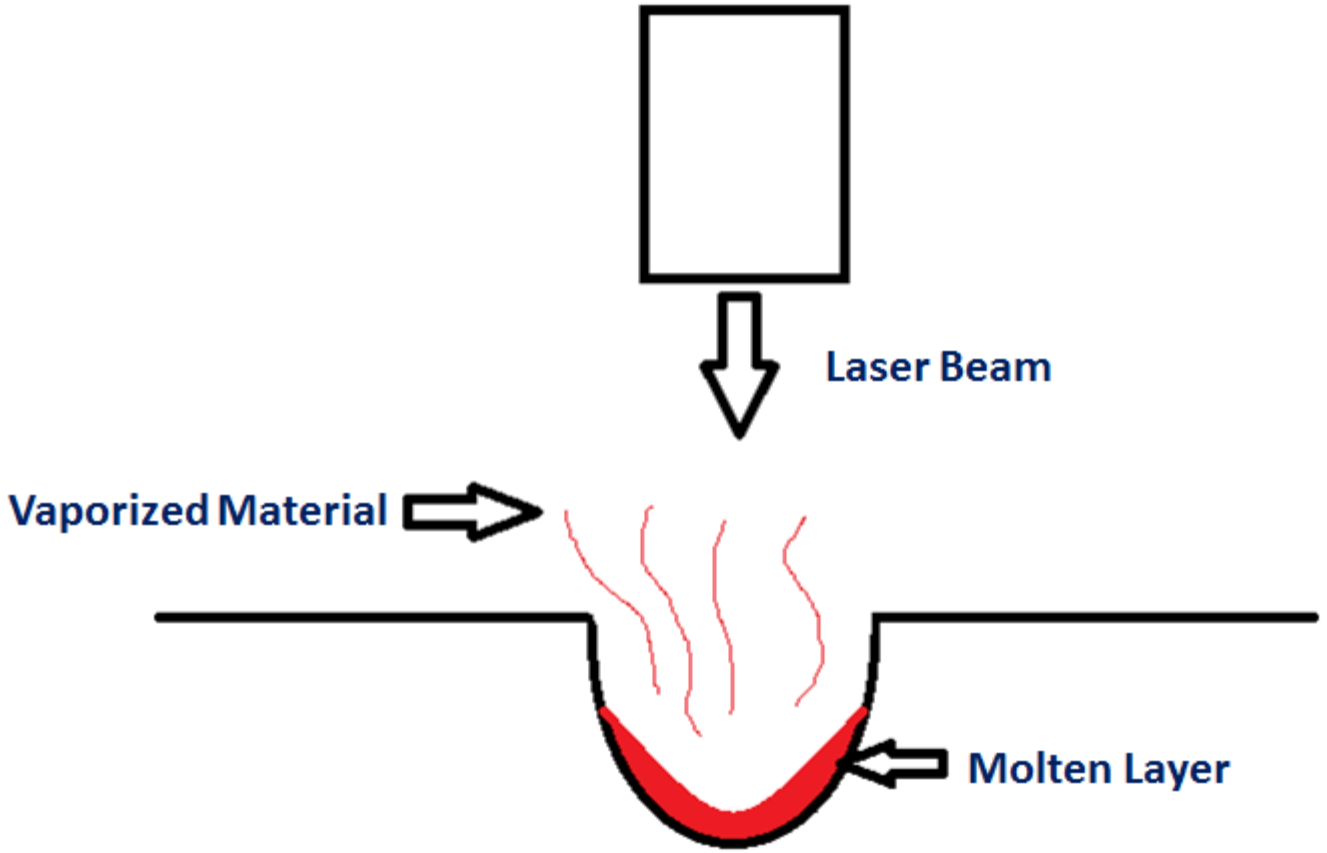
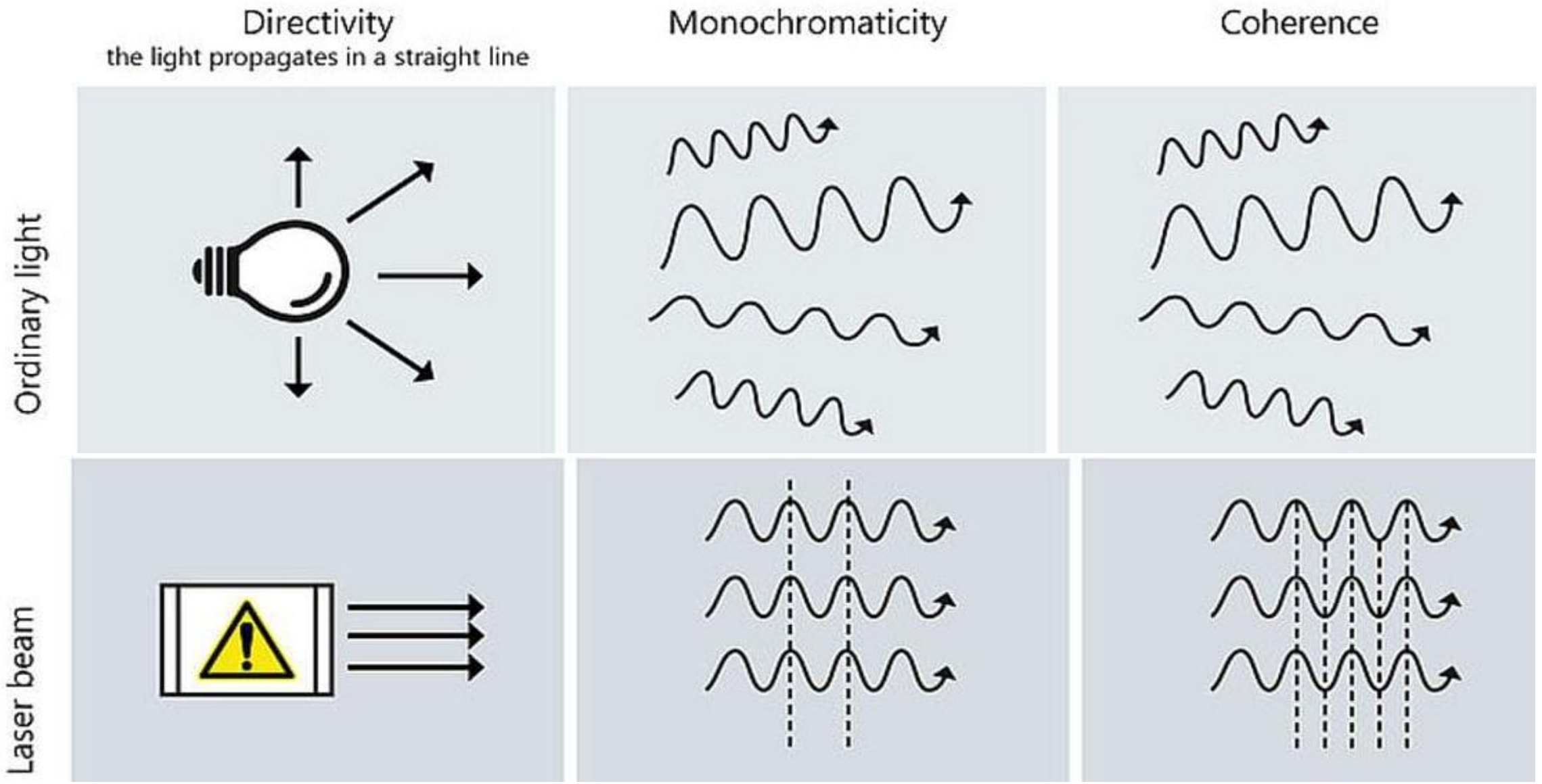
Do you know that some machining operations do not involve a physical tool ?

