Laser Disposal Guide

Introduction

Lasers have a finite lifetime, which is based on use, experimental needs or technological advances. The goal of this guide is to provide guidance for the laser users and in particular, the LBNL Surplus/Excess staff and EHS waste disposal staff when dealing with lasers at the end of their life cycle.

For the purpose of this guide, we will break lasers into several different types: gas, solid-state rod, liquid, and semiconductor. Laser systems also come in a variety of sizes, which does not relate to their optical laser output. In addition, when a laser is disposed of, a power supply often travels with it. Standard electrical safety protocols adequately address the power supply and will not be addressed in this document.

All lasers that utilize electricity as their main energy source and were manufactured prior to July 1, 2006, will most likely have lead in their printed circuit boards. Therefore these boards need to be disposed of as electronic waste (e-waste).

There are United States regulations such as export control and European Reduction of Hazardous Materials regulations, known as RoHS rules, that affect how and the manner surplus lasers are to be dealt with. In California there is the CA Dept. of Toxic Substances.

Document prepared by Ken Barat & Justine Woo April 2012, revised 2016

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Before a Laser Can Be Disposed

Laser User

1) Have you contacted Property Management to ask which forms need to be filled out?
2) If you are disposing of a Dye or Excimer laser, have you flushed out the chemicals in the pump containers, tubing and inner cavity? For instructions, please see the Dye Laser or Excimer Laser sections.
3) Do you have the user manual for the laser? If so, send it for disposal with the laser.
4) Did you contact the LSO to see if he/she can find a new home for your laser?
5) Remember to remove the laser from your WPC Activity and Laser Management System (laser inventory).

Hazardous Waste Generator Assistant

1) If it is a Dye or Excimer laser, ensure the user has flushed out the chemicals in the pump containers, tubing and inner cavity and disposed of correctly or saved for you (See the Dye Laser section for list of common laser dyes and solvents)
2) Majority of power supplies built prior to 2000 with capacitors will contain capacitor oil
3) Any other type of laser has no special precautions required for transportation

Excess Receiver

1) Have you received the proper paperwork?
2) Is the laser type identified, so the proper disposal steps can be taken? Disposal steps are outlined in this guide per laser type.

Laser User Responsibilities

When a laser is getting ready to be released for disposal, the laser user should find the laser system user manual and send it along with the laser. While commercial lasers should have several labels on them, the most important for surplus are the manufacturer label and the logo label. From the manufacturer label, one obtains the model and serial numbers. The logo label contains wavelength and output data and might indicate the general laser name (i.e. Argon, HeNe). Before sending the laser to Excess, the laser user must place a sign on the laser indicating its optical laser medium (i.e. Nd:YAG, Dye, Argon etc). This will be a great help to the property disposal group especially if the user manual cannot be found.

Government Regulations on Export Controls

Export controls are extremely complex and are subject to change at any time. Some technologies cannot be sold to sources outside the United States. Hence, lasers at LBNL surplus should be destroyed rather than put out for general public auction. They may still go on the DOE surplus property list for other national labs to use. Experience has shown questionable value of such lasers at the end of their lifetime to others.

If you have a question or concern about an export control matter, please don't hesitate to contact the Laboratory's Export Control Officer at Ext. 486-7096.

Export Control web page can be accessed with a valid LDAP at:

https://www2.lbl.gov/Workplace/olc/exportcontrol/index.html

U.S. Department of Commerce Control List – Sensors and Lasers

https://www.bis.doc.gov/index.php/regulations/export-administration-regulations-ear
Commerce Control List Index, Category 6 – Sensors and Lasers

Transportation Concerns

If the laser is a Dye or Excimer laser, ensure that the pump containers, tubing, inner cavity, and mixing chambers are rinsed thoroughly before transporting. For further instructions, see the Dye Laser or Excimer Laser sections.

Contact Property Management to ensure that the correct paperwork is filled out, especially if the laser will be transported offsite. These forms may be found at the Property Management Website: http://www.lbl.gov/Workplace/CFO/pro/property/prty_forms.html

General Approaches to Disposal of Laser

1) **Contact the Laser Manufacturer to see if they will take it back for disposal**. Some manufacturers will accept old lasers for recycling value or just as a service to users. Notify the LSO to update the laser inventory.

