LASER in Industrial Application

Dr. Enas A. Khalid

What is Laser?

Light Amplification by Stimulated Emission of Radiation

- A device produces a coherent beam of optical radiation by stimulating electronic, ionic, or molecular transitions to higher energy levels
- Mainly used in Single Mode Systems
- Require Higher complex driver circuitry than LEDs
- Laser action occurs from three main processes: photon absorption, spontaneous emission, and stimulated emission.

Properties of Laser

- Monochromatic

  Concentrate in a narrow range of wavelengths (one specific colour).

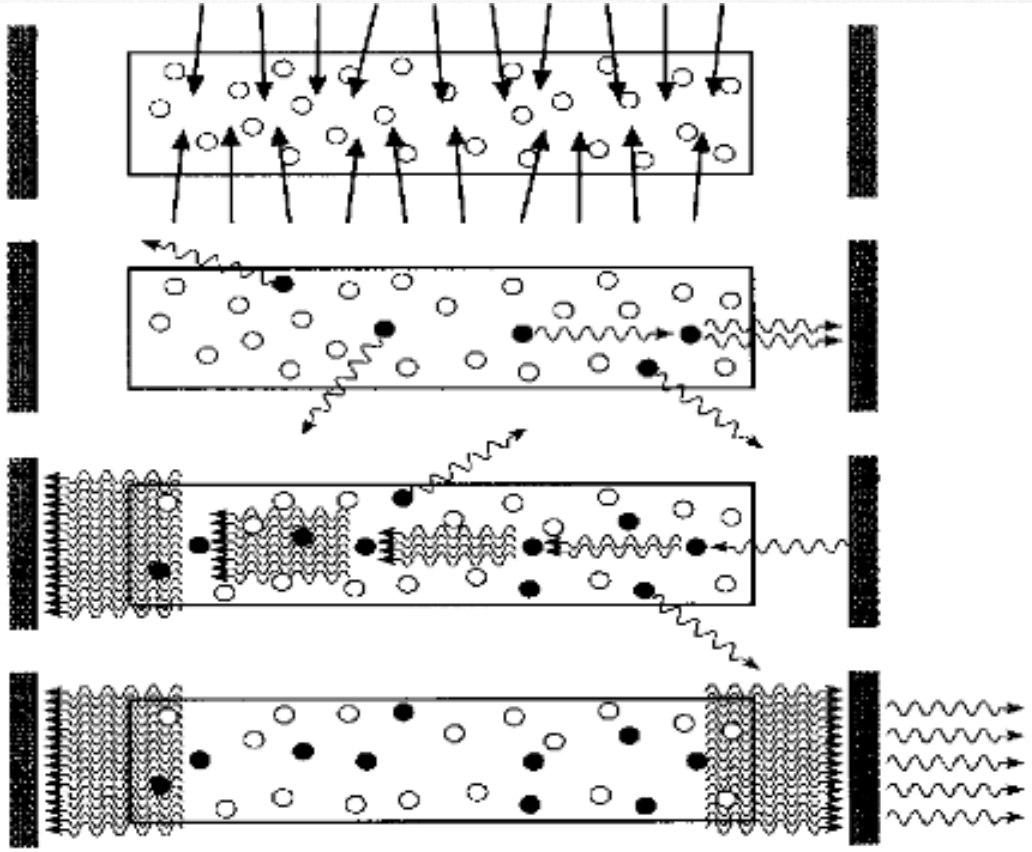
- Coherent

  All the emitted photons bear a constant phase relationship with each other in both time and phase

- Directional

  A very tight beam which is very strong and concentrated.