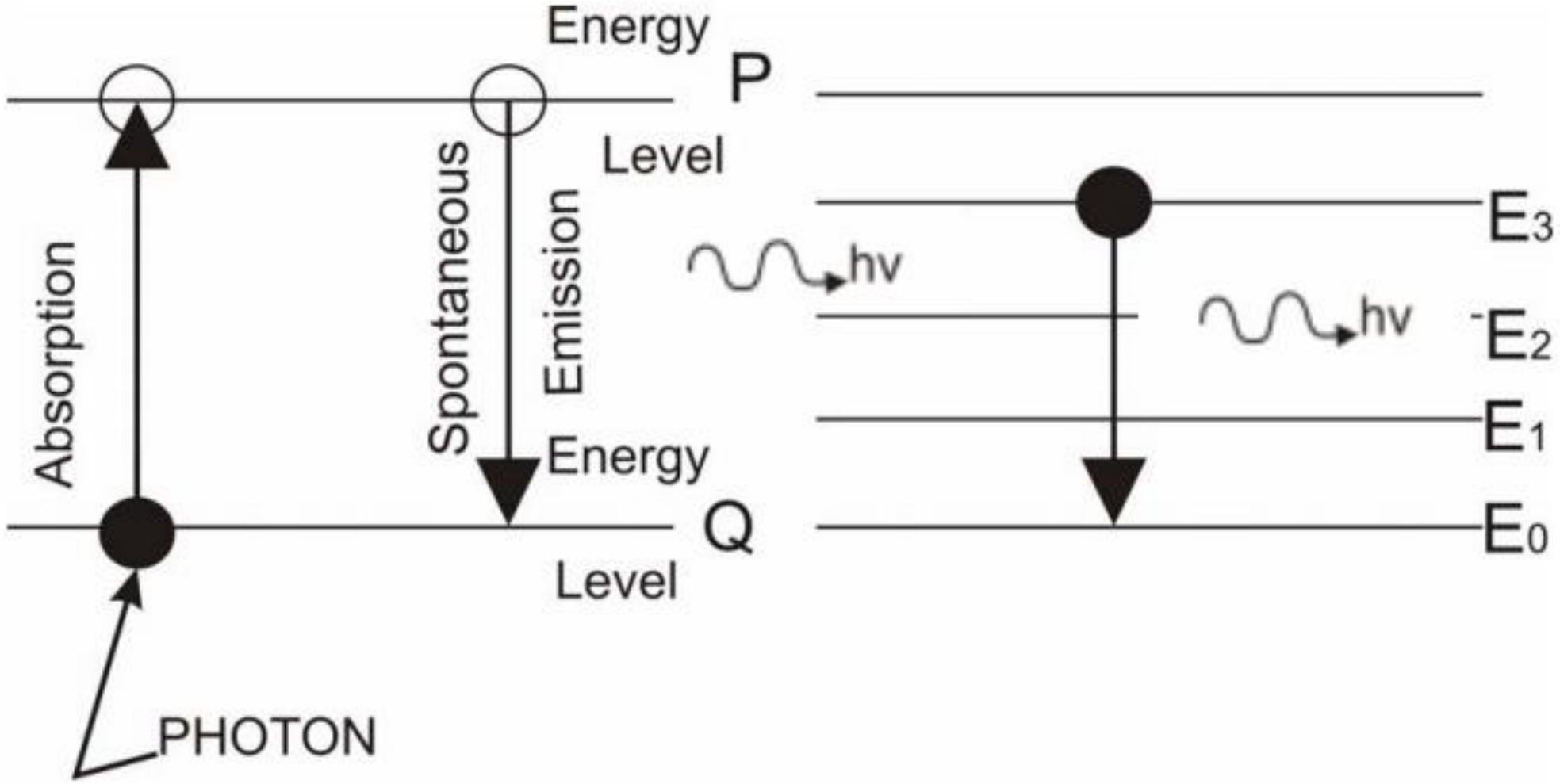
Laser Beam Machining



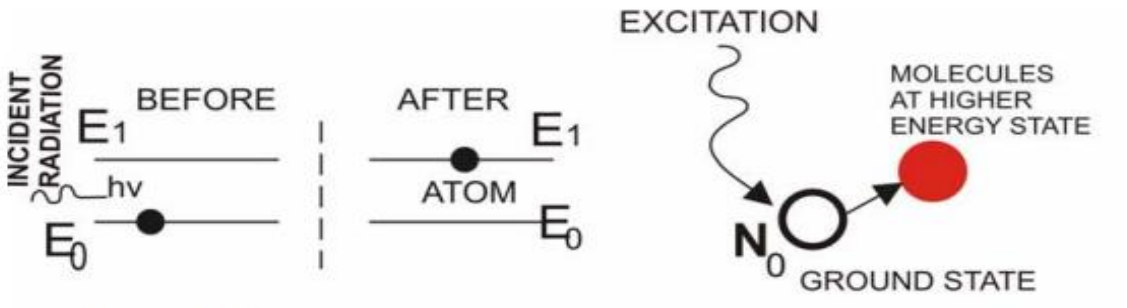
What is LASER- Light Amplification by Simulated Emission of Radiation