2) **Send the laser to LBNL Excess (Salvage),** or eliminate the possibility of activating the laser by removing all means by which it can be electrically activated. The laser may then be discarded. If hazardous material in the laser components is present (e.g., mercury switches, oils, organic dyes), contact the waste generator to ensure proper disposal and compliance with the applicable hazardous waste disposal regulations. Notify the LSO to update the laser inventory.

3) **Transfer it to another DOE facility**

- Transfer the laser to other DOE organization. A "Request to Transfer" form from the Property Management web page is needed: https://drive.google.com/a/lbl.gov/file/d/0B_SXHe_2oo1lN3B5VFl6NVQzdVk/view
- Ensure the laser system complies with all applicable product safety standards, such as the FLPPS, and adequate instructions for safe operation and maintenance are provided. Verify the receiving organization has a viable laser safety program for the class of laser being donated and ensure receiving organization contacts the LBNL LSO.

4) **DOE does not donate to equipment to non-DOE organizations.** It must be transferred to a DOE Grant. The custodian must contact the institution to find out if there was a DOE grant they could use.

The lasers or laser systems must not be moved offsite or given to any other organization without evaluation by the LSO. The LSO will assist the donor in determining if the laser or laser system complies with all applicable product safety standards, such as the FLPPS, and adequate instructions for safe operation and maintenance is provided.

Exceptions to the required LSO evaluation include unmodified, commercially-available consumer products, such as laser pointers, laser gun sights, laser printers, compact disk players, and barcode scanners, or units being returned to the original manufacturer or qualified service company for repair, maintenance, warranty work, modification, or similar circumstances.

Lasers, which are to be disposed of by LBNL are not to go to public auction. This is due to concerns over the misuse of the laser system; one example is lasers being used to expose commercial aircraft pilots while in flight. The laser must be rendered unusable.

Power Supplies

- Simple action is to cut off plug and as much as possible of the AC source cord
- For lasers that utilize electricity as their main source of energy and manufactured prior to July 1, 2006, they have lead in the Printed Circuit Boards. Dispose of them as electronic waste
- Many laser systems unitize a high voltage capacitor system hence an electrical shock hazard is a real possibility. Standard capacitor safety needs to be followed, use of ground hooks, etc.

Optics

- For optics, remove the optics and place them in a zip lock bag. Find them a new home or dispose of them.

Type of Lasers – Lasing Medium

Lasers receive their name from the medium selected to lase (generate an optical laser beam). Therefore, lasers fall into a number of broad families.

Dye Lasers

ACTIVE CONCERN

These lasers use a liquid medium. This medium is composed of organic dyes and solvents, all which must be considered carcinogenic or mutagenic.

DISPOSAL

Wear personal protective equipment. This includes goggles, particle masks, chemical resistant apron, and gloves. Rinse pump containers, tubing and inner cavity several times with methanol and then followed with water until internal circulating fluid appear to be clear. All washing must be considered hazardous waste and dealt with as such. For more insight regarding safe handling of dyes and solvents refer to the following link within LBNL: http://www.lbl.gov/ehs/chsp/html/laser_dyes.shtml

Once done cut power cord, remove optics.

COMMON DYES AND SOLVENTS

- Coumarin
- Rhodamine
- Exalite
- Stilbene
- Oxazine
- DMSO

Dye Lasers	
Common Manufacturers	**Laser Names**
Continuum	ND6000
Lexel	
Martek Power Laser Drive	
Newport: Spectra-Physics	Sirah

Excimer Lasers

ACTIVE CONCERNS

Excimer lasers use a combination of Halogen and Noble gas. Each has its own risks depending on the quantity and concentration. It also includes an internal electrical system that is required to make the two family of gases form a dimer.

Common Types of Excimer Lasers

- Argon Fluoride Laser
- Hydrogen Fluoride Laser
- Krypton Fluoride Laser
- Xenon Fluoride Laser

DISPOSAL

User should have flushed out the resonator prior to sending to surplus as well as any pre-mix chambers. Wear gloves and safety glasses. Remove chamber and crack open in a well-vented area. Remove any circuit boards and dispose of as electronic waste. Remove power cord.

