Argon lasers are normally rated, with standard mirror coatings, by the power level produced by the six simultaneously lasing wavelengths from 514.5 nm to 457.9 nm. They can be separated into their individual lines by using an external prism or other dispersive elements as illustrated. The approximate distribution of the output power among the six wavelengths of a multiline argon laser operating at full rated power is given in the following chart.

Wavelength	Percent of Total Power
514.5 nm	43
501.7 nm	5
496.5 nm	12
488.0 nm	20
476.5 nm	12
457.9 nm	8

Pumping requirements for Ar^+ laser

As it was mentioned before, He-Ne laser operates at high voltage and with relatively low current(this situation is also hold to CO_2, metal vapor, and excimer lasers), but Ar^+(or Kr^+)lasers have different power requirements than do the gas lasers. The Ar^+ laser requires much higher current to achieve the necessary amount of ionization, where it may be draw (10 – 70) A of current depending on the output power required, but typical operating voltages are low, perhaps around 200 V, as it could be seen in Fig.2.10 which shows the current / voltage Characteristics of

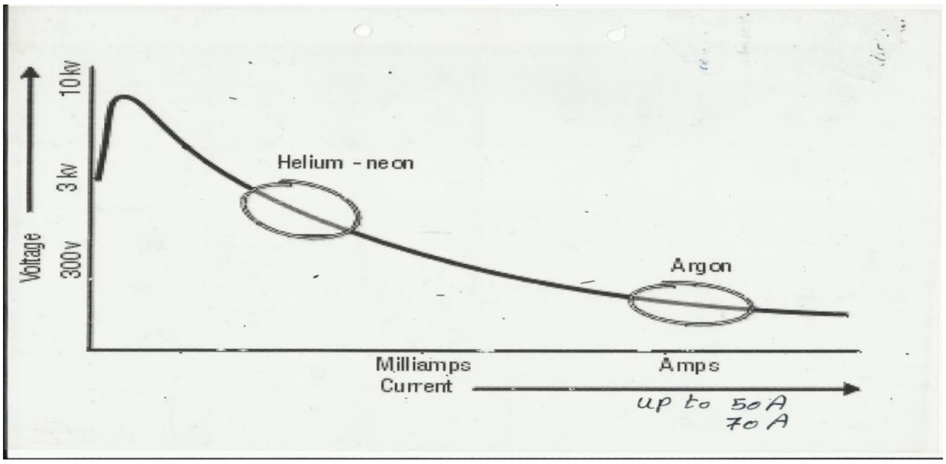


Figure 2.10: Voltage – current characteristic curve.

a gas discharge with the relative regions for operation of He-Ne lasers and Ar^+ lasers. In the region where Ar^+ lasers operate, a change of (1-2)A in tube current may result in a voltage change of only a few volts.

Because of the large pumping energies required the discharge itself must be very intense, requiring current densities of up to 1000 A/ cm^2(0.16 A/ cm^2 for a small He-Ne laser).Even in a relatively low-powered device about a kilowatt or so of power may need to be dissipated. As a result Ar ion laser requires active cooling; water cooling for high power lasers and forced-air cooling for low power lasers.

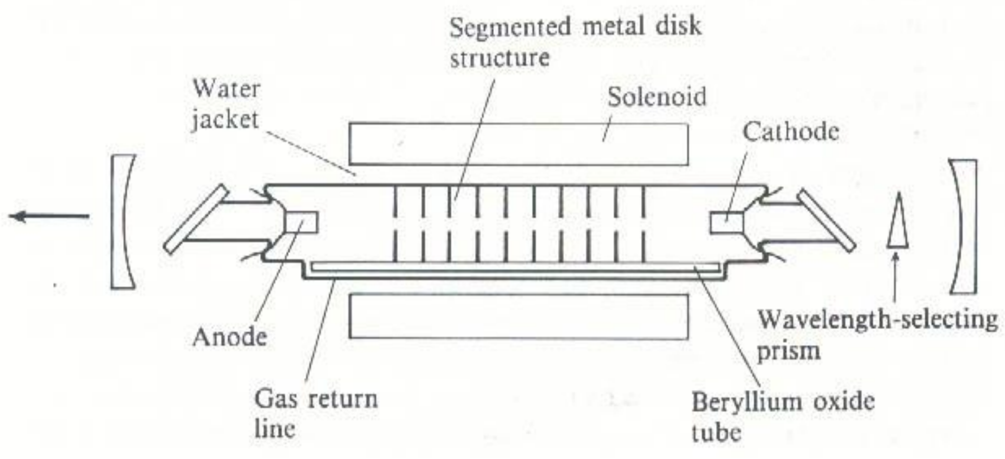
Many hostile conditions inside Ar^+ laser might arise from the high current densities. They are :

1. Sputtering of materials in the laser tube.
2. Erosion of the surfaces.
3. Electrode degradation.
4. Contamination of the laser gas.
5. trapping of gas atoms in the walls of the tube.