How a Laser Works



pump on
○ = atoms in excited state

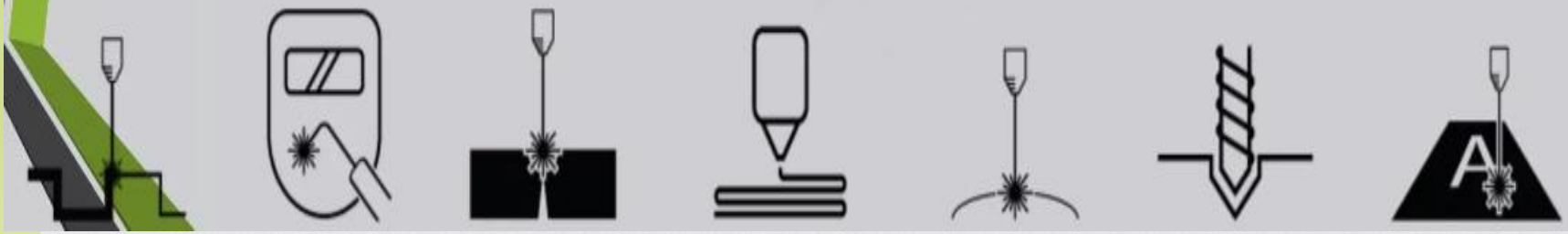
spontaneous emission &
rare stimulated emission

