

# Lecture: Alexandrite Laser

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## 1. Introduction

The **Alexandrite laser** is a **tunable solid-state laser** that uses a crystal of **chromium-doped chrysoberyl ( $\text{BeAl}_2\text{O}_4:\text{Cr}^{3+}$ )** as its active medium. It is widely used in **dermatology, medicine, and spectroscopy** due to its ability to emit light over a range of wavelengths.

The most commonly used wavelength is **755 nm**, which is strongly absorbed by **melanin**, making it highly effective for **hair removal and pigment treatment**.

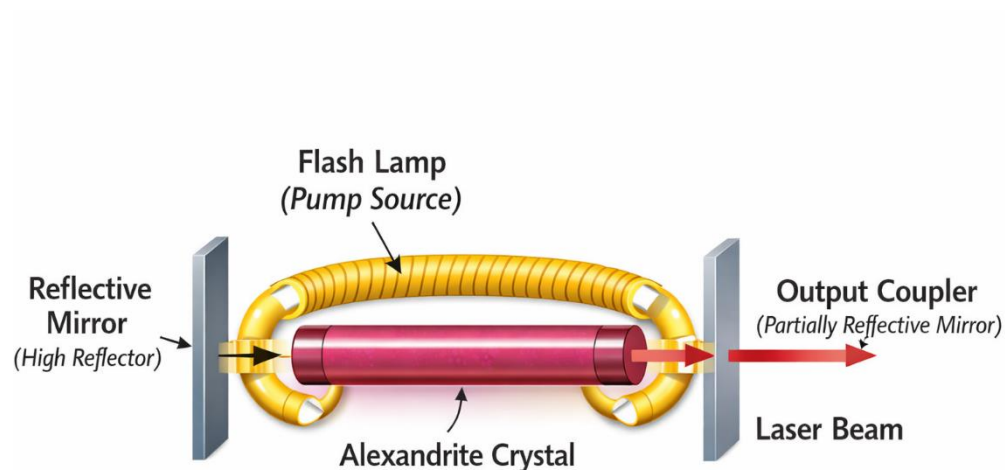
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## 2. Construction of Alexandrite Laser

### Main Components:

1. Active medium (Alexandrite crystal)
2. Pump source (flash lamp)
3. Optical resonator (two mirrors)

### Diagram 1: Laser Setup (Description)



### 3. Working Principle

The laser works based on **stimulated emission** and **population inversion**.

#### Steps:

- Energy supplied via flash lamp
- Electrons excited to higher state
- Stay in metastable state
- Return to ground state emitting photon

#### 4- Gain Equation

$$G=e^{(N_2-N_1) \sigma L}$$

Where:

- $N_2$  and  $N_1$  = population levels
- $\sigma$  = cross-section
- $L$  = length of medium

#### 5 Threshold Condition

$$g_{th}=\frac{1}{2L} \ln\left(\frac{1}{R_1R_2}\right)$$

Where:

- $R_1$  and  $R_2$  = mirror reflectivity
- $L$  = cavity length

### 6. Wavelength and Tunability

- Tunable range: **700 – 820 nm**
- Common wavelength: **755 nm**

This tunability is due to **vibronic transitions** in  $Cr^{3+}$  ions.

## 7. Modes of Operation

1. Continuous Wave (CW)
2. Pulsed Mode
3. Q-Switched Mode

### Q-Switching Equation

$$P_{\text{peak}} = E / \Delta t$$

Where:

- $P_{\text{peak}}$  = peak power
  - $E$  = energy
  - $\Delta t$  = pulse duration
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## 8. Optical Properties

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### 9. Advantages

- Broad bandwidth
  - High efficiency
  - Polarized output
  - High gain
  - Tunable wavelength
  - High absorption in melanin
  - Effective in dermatology
  - High precision
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### 10. Disadvantages

- Expensive crystal
- Requires cooling
- Complex alignment

## 11. Applications

### Medical

- Hair removal
- Tattoo removal
- Pigmented lesions

### Industrial

- Material processing

### Scientific

- Spectroscopy
  - Laser experiments
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## 13. Safety

- Eye protection required
- Avoid skin burns
- Controlled exposure

## 15. References (Chicago Style)

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