Hazardous Materials to Consider

- Argon
- Fluoride
- Krypton
- Xenon

Excimer Lasers	
Common Manufacturers	**Laser Names**
Coherent	BraggStar COMPexPro ExciStar IndyStar LAMBDA SX LEAP LPXpro VYPER Xantos
GAM Lasers	
Lambda Physick	Bought out by Coherent

Gas Lasers

ACTIVE CONCERN

Many of these will have a glass or metal plasma tube. The tube can contain Beryllium (Be) Oxide in a ceramic form, safe for handling unless broken up, in which case it will then generate Be dust. Many gas lasers will also contain extensive windings of copper (i.e. Spectra Physics model 2016-2080). Argon Ion lasers can also have an internal electrical capacitor.

Common Types of Gas Lasers

- Argon Laser
- Argon Ion Laser
- Carbon Dioxide Laser
- Copper Vapor Laser (rarely found, contain copper core)
- Helium-Cadmium Laser
- Helium Neon Laser
- Krypton Laser
- Nitrogen Laser
- Excimer Laser (See Excimer Section)

DISPOSAL

Remove power cord from unit. Crack glass tubes in a well-vented area (cracking of one end is sufficient). Metal plasma tubes should be sent to LBNL Hazardous Waste for disposal. Common examples of this are the Spectra Physics laser Model 160, 163, 177, 183D, 185, 185F.

Hazardous Materials to Consider

- Argon
- Carbon Dioxide
- Cadmium
- Neon
- Krypton
- Nitrogen

Gas Lasers		
Laser Types	**Common Manufacturers**	**Laser Names**
Argon Laser	Coherent	Innova 300
	JDS Uniphase Corporation (JDSU)	
	Newport: Spectra-Physics	BeamLok 2060

Gas Lasers		
Laser Types	**Common Manufacturers**	**Laser Names**
		Stabilite 2017 Stabilite 2018
Argon Ion Laser	Cambridge Laser Laboratories	
	Coherent	
	CVI Melles Griot	
	JDSU	
	Lexel Laser Products	
	Martek Power Laser Drive	
	Newport: Spectra-Physics	
Argon-Krypton Mix	Newport: Spectra-Physics	Stabilite 2017 Stabilite 2018
	Omnichrome	
Carbon Dioxide Laser	Coherent	DIAMOND
	Synrad	48-Series Firestar 9.3 µm Series 10.2 µm Series
Copper Vapor Laser		
Helium-Cadmium Laser	CVI Melles Griot	XRM XRS
	Kimmon Koha, Co., Ltd.	
Helium Neon Laser	CVI Melles Griot	LGX LLX LPL LYX LHX STP SRX
	JDS Uniphase Corporation (JDSU)	
	Martek Power Laser Drive	
	Newport: Spectra-Physics	
	Power Technology Incorporated	
	Qioptiq	
Krypton Laser	Coherent	Innova
	Newport: Spectra-Physics	BeamLok 2060 Stabilite 2017 Stabilite 2018
Nitrogen Laser	LTB Lasertechnik Berlin GmbH	
	Optical Building Blocks Corp.	

Solid State and Rod Lasers

ACTIVE CONCERN

Some of these are on export control list. Circuit boards may contain lead.

COMMON SOLID STATE LASERS

- Alexandrite Laser
- Erbium: Glass
- Ho: YAG
- Nd: YAG Laser
- Nd: YLF
- Nd: YVO_4
- Ruby Laser
- Ti: Sapphire
- Yb: YAG
- Ruby

DISPOSAL

Remove power cord, remove circuit boards (e-waste), and remove any obvious optics or crystal rods. Wear protective eyewear and safety gloves. Small quantity of Gallium Arsenide can be found in diodes.

Of the laser systems noted above, most contain Rod lasers modules that generally contain Xenon or Krypton Arc "Flash Lamps" that serve as the excitation mechanism for the laser medium. By the nature of these components, extreme care needs to be taken when handling the flash lamps as they can potentially explode and/or break upon removal. Treat like glass bulb waste.