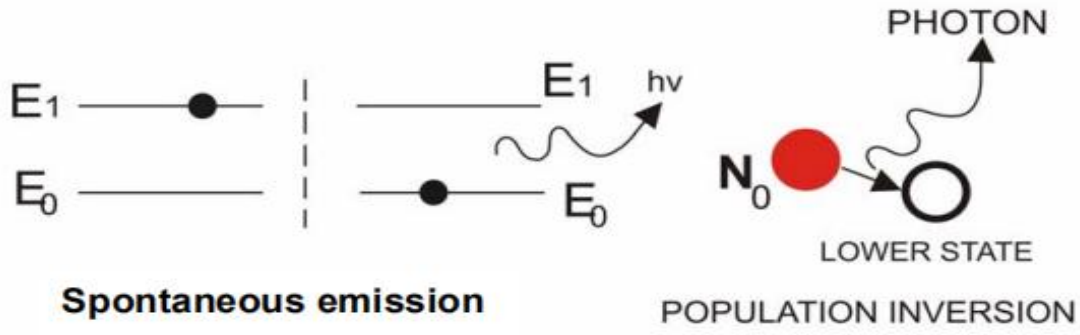
Energy Bands in Materials



Mechanism for LASER

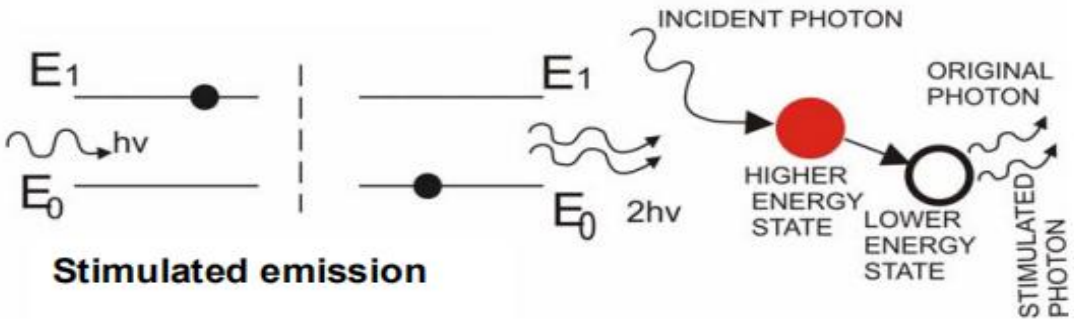


Stimulated absorption



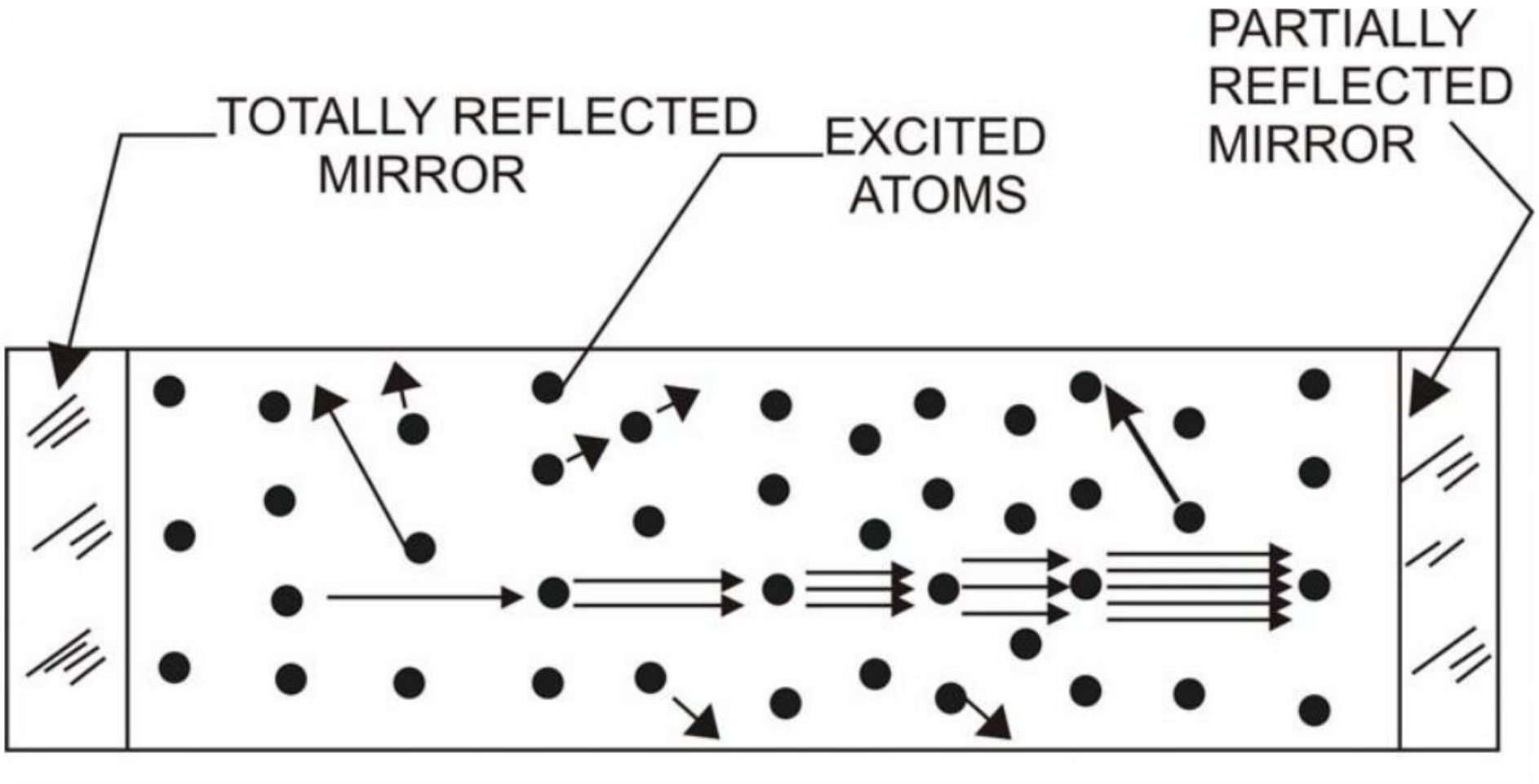
Spontaneous emission

POPULATION INVERSION



Stimulated emission

Lasing Action



Lasing Medium

- Many materials can be used as the heart of the laser.