stimulated emission of
light along the laser axis

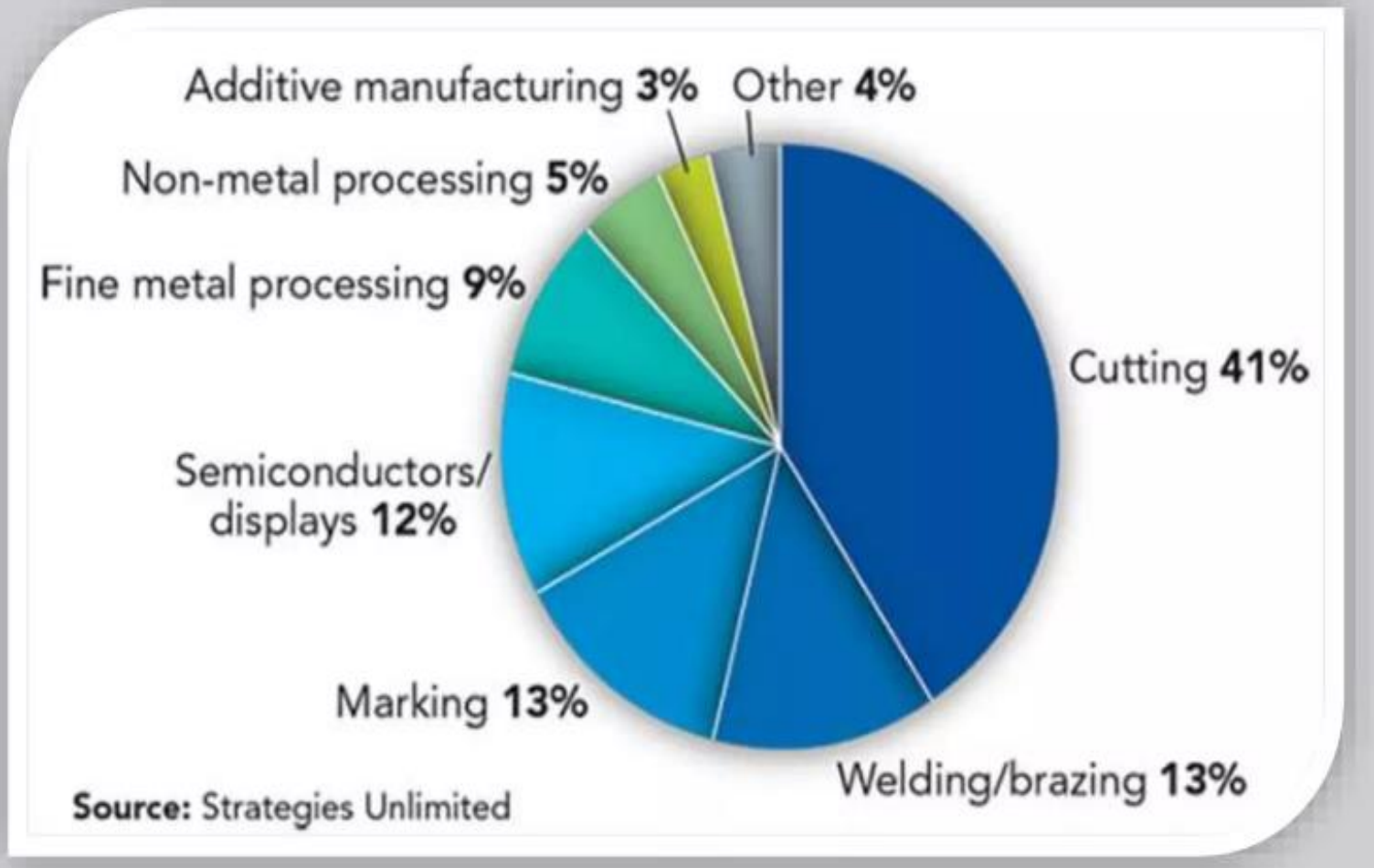
steady-state
laser operation

INTRODUCTION

- Laser materials processing is done on various materials such as **metals, alloys, ceramics, glass, polymer** materials.
- New manufacturing process is based on **Laser as a tool**.
- Laser processing provides a competitive **advantage over traditional methods** of industrial fabrications.
- High power **Pulsed, Continues** wave or both forms of Laser beam are used.
- Novel applications using Lasers are still emerging everyday.



Total Industrial Laser Applications



- CO_2 lasers are primarily deployed for cutting, welding and drilling of medium-size and large workpieces.

Laser Interaction with Materials

- Two types of Laser processes:-

a) **Athermal Processing**- Photoelectric, Photochemical & Photophysical.

b) **Thermal Processing**- Heating, Melting & Vaporization.

- When a laser beam is incident on a metal or other material, the radiation energy is absorbed, and the material heats up.
- Depending on the amount of absorbed energy and interaction time, the material is even melted or vaporized.
- Once the surface of the materials absorbs energy, the material starts to melt and then vaporize.

Type of Industrial Lasers

❖ Lasers widely used in material processing are CO_2 laser and Nd:YAG laser.

➢ **CO_2 Lasers :**

- CO_2 lasers operate at 10.6µm. Metals having high reflectivity and Glass have better absorption at this wavelength.
- Instead of CW CO_2 laser, a pulsed mode CO_2 laser produces high peak powers and makes possible to work on metals.

➢ **Nd:YAG lasers :**

- Nd:YAG lasers operate at 1.06µm, can be focused to a smaller diameter and fiber optic beam delivery is possible.
- Nd:YAG lasers offer the advantage of compactness.

❖ CO_2 lasers are cheaper compared to Nd:YAG lasers.

❖ CO_2 lasers are more generally preferred laser.

❖ Multikilowatt fiber lasers are also used.