Hazardous Materials to Consider

- Alexandrite
- YAG

Solid State and Rod Lasers		
Laser Types	**Common Manufacturers**	**Laser Names**
Alexandrite	Martek Power Laser Drive	
	Unitech Corp.	
Erbium: Glass	Jenoptik	
	Megawatt Lasers	

Solid State and Rod Lasers		
Laser Types	**Common Manufacturers**	**Laser Names**
Ho: YAG	Convergent Laser Technologies	
	IB Laser Consulting	
	Trimedyne	
Nd: YAG	B&W Tek, Inc	
	Coherent	
	Continuum	Inlite Leopard Minilite Powerlite Surelite
	CrystaLaser	
	CVI Melle Griot	
	JDSU	
	Jenoptik	
	Kimmon Koha, Co., Ltd.	
	Newport: Spectra-Physics	GCR series
	Photonics Industries	DC Series DS Series SM Series
	Quantel	Brilliant Crio Centurion CFR Ultra Evergreen Twins Twins B Twins BSL Yasmin YG 980
	Quantronix	Harrier Hawk
Nd: YLF	CrystaLaser	
	Klastech – Karpushko Laser	
	Photonics Industries International	DC Series DS Series DM Series
	Quantronix	Darwin Darwin-Duo
Nd: YVO_4	CrystaLaser	
	CVI Melles Griot	

Solid State and Rod Lasers		
Laser Types	**Common Manufacturers**	**Laser Names**
	DPSS Lasers, Inc	
	Jenoptik	
	Photonics Industries International	DC Series DS Series
	Quantronix	Osprey
Ruby Laser		
Ti: Sapphire	Clark-MXR, Inc.	
	Coherent	Legend Elite, Libra, Vitesse, Mira, Chamelean, Vitra, Mantis,
	Del Mar Photonics	
	Femto Lasers	FemtoPower, Femtosource
	High Q laser	
	Kapteyn-Murnane Laboratories	
	Lexel	
	Newport: Spectra-Physics	Mai Tai Tsunami Spitfire
	Photonics Industries International	TU Seriees
	Quantronix	Integra Katana Odin
Yb: YAG		

Diode/Semiconductor Lasers

ACTIVE CONCERNS

From a size perspective 95% of these laser units are made up of heat sink, current controls etc. The actual laser diode is smaller than paper clip. Some diode laser systems may be a part of a diode fiber system.

COMMON DIODE LASERS

- Gallium Aluminum Arsenide
- Gallium Arsenide
- Indium Gallium Aluminum Phosphide Laser

DISPOSAL

For individual diode units or arrays, simply break the housing unit taking care to wear protective eyewear. Only if multiple units are received at one time should they be sent to the LBNL Hazardous Waste Group. For fiber optic systems, while wearing safety glasses and protective eyewear, the fiber should be cut near the diode end and fiber segment put in a sharps container.

Hazardous Materials to consider

- Gallium Arsenide (Hazardous Waste)

Diode/Semiconductor Lasers	
Common Manufacturers	**Laser Names**
B&W Tek	
Blue Sky Research	Chromalase
Coherent	AVIA Evolution Talisker
CrystaLaser	
CVI Melles Griot	
Dilas	
Hamamatsu	
IPG Photonics	
JDS Uniphase Corporation (JDSU)	
Klastech – Karpushko Laser	
Martek Power Laser Drive	
Micro Laser Systems	Lepton OEM Series Pion Turnkey
Newport: Spectra-Physics	Innova, Millennia, Empower
OEM Laser	

Diode/Semiconductor Lasers	
Common Manufacturers	**Laser Names**
Oxxius	
Power Technology Incorporated	
Qioptiq	
Quantel	
Sacher	

