Tipos de lasers

LASER

(Light Amplification by the Stimulated Emission of Radiation)

Laser é um oscilador óptico – possui um amplificador óptico ressonante onde o *output* é retro-alimentado ao *input* com casamento de fase.

1- Amplificador com meio de ganho saturado (meio ativo bombeado)

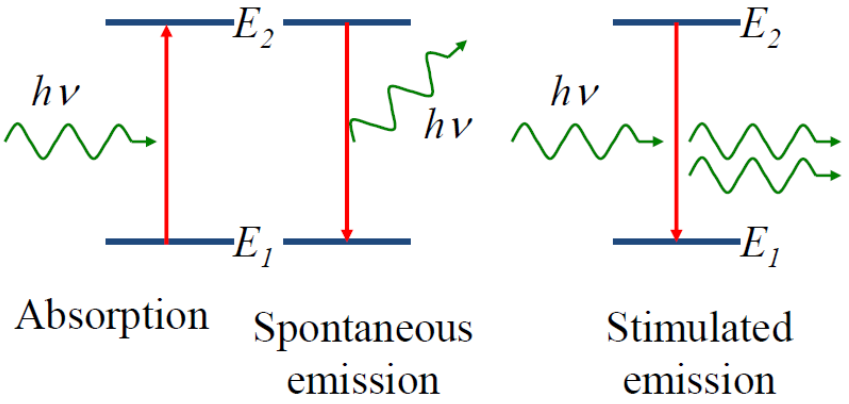
2- Sistema de retroalimentação (cavidade Fabry-Perot)

3- Mecanismo de seleção de frequência (amplificação ressonante)

4- Tipo de acoplamento de saída (espelho de reflexão parcial)

Princípio da emissão laser

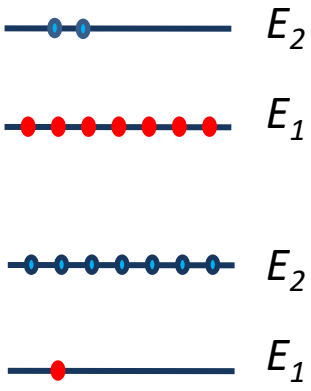
$h\nu = E_2 - E_1$



Quando $n_1 > n_2$: radiação é predominantemente absorvida
efeito dominante - emissão espontânea

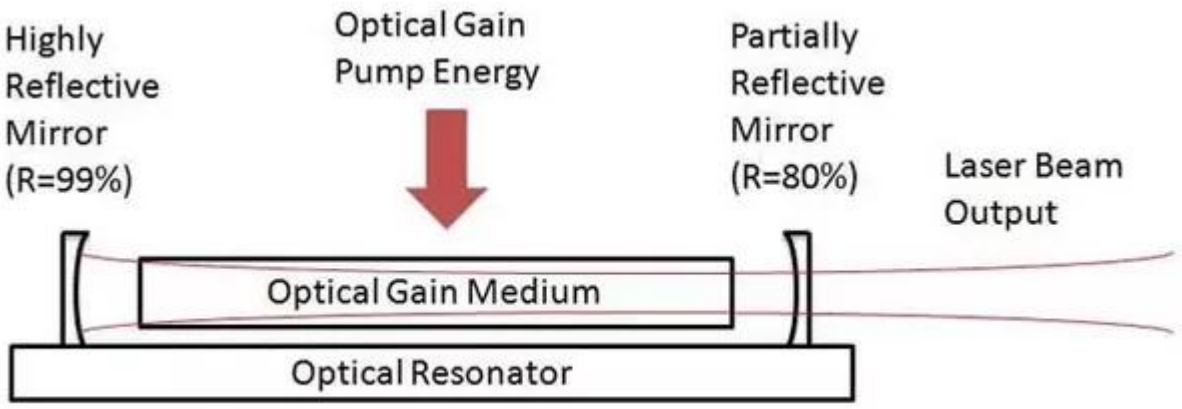
Quando $n_2 >> n_1$: a maioria dos átomos ocupa E_2 – fraca absorção
efeito dominante – emissão estimulada
luz é amplificada

Condição necessária: inversão de população



Componentes principais de um laser

- Meio ativo (sólido, líquido, gás)
- Bombeamento (elétrico, óptico, químico)
- Cavidade óptica (ressonador óptico)



Laser Building Blocks: the Optical Gain Medium and the Optical Resonator

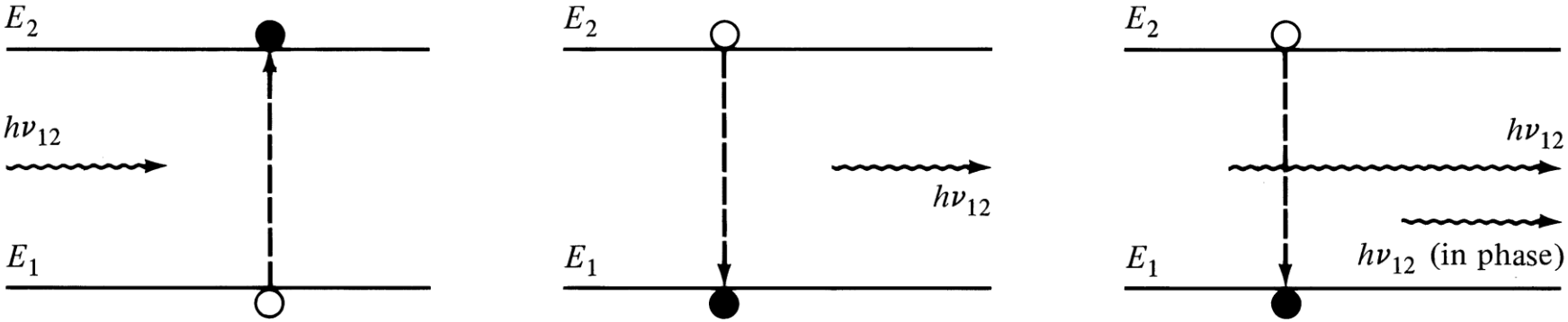
Meio ativo (de ganho)