Because of these hostile conditions, the design of Ar ion laser requires considerable engineering skill to achieve operational reliability in the face of these harsh operating conditions. For example, extensive research led to development of two major types of ion laser tubes that are used in all argon and krypton lasers today.

The Argon Ion laser Structure

A typical tube design is shown in Figure 2.11. Brewster windows and the use of external cavity mirrors serve to eliminate damage to the mirror surfaces. The tube itself must be made from a refractory material (special high melting material and has very high thermal conductivity)



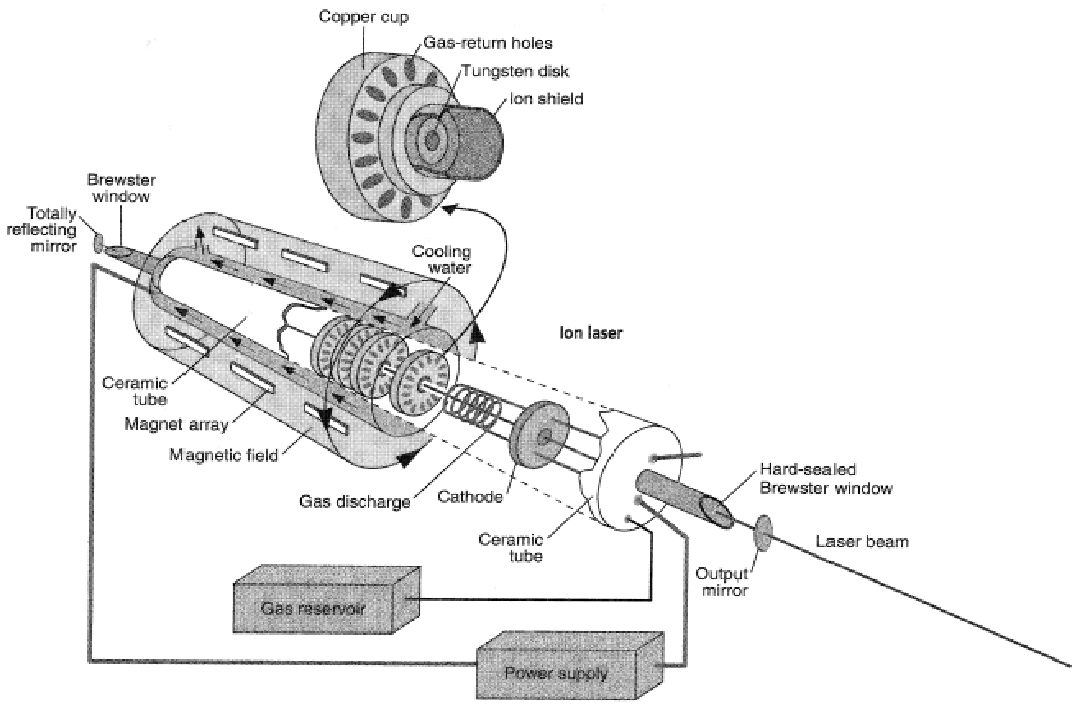


Figure 2.11: Construction of a typical argon ion laser.

such as graphite or beryllium oxide in order to withstand the high temperatures (about 5000^0C) and is not destroyed by the electrical discharge. There is a solenoid (magnet) surrounding the laser tube which produce magnetic field along the tube axis to increase the efficiency of the laser since the ions spiral along the tube axis and are kept away from the walls. This has the effect of confining the current near the center of the tube and increase the current density there. This will increase the output power of the laser. Annular metal disks with holes at their centers are usually placed at intervals along the tube. The holes define the active discharge region, while the disks themselves serve to conduct heat away from the discharge to the tube walls. Also there are off axis holes around the central holes to allow for a gas return path. This is necessary because during operation the positive ions generated tend to collect at the cathode, a return line helps to equalize the pressure throughout the tube.