- Depending on the lasing medium, lasers are classified as solid state lasers and gas lasers.

Solid-state lasers are commonly of the following type

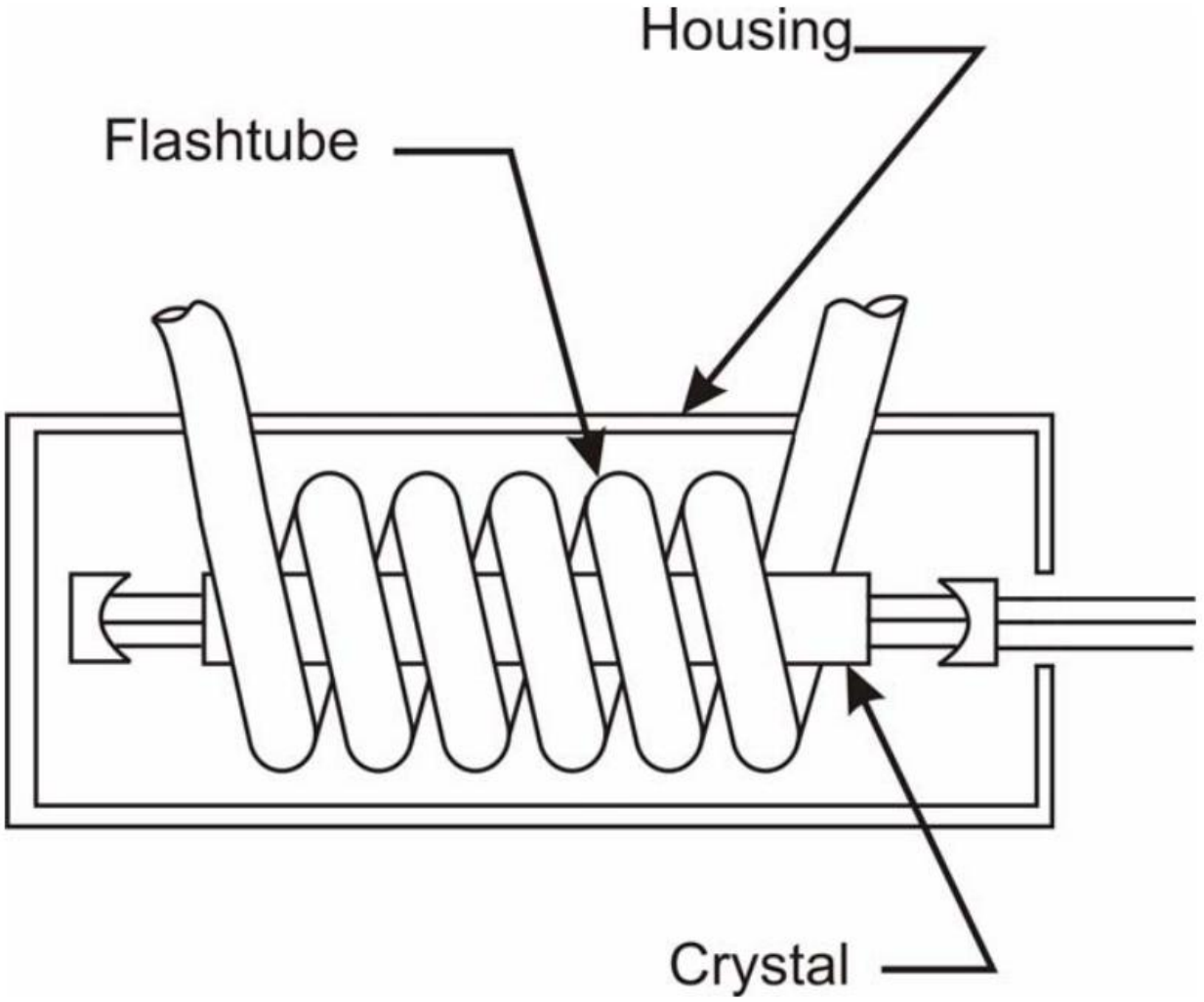
- Ruby which is a chromium – alumina alloy having a wavelength of 0.7 μm
- Nd-glass lasers having a wavelength of 1.64 μm
- Nd-YAG laser having a wavelength of 1.06 μm