- Processos para a emissão laser

  1- Absorção

  2- Emissão espontânea

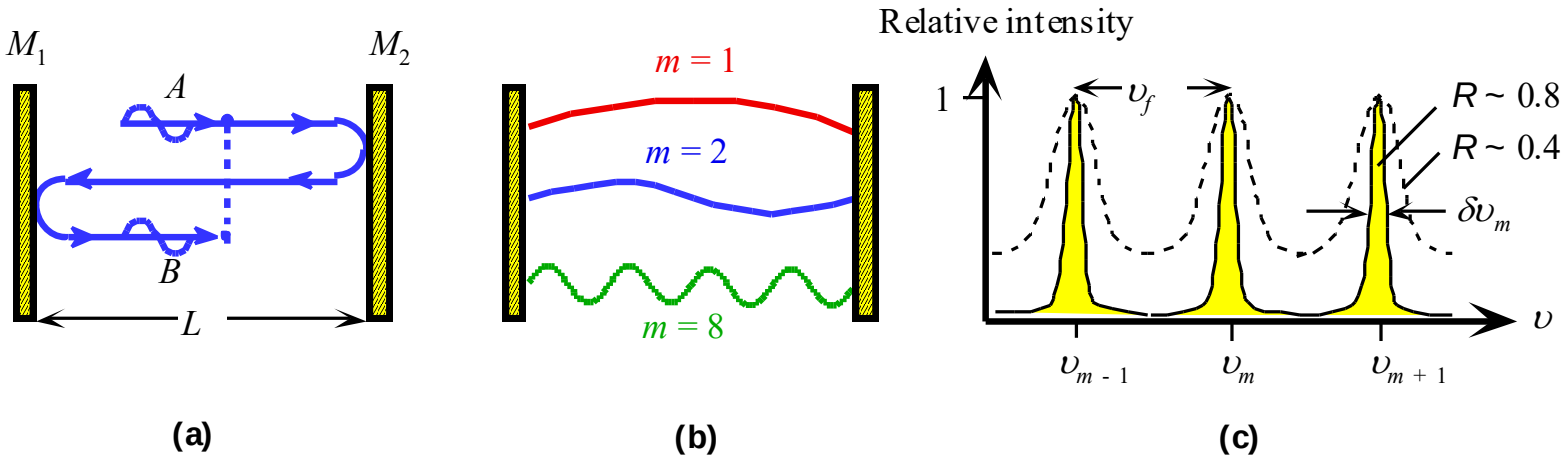
  3- Emissão estimulada



(a) Absorption (b) Spontaneous emission (c) Stimulated emission

Optical Fiber communications, 3rd ed.,G.Keiser,McGrawHill, 2000

Fabry-Perot Resonator

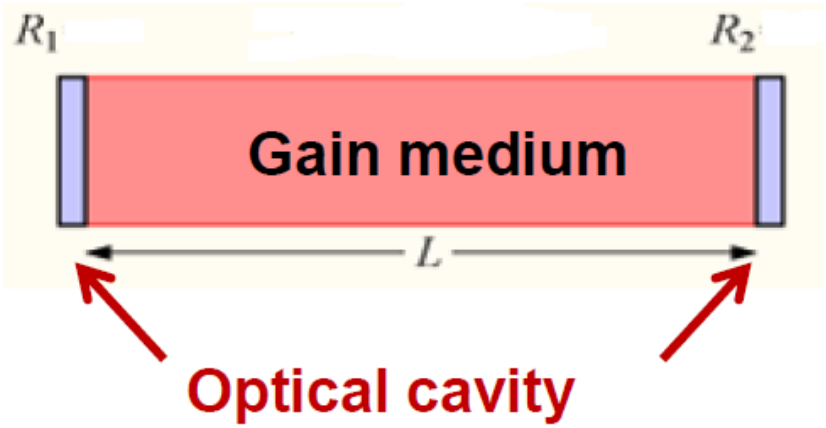


Schematic illustration of the Fabry-Perot optical cavity and its properties. (a) Reflected waves interfere. (b) Only standing EM waves, *modes,* of certain wavelengths are allowed in the cavity. (c) Intensity vs. frequency for various modes. R is mirror reflectance and lower R means higher loss from the cavity.

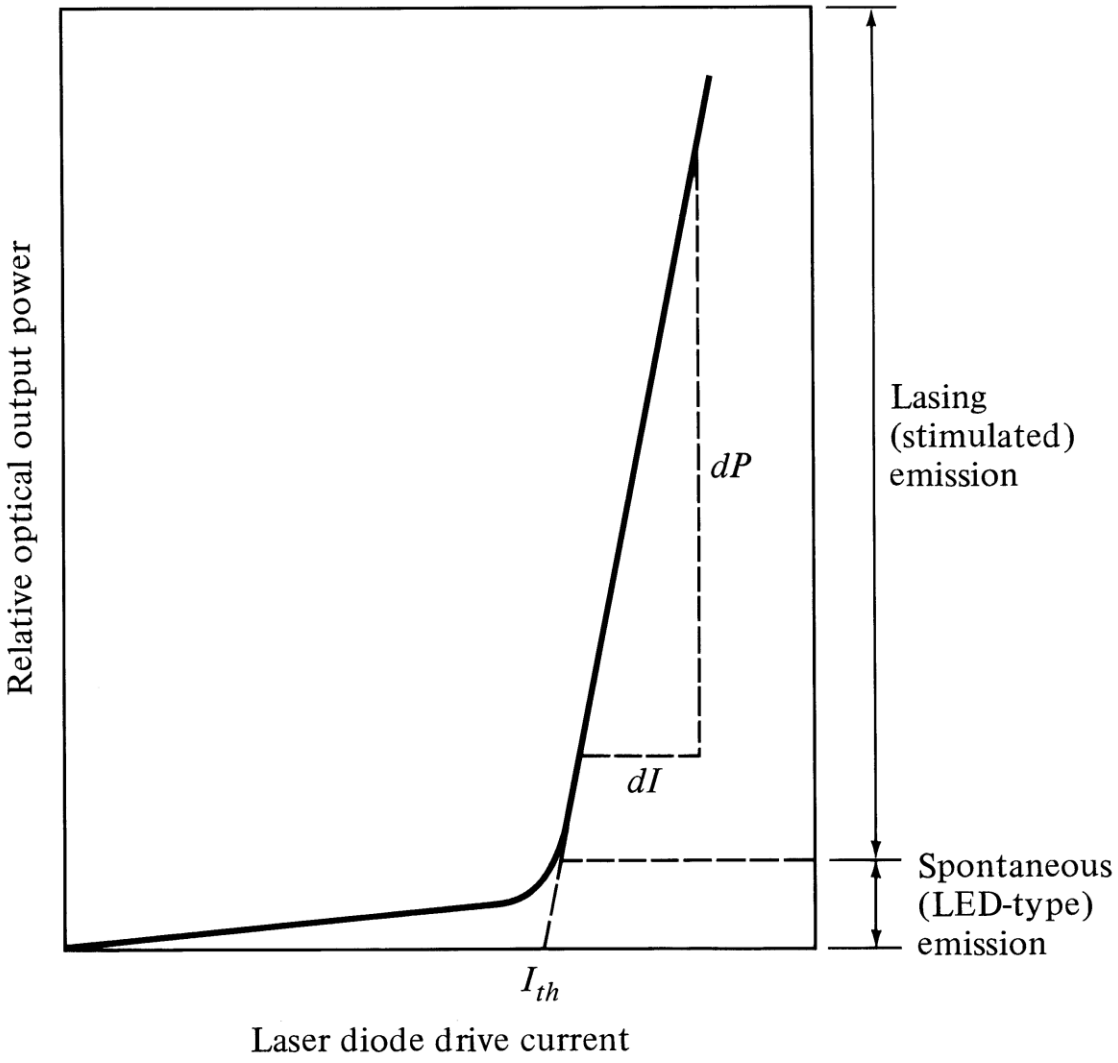
Resonant modes: $kL = m\pi \quad m = 1,2,3,..$

