Interlocks are connected to a _____ or power supply.
15. Process by which UV causes biological damage.
18. Completion of ___ and a laser eye exam are required to operate a Class 4 laser.
19. Heating effect.
20. A laser interlock is an _____ Control.
21. Are tested at a frequency no greater than annually to ensure proper operation.
23. Blink reflex or _______ response.
24. There are 24 total in NIF.
25. Clear liquid that fills the eye between the lens and the retina.

Down

1. Highest laser classification.
2. Hardens and yellows with age.
3. Laser Protective Eyewear is classified by ______ and Optical Density.
5. Laser curtains are an _______ Control.
9. Greater than 600 volts.
10. _____Interlocks have a bypass control.
12. A GFCI interrupts ground _______.
13. A laser is monochromatic, coherent, and ______.
16. Research laboratory where first optical laser was invented.
17. Most eye injuries occur during ______ operations.
18. Maximum non-hazardous electrical shock energy is ____ Joules.
22. First optical laser.
26. Used to make a laser a class 1 System.
27. A place one goes to relax.