Lasing Medium

The generally used gas lasers are

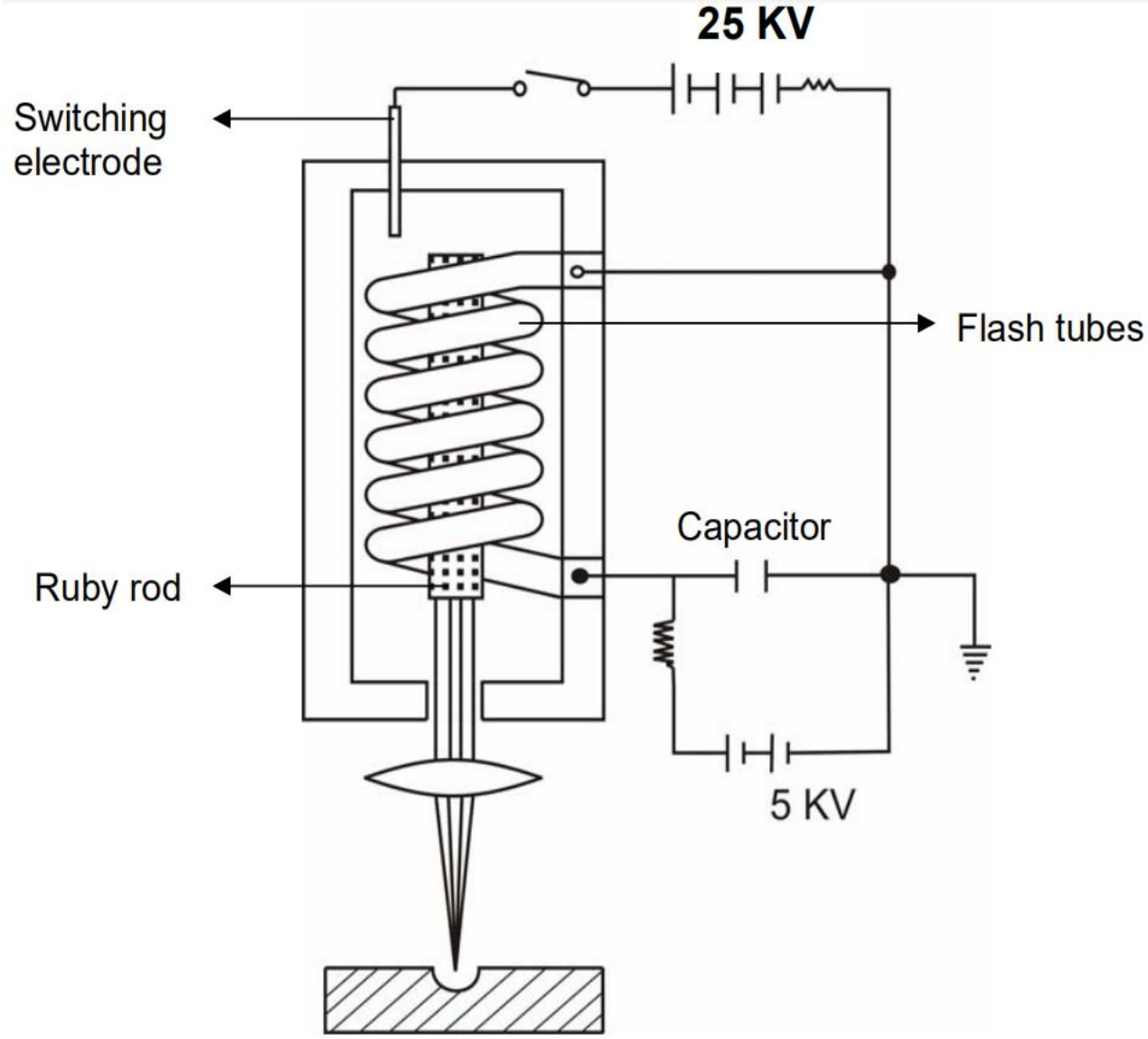
- Helium – Neon
- Argon
- CO_2 etc.
- Lasers can be operated in continuous mode or pulsed mode.
- Typically, CO_2 gas laser is operated in continuous mode for cutting operations.
- Nd – YAG laser is operated in pulsed mode.

Solid-state laser with its optical pumping unit



Solid-state laser – The device

- The figure shows the electrical circuit for operation of a solid-state laser.
- The flash tube is operated in pulsed mode by charging and discharging of the capacitor.
- There is also a high voltage switching supply for initiation of pulses.



Process Characteristics of different types of Lasers

Application	Type of laser
Large holes upto 1.5 mm dia.	Ruby, Nd-glass, Nd-YAG
Large holes (trepanned)	Nd-YAG, CO_2
Small holes > 0.25 mm dia.	Ruby, Nd-glass, Nd-YAG
Drilling (punching or percussion)	Nd-YAG, Ruby
Thick cutting	CO_2 with gas assist
Thin slitting of metals	Nd-YAG
Thin slitting of plastics	CO_2
Plastics	CO_2
Metals	Nd-YAG, ruby, Nd-glass
Organics, Non-metal	Pulsed CO_2
Ceramics	Pulsed CO_2, Nd-YAG

Laser Beam Machining – Application

- Laser can be used in wide range of manufacturing applications
- Material removal – drilling, cutting and trepanning
- Welding
- Cladding
- Alloying

Laser Beam Machining – Application

- Drilling micro-sized holes using laser in difficult – to – machine materials is the most dominant application in industry.
- In laser drilling the laser beam is focused over the desired spot size.
- For thin sheets, pulse laser can be used.
- For thicker ones, continuous laser may be used.