Laser de diodo

1. Meio de ganho: semicondutor
2. Bombeado eletricamente
3. Junção *band-gap* controla o comprimento de onda emitido
4. Cavidade ressonante: geometria e estrutura do sólido (secção das paredes)

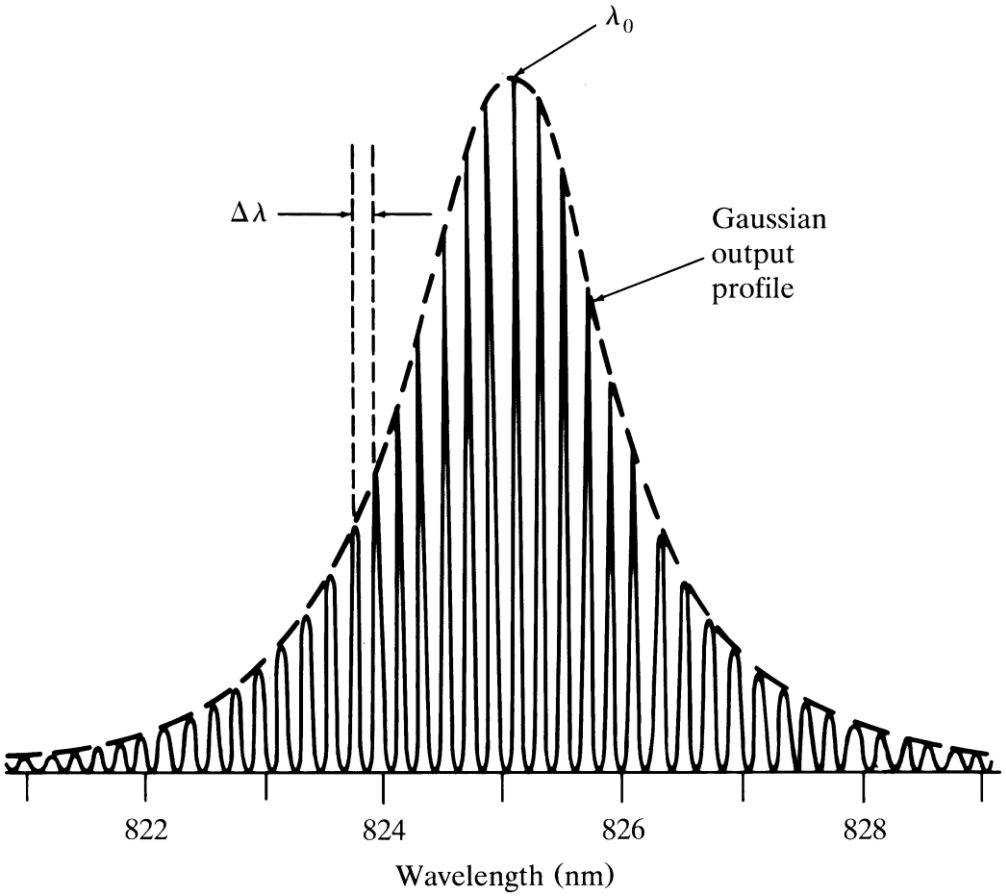


Potência de saída em função da corrente elétrica



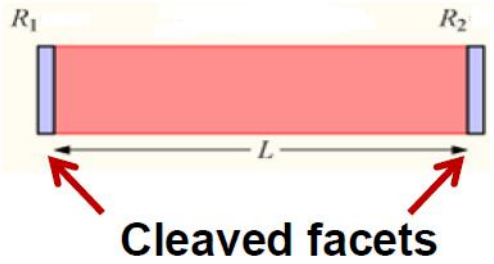
Optical Fiber communications, 3rd ed.,G.Keiser,McGrawHill, 2000