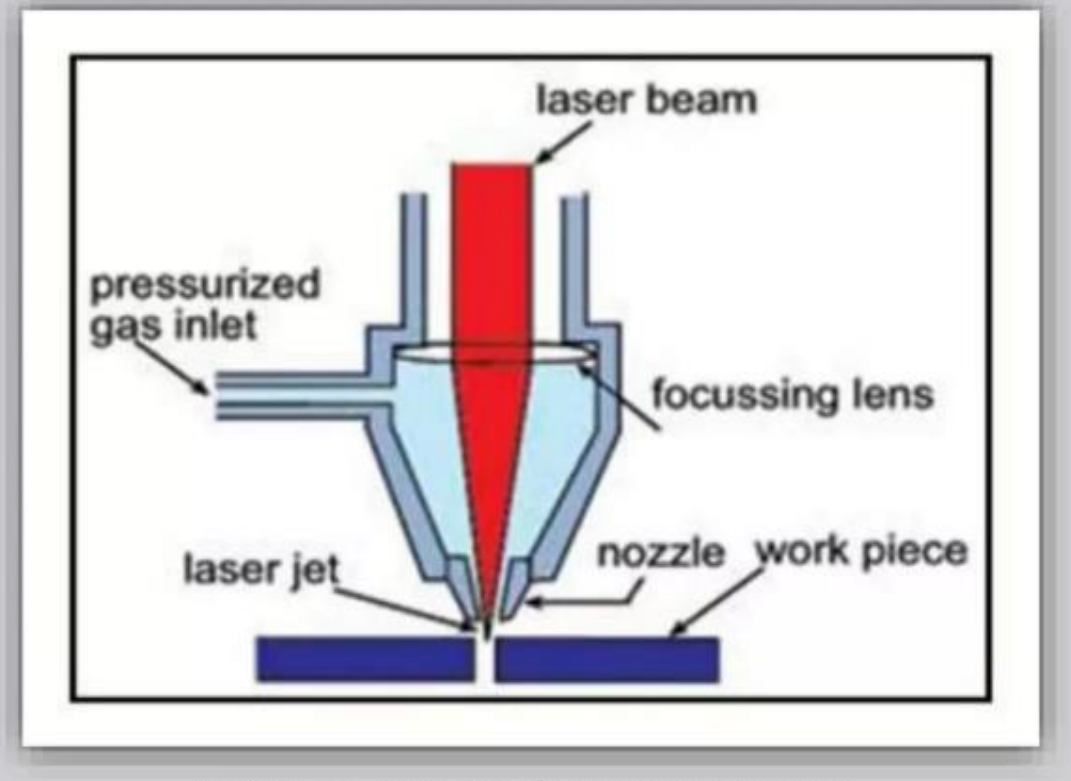
Laser Cutting

- Cutting of Metal Sheets, Foils and Glasses. Provides **high edge quality**.
- Laser cutting is highly focusable to about 25 microns.
- Computer Numerical Control **(CNC)** programmed cutting machines.
- **Melt fusion mechanism-** material is expelled by the kinetic energy of a assist gas.
- The efficiency of laser cutting can be increased by making use of a gas jet coaxial with the laser.

CO_2 laser (1kw-10kw).
Use of assist gas like Ar,He,N_2.

Conventional cutting methods:

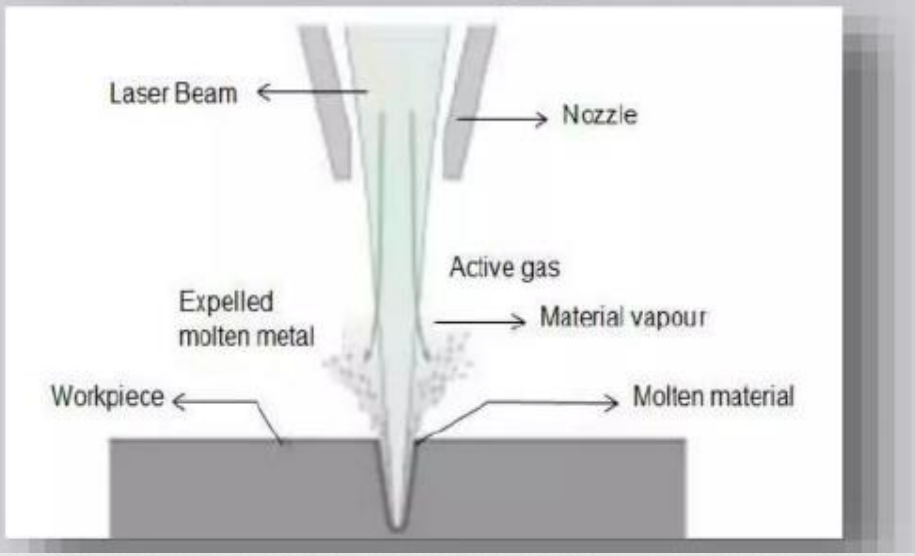
- Plasma arc cutting
- Mechanical cutting
- Water jet cutting
- Glass cutting using diamond



Schematic diagram of a laser cutting head

Laser Drilling

- A series of pulses is fired at a fixed location on the workpiece.
- Usually powerful light pulses of duration 10^{-4} to 10^{-6} sec is used.
- The material subject to laser drilling is vaporized and melted layer by layer until drill holes are created.
- Radiation becomes trapped in the keyhole, inducing plasma formation.
- Use of assist gas like O_2.



Conventional drilling methods:

- Mechanical drilling
- Mechanical punching
- Electro chemical machining
- Electro discharge machining

Laser Welding

- Metal sheets are welded together by so-called **heat conduction welding.**
- The laser beam heats the edges of two plates to their melting points and cause them to **fuse** together where they are in contact.
- Laser beam is scanned over the surface of the mating parts **along common joint**.
- Widely used in **Automobile, Electronics, Jewellery, Engineering** manufacturing industries.