Advantages of LBM

- In laser machining there is no physical tool.
- Thus no machining force or wear of the tool takes place.
- Large aspect ratio in laser drilling can be achieved along with acceptable accuracy or dimension, form or location
- Micro-holes can be drilled in difficult – to – machine materials
- Though laser processing is a thermal processing but heat affected zone specially in pulse laser processing is not very significant due to shorter pulse duration.

Laser Beam Machining – Shortcomings

- High initial capital cost
- High maintenance cost
- The process efficiency is low
- Presence of Heat Affected Zone – specially in gas assist CO_2 laser cutting
- Thermal process – not suitable for heat sensitive materials like aluminium, glass fibre laminate

Abrasive Jet Machining (AJM)

AJM- Definition

In AJM, The material removal takes place due to the impingement of the fine abrasive particles. These particles move with a high speed air (or gas) stream. The abrasive particles are typically of 0.025 mm diameter and the air discharges at a high pressure (0.2 N/mm^2 to 1.0 N/mm^2).

AJM- Schematic

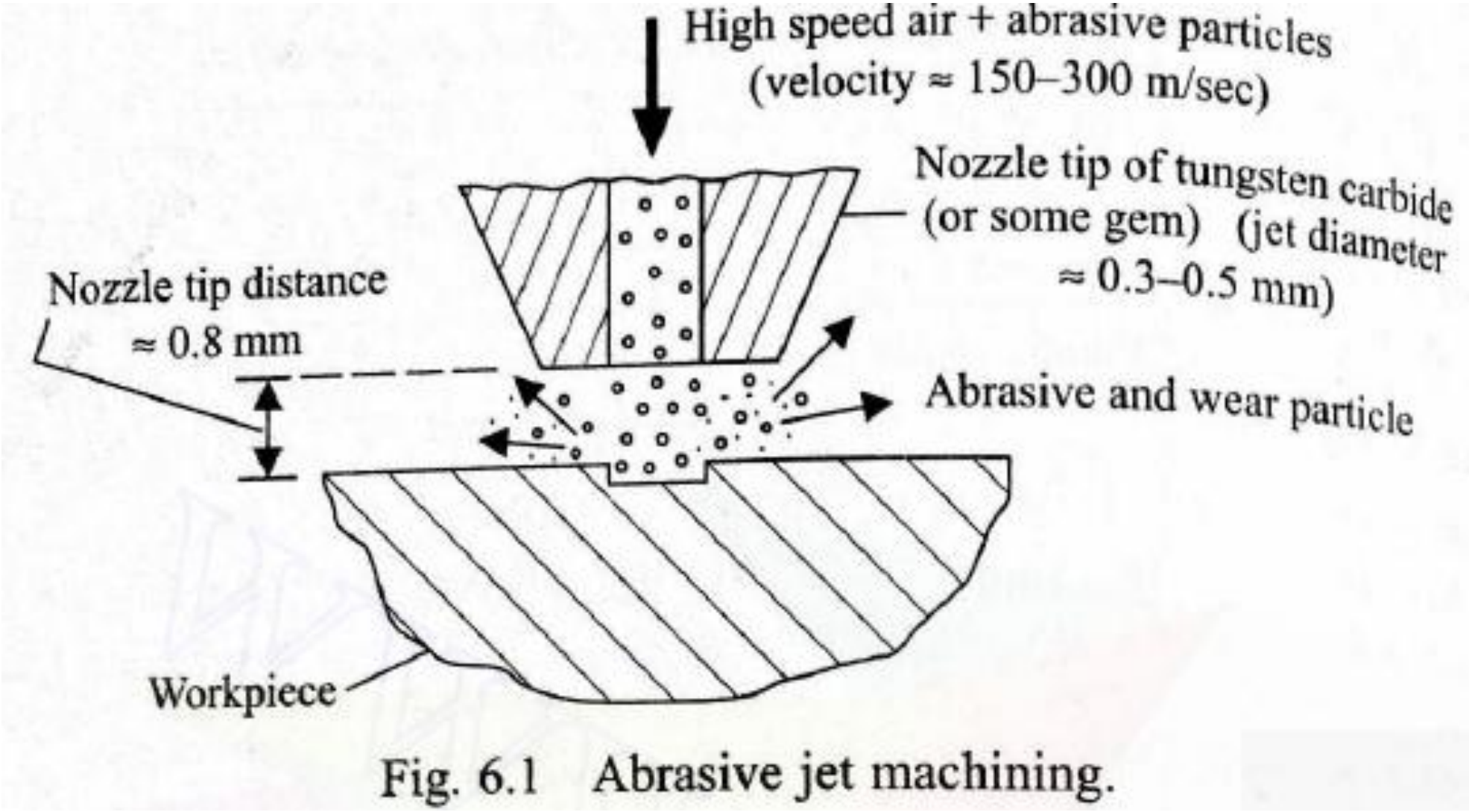
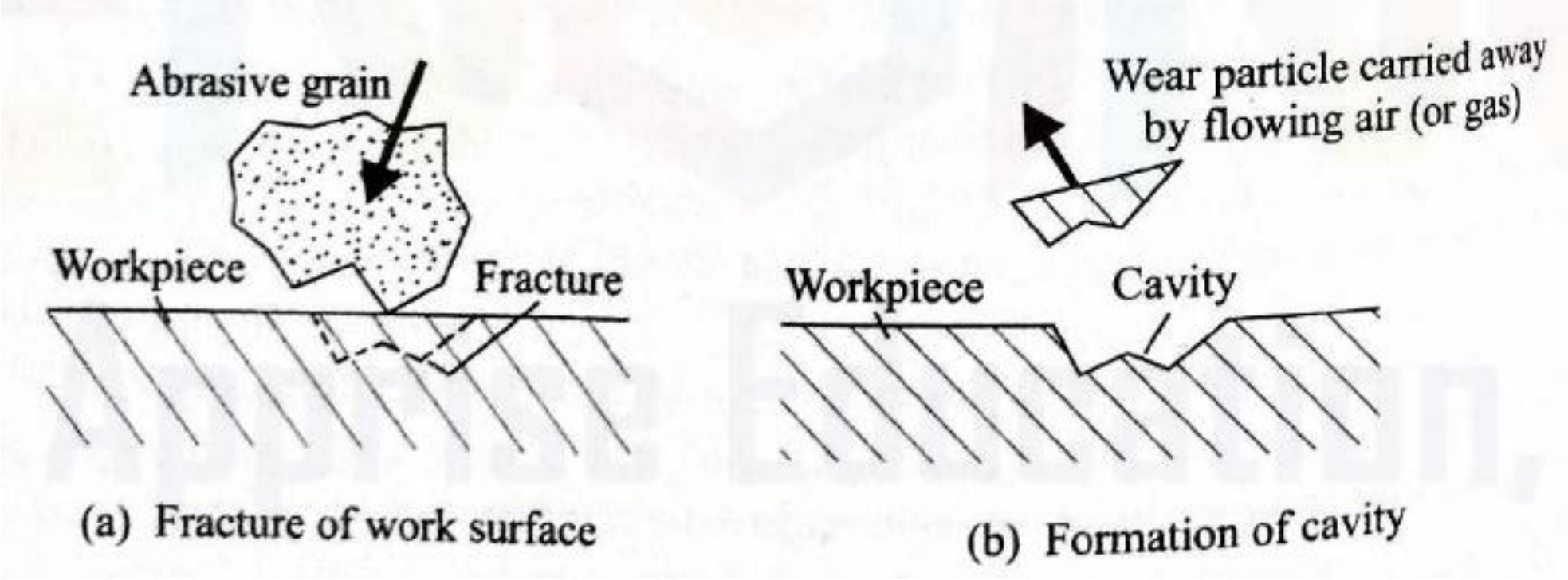