Largura espectral de um laser de diodo

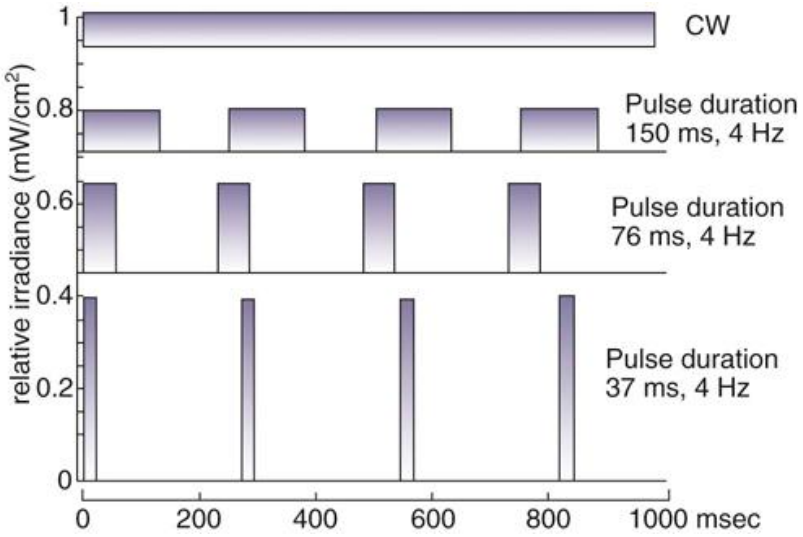


Vantagens dos lasers de diodo

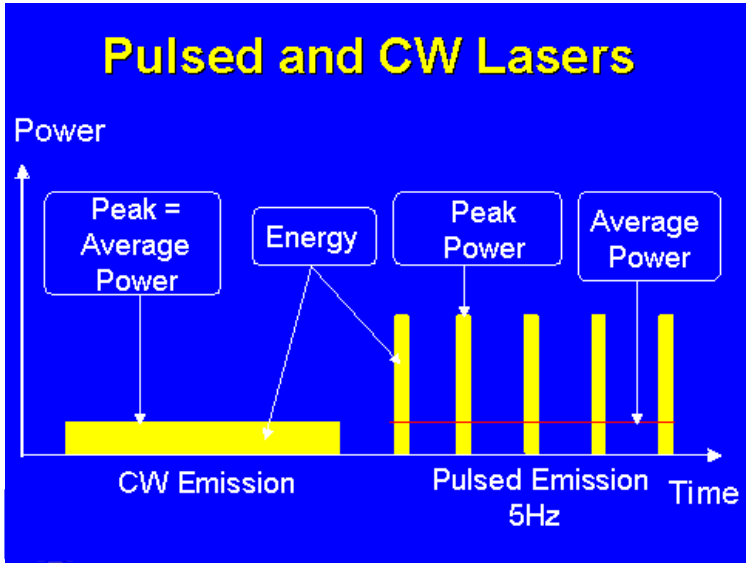
1. Meio semicondutor: alto ganho
2. Cavidade ressonante: robusta e sem necessidade de alinhamento dos espelhos.
3. Miniaturização do laser.
4. Baixo custo: tecnologia já existente.
5. Alta eficiência (potência óptica versus elétrica)
6. Alta potência de saída (considerando o tamanho pequeno)
7. Baixo limiar de corrente, baixo consumo de energia.