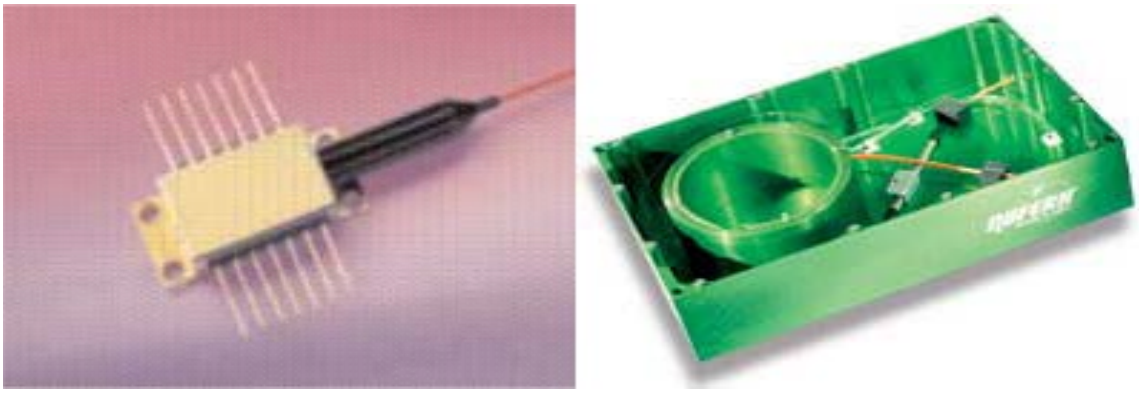

Figure 1: Optical Fiber and Diode Assembly

Diode/Telecommunications Laser Systems

ACTIVE CONCERNS

In a majority of cases, these lasers contain optical fibers, which are used to deliver laser radiation. A majority of injuries come from handling the fibers. Treat them as potentially "sharp" components.

COMMON TELECOMMUNICATION LASERS

- Gallium Aluminum Arsenide
- Gallium Arsenide
- Indium Gallium Aluminum Phosphide Laser
- Ytterbium-Doped Fiber

DISPOSAL

Fibers are to be treated as sharp optical components and need to go into sharp, disposable container. Safety glasses and gloves are to be worn when handling (cut or remove from diode on laser box).

Hazardous Materials to consider

- Silicon

Diode/Telecommunications Laser Systems
Common Manufacturers
Hamamatsu Photonics
Calmar Laser Inc.
Rofin-Baasel Inc
IPG Photonics Corp
IMRA America Inc
SPI Lasers
nLight Corp
MPB Communications Inc
OZ Optics Ltd

Figure 2: Commercial Diode Systems and Telecommunication Products

Optical Parametric Oscillators and Amplifiers (OPO/OPA)

ACTIVE CONCERNS)

There are no active concerns for OPO/OPA.

DISPOSAL

Remove the optics and place in a ziplock bag.

APPENDIX A: Vendors Specializing in Selling Used Laser Equipment
For each of the following companies, check to ensure they will dispose of the laser.

Directed Light Inc: http://www.directedlight.com (Local Company)

DZ Laser Service, Inc.: http://www.dzlaser.com/

Cambridge Laser Laboratories: http://www.cambridgelasers.com/home.html

Evergreen Laser Corporation: http://www.evergreenlaser.com/

Holo-Spectra Inc: http://www.lasershs.com/ion_laser_repair_refurbishment.htm

Laser Labs Inc.: http://www.laserlabs.com/index.php

Laser Resale, Inc.: http://www.laserresale.com/

Meredith Instruments: http://www.mi-lasers.com/

Midwest Laser Products, LLC: http://www.midwest-laser.com/index.html

APPENDIX B: Electronics Recyclers
For each of the following companies, check to ensure they will dispose of the laser.

http://www.americanewasterecyclers.com/

http://www.epa.gov/osw/conserve/materials/ecycling/

http://electronicrecyclers.com/

APPENDIX C: Overview on Lasers

What is a Laser

Laser is also an acronym for **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation.