Fig. 6.1 Abrasive jet machining.

Mechanism of Material Removal in AJM

The impact of high velocity abrasives leads to tiny brittle fracture and the following air (or gas) carries away the dislodged small wear particle. Obviously, brittle materials are more suitable for this type of machining process.



Control Parameters of AJM

The control parameters depend on:

1. The abrasives (composition, size, and mass flow rate)
2. The gas (composition, pressure, and velocity)
3. The nozzle (geometry, material, distance from and inclination to the work surface)

Role of Abrasives-

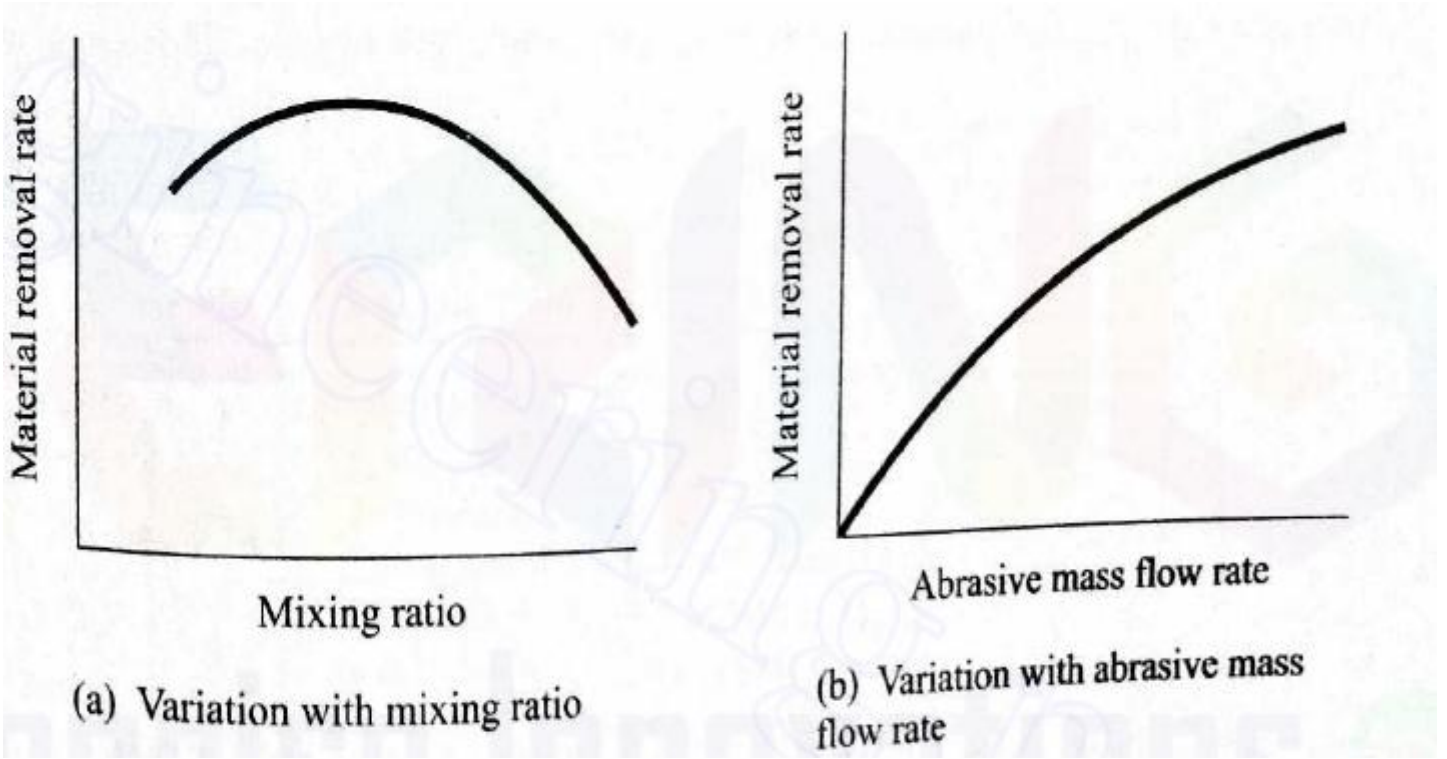
- Mainly, two types of Abrasives are used Aluminium oxide and Silicon Carbide. However, Aluminium oxide is preferred in most applications.