Conventional welding methods:

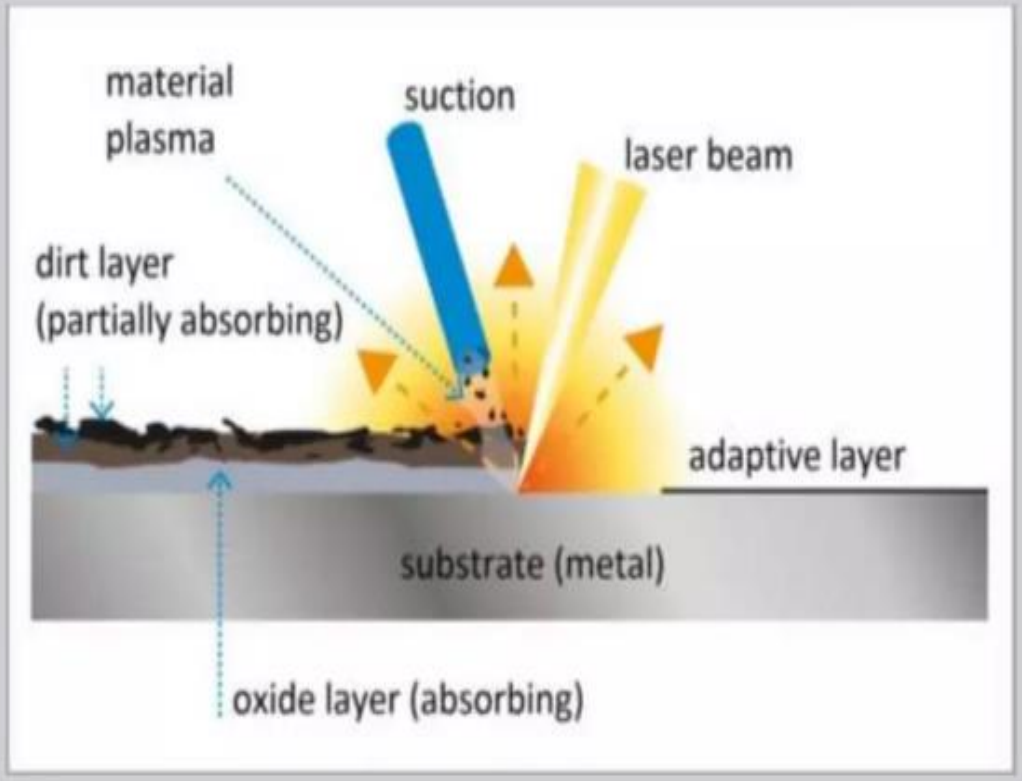
- Resistance welding
- Ultrasonic welding
- Soldering
- Brazing

Surface Cleaning

- Laser cleaning is an **non-contact** process used to remove rust, paint, oxide and other contaminants from metal surfaces.
- The physical reaction during the surface cleaning of metal surface oxide is also known as **Ablation**.
- Laser ablation occurs when a material layer or a coating is removed with a laser beam.
- Vaporize the undesired material into **fumes** by heating effect of Laser beam.
- Energy transferred by the laser beam must be above the **ablation threshold**.
- Laser cleaning requires a pulsed fiber laser (typically 50 watts or more).

Conventional cleaning methods:

- Oxides removal using hazardous chemicals.
- Paint removal by sand blasting.



Surface Cleaning Applications

- Old paint removing
- Fine finish surfaces
- Rust & Oxide removing
- Welding pre & post treatments
- Removing oil from the surface of materials
- Removing the burnt rubber residue from tire molds

Other Applications

- Hardening of Ferrous materials- Stainless steels, Titanium alloys .
- Labeling and Marking/Engraving- Serial number, Barcodes.
- Production of Semiconductor Devices- Laser Annealing.
- Laser Deposition of Thin film- Photolithography.
- Electronic Components- PCB fabrication.
- Optical communications.
- Military.

Advantages

- Accuracy & **Precision**.
- **Non-contact** technique.
- **Rapid** processing.
- Multi functional machines.
- Flexible beam guiding through **optical fibers**.
- Beam can be focused to very small to large areas.
- Compactable with **computer-aided manufacturing** (CAM) systems.
- Absence of tool wear and tear.

Thank You