Laser pulsado vs CW

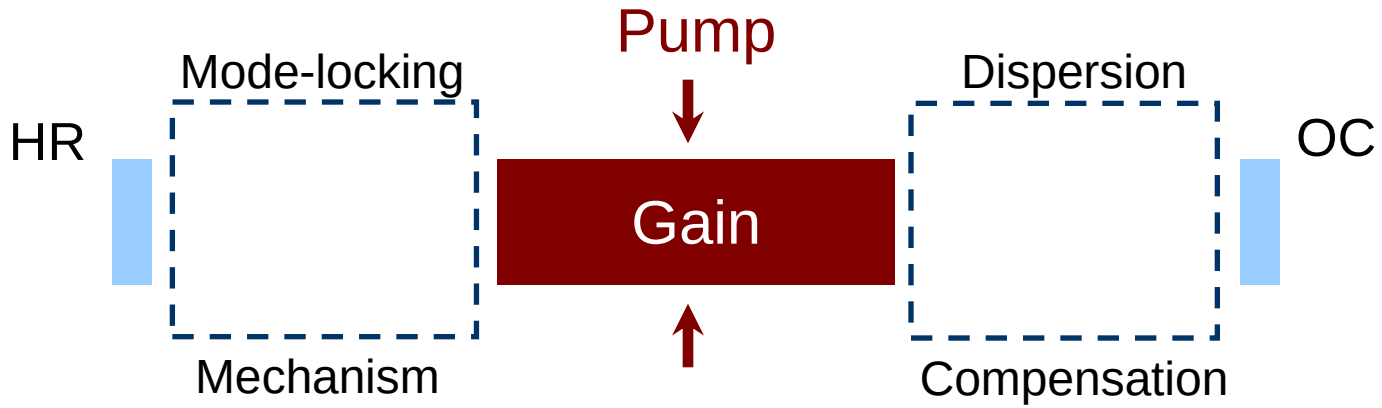


1 J = 1 W.s

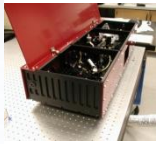


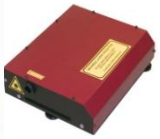
Basic principles of ultrafast lasers

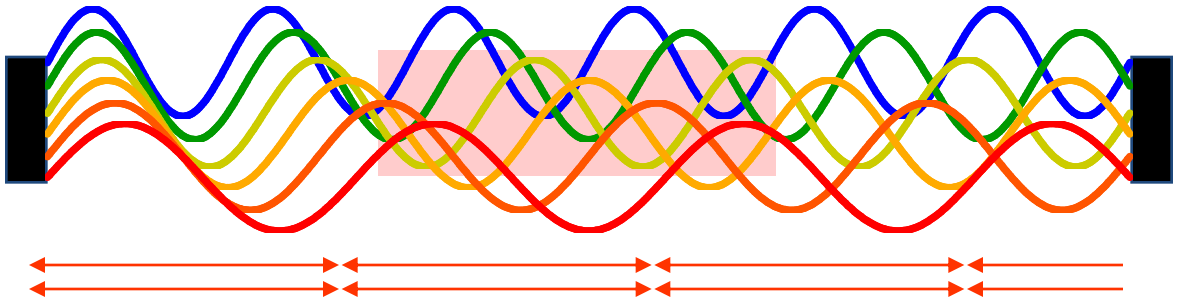
Components of ultrafast laser system



Cavity modes





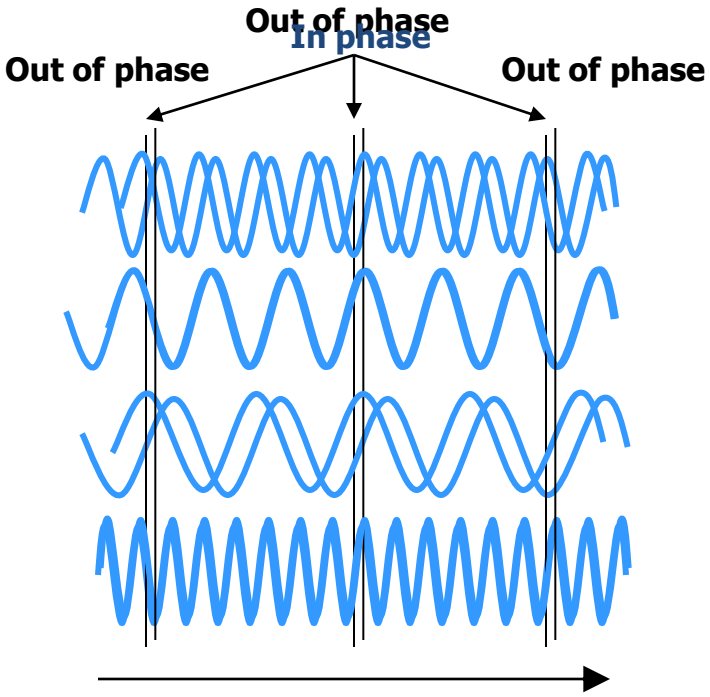


$\lambda_n = 2\,L/n$ $\Delta f = c/2\,L$

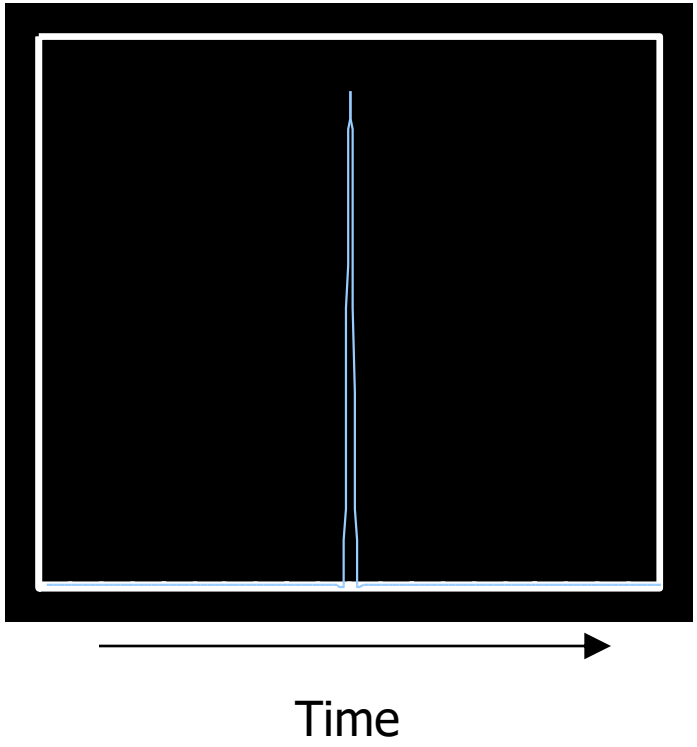
Del Mar Photonics

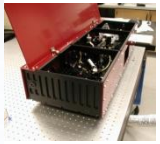
Concepts of Mode Locking

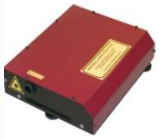
Mode locking is a method to obtain ultrafast pulses from lasers, which are then called mode-locked lasers mode



Irradiance vs. Time







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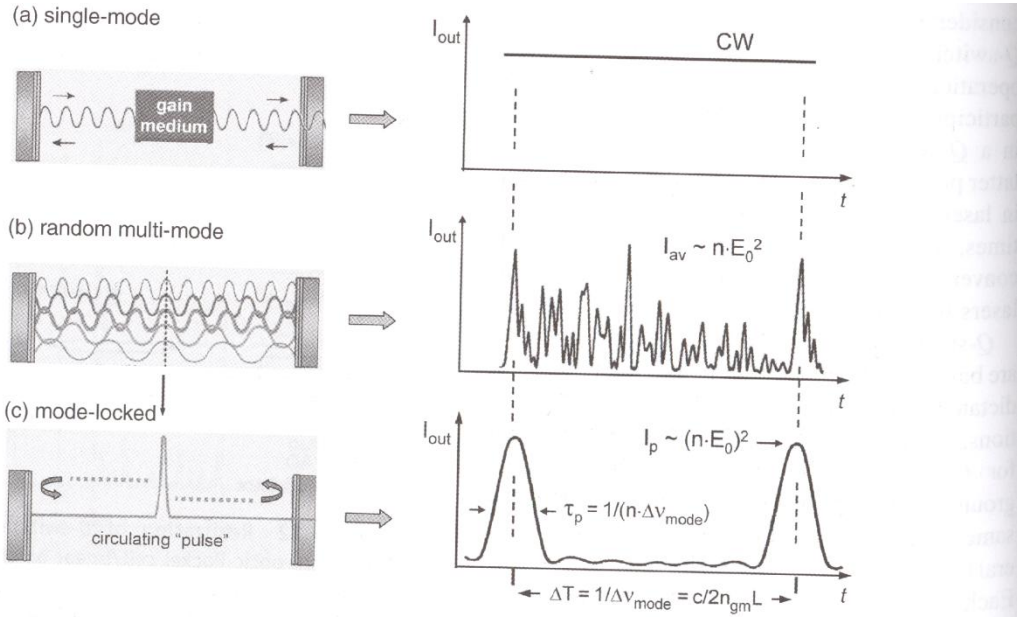
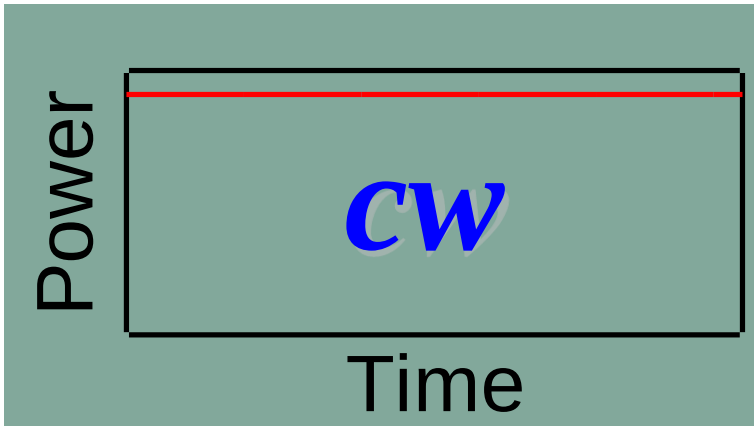
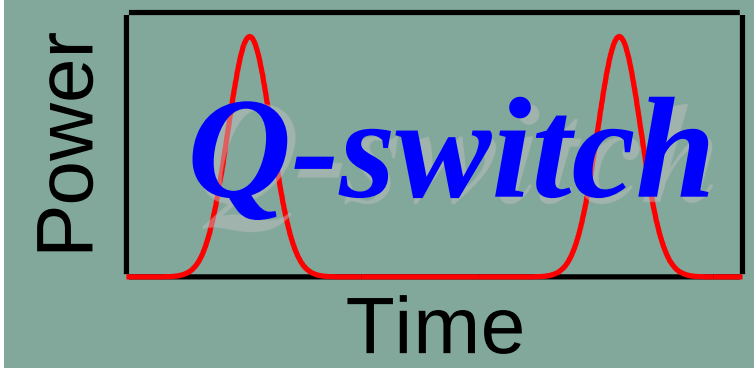
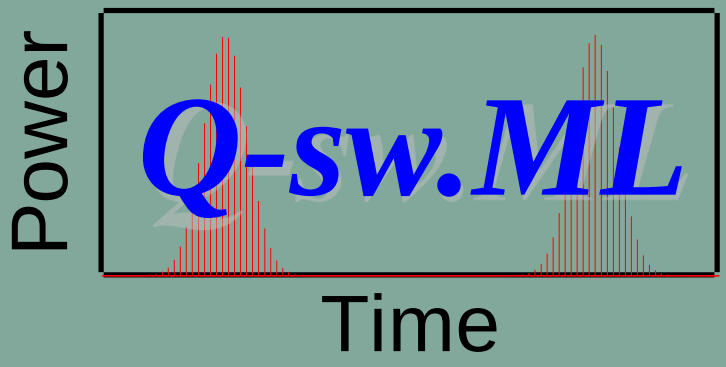