How Lasers Work

Lasers are made up of several components:

- Excitation Mechanism
- Active/Lasing Medium
- Optical Resonator

In a laser, the lasing medium is “pumped” to get the atoms into an excited state. In the excited state, the electrons release their excess energy by giving off a particle of light or a photon. Electrons release their excess energy because they like being in the lowest state possible or ground state. This release of light energy from electrons is called emission. The emitted photon of light has a very specific wavelength that depends on the state of the electron’s energy when the photon was released. Atoms that have the same electrons in identical states will release photons with the same wavelengths. The photon that any atom releases has a certain wavelength that is dependent on the energy difference between the excited state and the ground state. If this photon (possessing a certain energy and phase) should encounter another atom that has an electron in the same excited state, stimulated emission can occur. The first photon can stimulate or induce atomic emission such that the subsequent emitted photon (from the second atom) vibrates with the same frequency and direction as the incoming photon. The other key to a laser is a pair of mirrors**,** one at each end of the lasing medium. Photons, with a very specific wavelength and phase, reflect off the mirrors to travel back and forth through the lasing medium. In the process, they stimulate other electrons to make the downward energy jump and can cause the emission of more photons of the same wavelength and phase. A cascade effect occurs, and soon we have propagated many, many photons of the same wavelength and phase. The mirror at one end of the laser is "half-silvered," meaning it reflects some light and lets some light through. The light that makes it through is the laser light.

- The light released is **monochromatic.** It contains one specific wavelength of light (one specific color). The wavelength of light is determined by the amount of energy released when the electron drops to a lower orbit.
- The light released is **coherent**. It is “organized” - each photon moves in step with the others. This means that all of the photons have wave fronts that launch in unison.
- The light is very **directional**. A laser light has a very tight beam and is very strong and concentrated. A flashlight, on the other hand, releases light in many directions, and the light is very weak and diffuse.