- Nominal grain diameter is 10-50 μm. For best results, it should be between 15-20 μm.

- Reuse of Abrasive Powder is not recommended as
    I. Cutting capacity decreases after the first application
    II. Contamination clogs the small orifices in the nozzle.

Role of Abrasives-

- When the mass fraction of the abrasives in the jet (mixing ratio) increases, the MRR initially increases, but with further increase in mixing ratio, It reaches a maximum and drops.



(a) Variation with mixing ratio

(b) Variation with abrasive mass flow rate

- When the mass flow rate of the abrasive increases, the MRR also increases.

Role of Gas:

- The composition of the gas affects the velocity-pressure relation, which in turn affects the MRR.

Role of Nozzle:

- The nozzle is continuously in contact with the abrasive grains flowing at a high speed, therefore, the nozzle material must be very hard to avoid significant wear. Normally, WC or sapphire is used

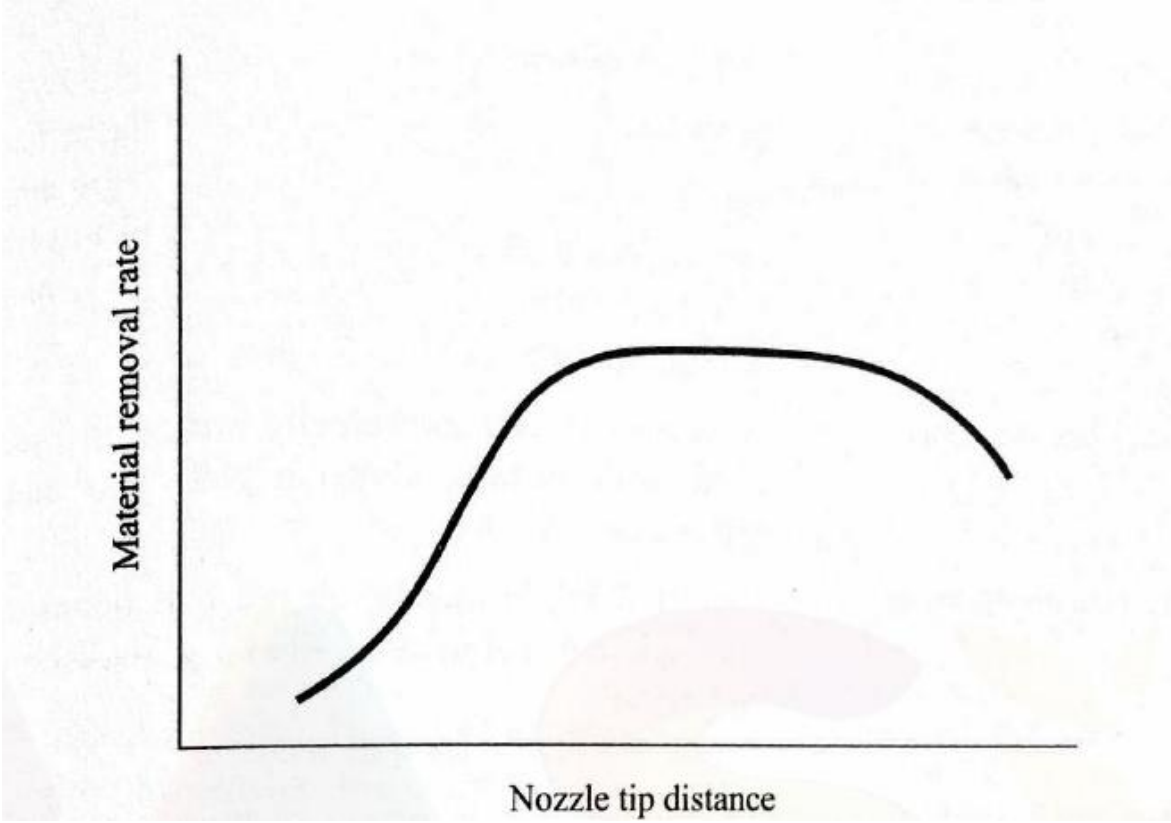
- Average life of a WC nozzle is between 12 hr and 30 hr, and sapphire nozzle lasts for 300 hr approximately.

Role of Nozzle Tip Distance in AJM

- One of the most important factors in AJM is the distance between the work surface and the tip of the nozzle, called nozzle tip distance (NTD).

- NTD affects the MRR, and size and shape of the cavity produced.

- When NTD increases, the velocity of abrasive particles increases due to their acceleration, increasing MRR. With further increase in NTD, the velocity reduces due to drag in the atmosphere, and therefore first checks the increases in MRR, and then finally decreases it.



Thank You !