A water jacket surrounding the tube is often used for additional cooling. The gas refill reservoir is used for gas replenishment since argon gas is depleted during operation hence argon pressure drops below a specified value. The wavelength selecting prism allows operation on a single one of the wavelengths available, i.e., allows easy tunability and selection of many of any of the individual lasing wavelengths. The radiation of Argon

Ion laser is hazardous to view, and working with it requires special protecting goggles for everyone in the room.

The Argon Ion laser applications

1. A source for optical pumping of Dye laser.
2. Entertainment - in laser light shows, discotheques, and laser displays.
3.General Surgery-for applications that use absorption at specific wavelengths.
4. Ophthalmic welding of detached retina.
5. Forensic Medicine - for fluorescence measurements.
6. Holography - Because of its high power in the visible spectrum.

2.5.2 Krypton Laser

The Krypton-ion laser is almost identical in construction, reliability and operating life to argon laser, but its efficiency is lower. Under some conditions krypton laser can produce wavelengths over the full visible spectrum with lines in the red, yellow, green and blue. The 647.1 nm and 676.4 nm red lines are the strongest and result in the best performance. The maximum output power in each line is about 100 mW. The main applications of this laser are in the art and entertainment business, to create fantastic visual effects.

QUESTIONS

1. What are the emission characteristics of ion lasers?
2. Why would we expect a low overall power efficiency of Ar^+ laser?

Ans:

Because of the high energy (≈ 35 eV) two – stage pumping process which is involved:

a- The ionization energy (≈ 16 eV) must be supplied to the laser but is not used for creating laser radiation.

b- The relatively large excitation energy (≈ 20 eV)

Hence low power efficiency is expected [few hundredths of a percent (< 0.1%)].

3. What are the different lines that emitted from Ar^+ laser? What are the two strongest lines?

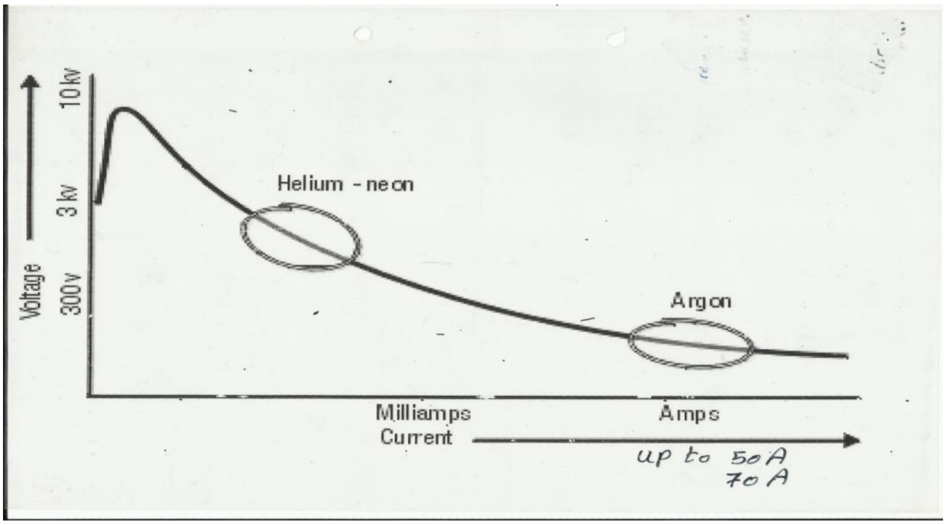
4. Why are the Ar^+ lasers require high current densities?

5. Why are the Ar^+ lasers require active cooling?

6. Describe the differences in the current/voltage characteristics of an Ar^+ laser as compared to a He-Ne laser?

Ans:

He-Ne laser operates at high voltage and with relatively low current (this situation is also hold to Co_2 , metal vapor and excimer lasers), but Argon (or krypton) ion lasers have different power requirement than do the gas lasers. The Ar^+ laser requires much higher current to achieve the necessary amount of ionization. Ar^+ laser may draw 10 to 70 amperes of current depending on the output power required. But typical operating voltages are low, perhaps around 200 Volts. The figure below shows the current / characteristics of a gas discharge with the relative regions for operation of He-Ne lasers and Ar^+ lasers. In the region where Ar^+ lasers operate, a change of 1-2 amperes in tube current may result in a voltage change of only a few volts.



7. Give an empirical relation for predicting approximate power output of an Ar^+ laser. What could you conclude from the relation?

8. What are the hostile conditions inside Ar^+ laser that might arise from high current density?

9. Why does the Ar ion laser require a considerable engineering skill?

10. Locate and identify the major components of an Ar ion laser. Give a list of the components and their functions.

11. Explain the function of the magnetic field used in Ar ion laser.