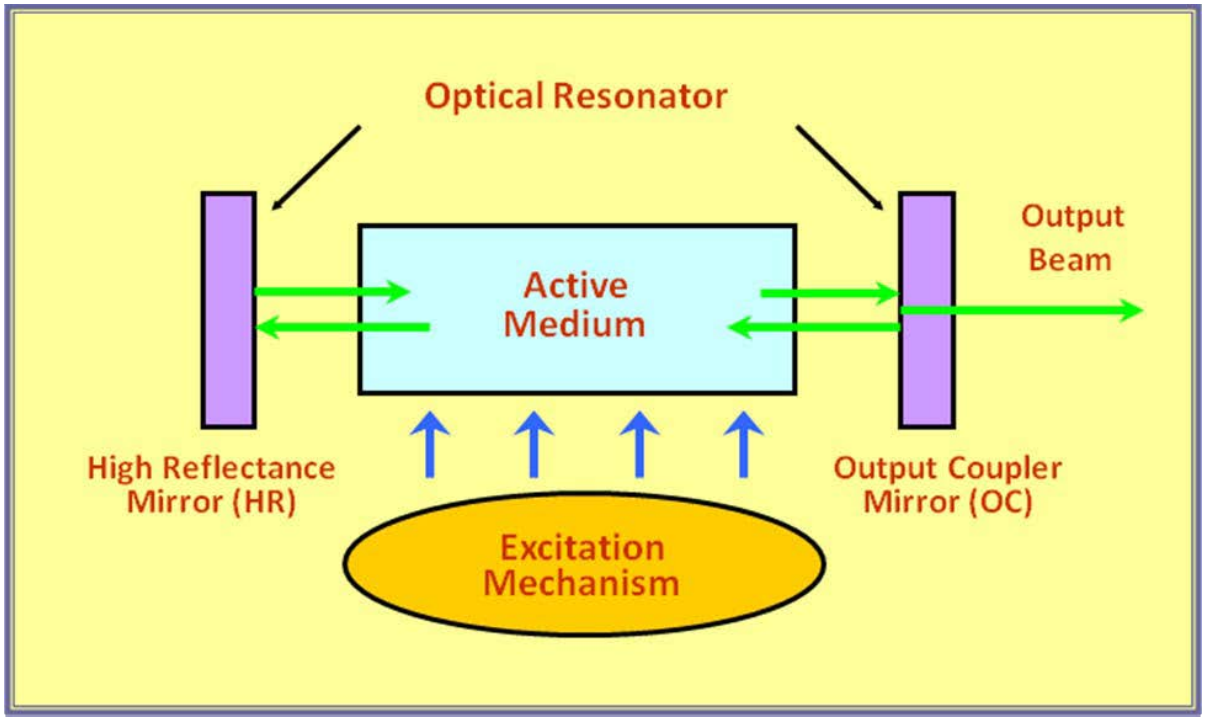

Figure 3: Classical Representation of a Laser

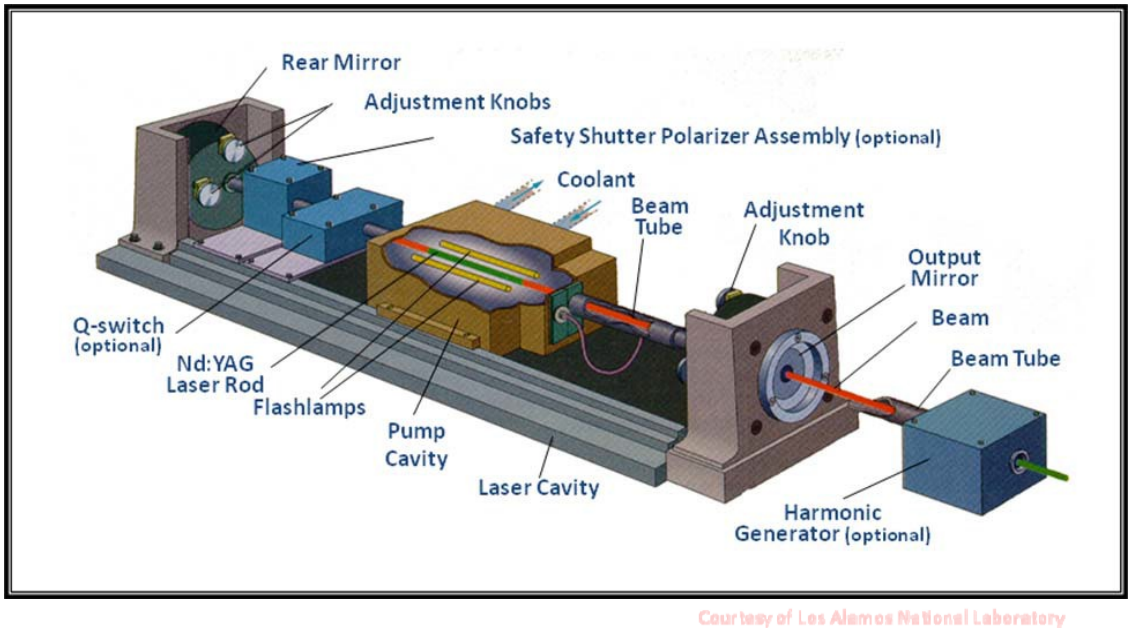

Figure 4: Real World Image of a Laser

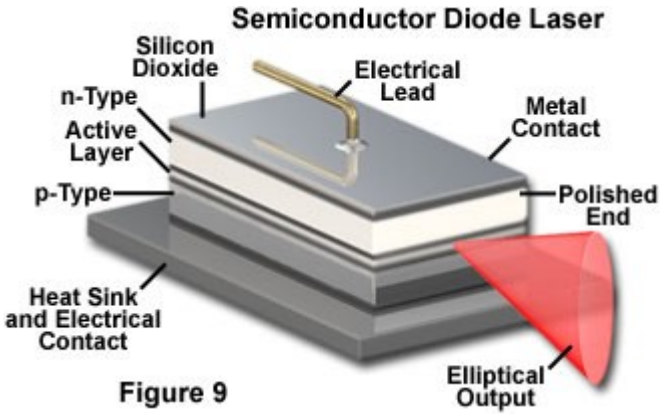

Figure 5: Semiconductor Diode Laser

APPENDIX D: MSDS Health Hazards for Common Chemicals Found in Lasers

What is the MSDS?

A Material Safety Data Sheet (MSDS) is an informational document prepared by the manufacturer or importer of a hazardous chemical that describes its physical and chemical properties, its physical and hazards and recommended precautions for handling, storage and disposal.

Where to Find the MSDS?

A Complete Database of MSDS can be found on the LBNL A-Z Index under MSDS: Material Safety Data Sheet. The Following MSDS are from ChemWatch (chemFFX) Material Safety Datasheets: http://www.ucmsds.com/?X.