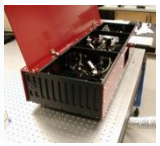
Figure 3.13 Temporal characteristic of laser output intensity: (a) for a single-mode CW laser; (b) for a random multi-mode CW laser; (c) for a mode-locked ultra-short pulse laser

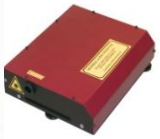
Types of Laser Output









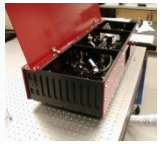


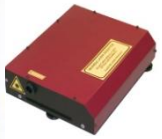
Del Mar Photonics

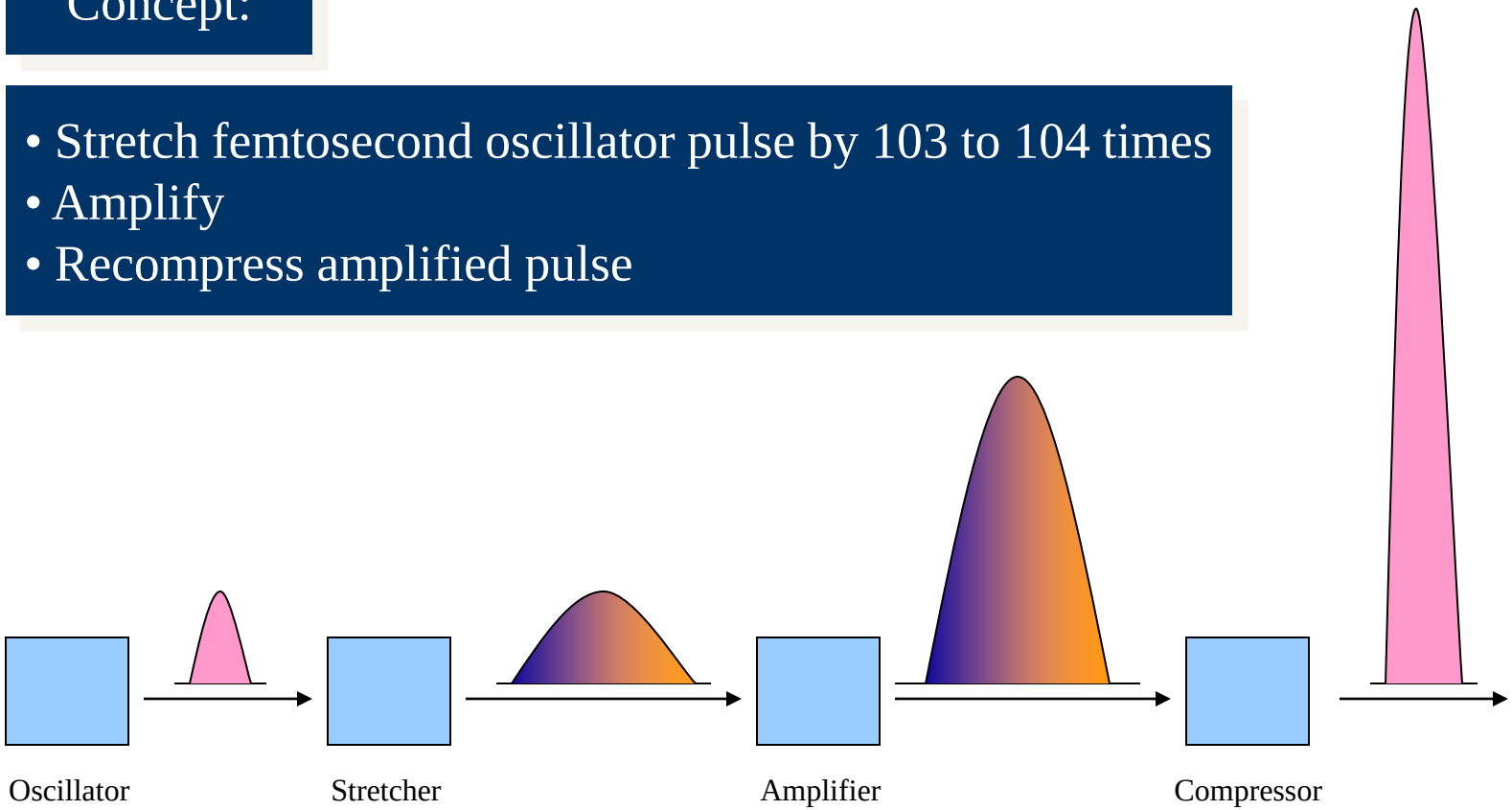
Amplification of fs Pulses

Concept:

- Stretch femtosecond oscillator pulse by 103 to 104 times
- Amplify
- Recompress amplified pulse

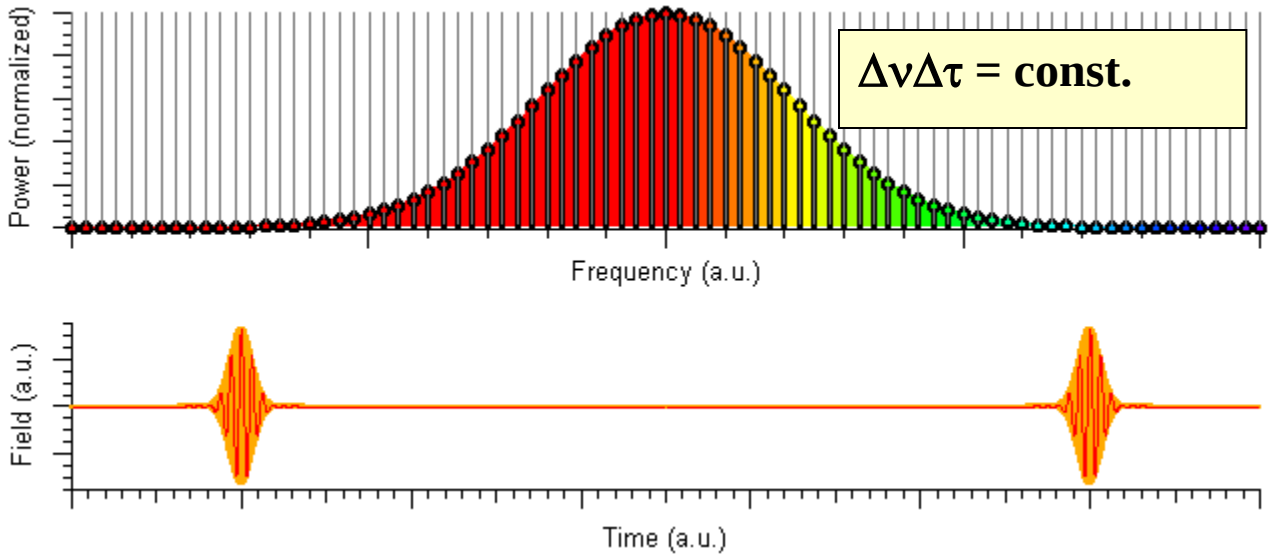


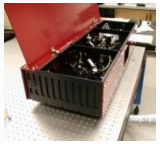


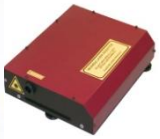


Basic principles of ultrafast lasers

Bandwidth vs Pulsewidth







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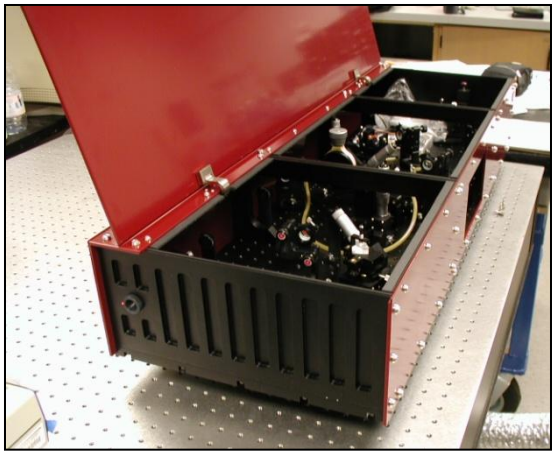
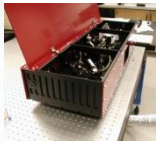
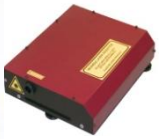
Cavity configuration of Ti:Sapphire laser



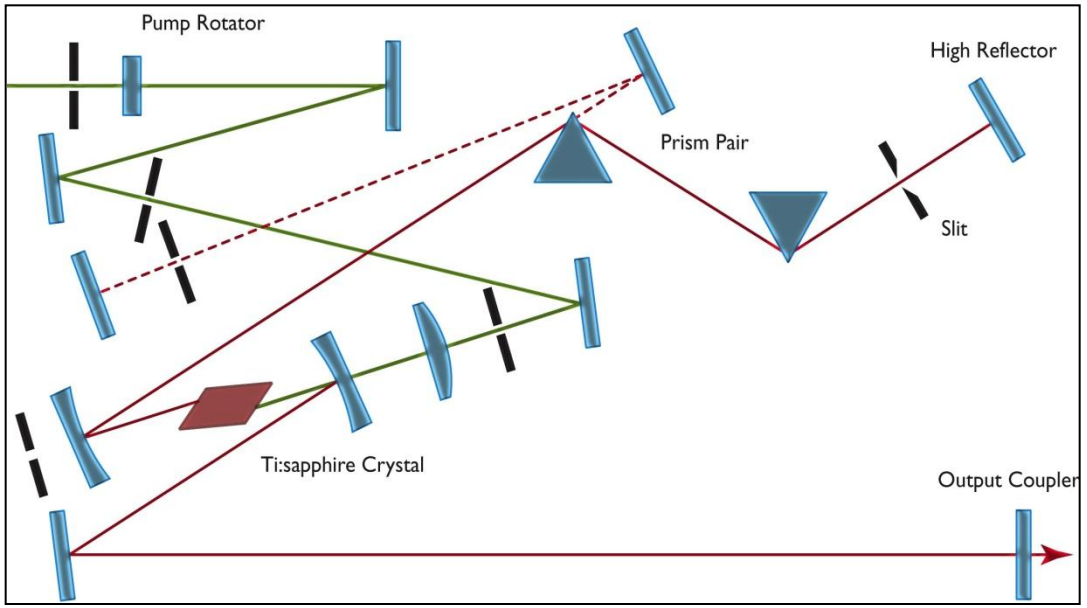
Tuning range 700-1000 nm
Pulse duration < 20 fs
Pulse energy < 10 nJ
Repetition rate 80 – 1000 MHz
Pump power: 2-15 W





Typical applications:

- time-resolved emission studies
- multi-photon absorption spectroscopy
- imaging



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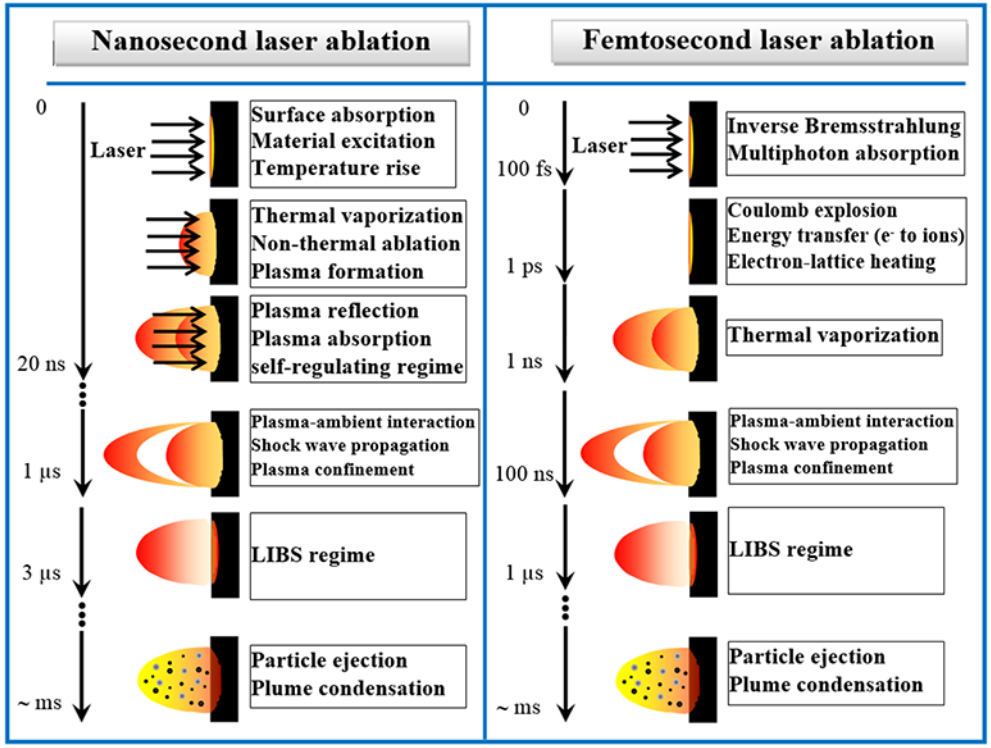
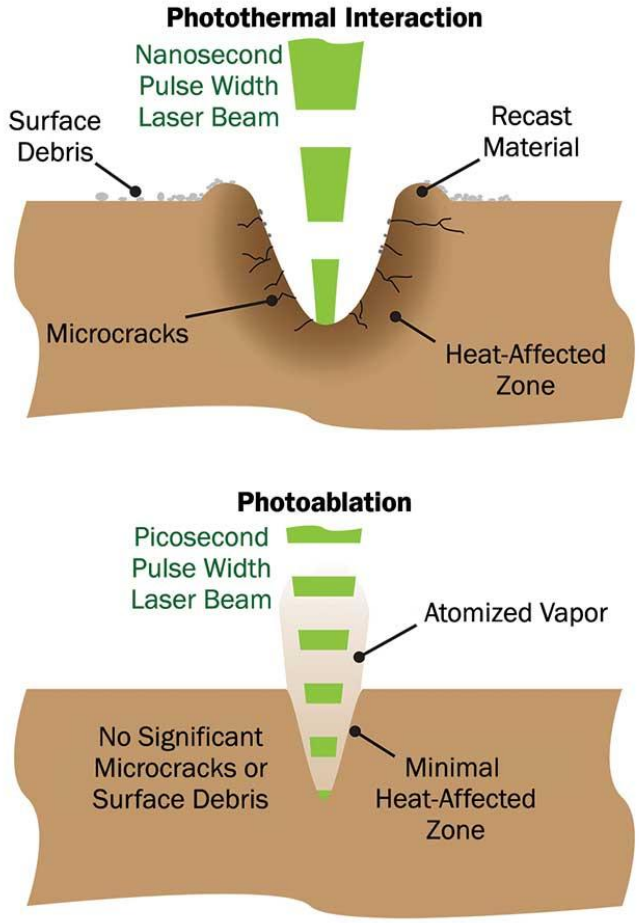
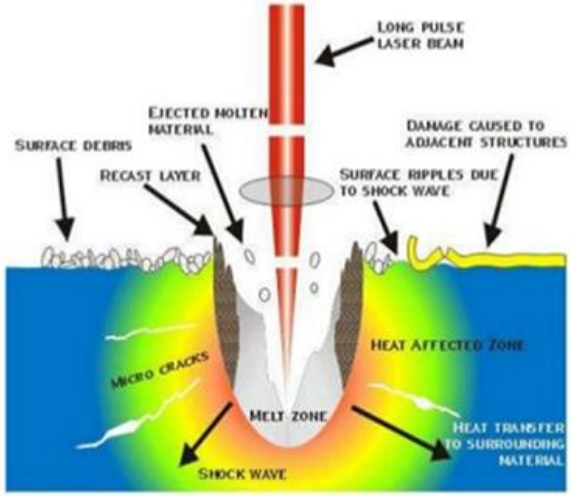
Largura de pulso

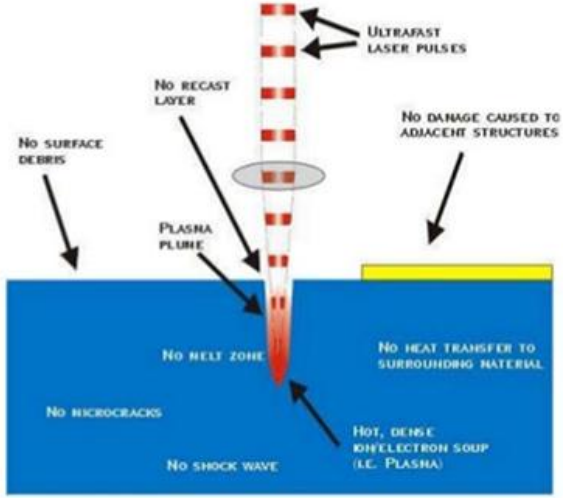


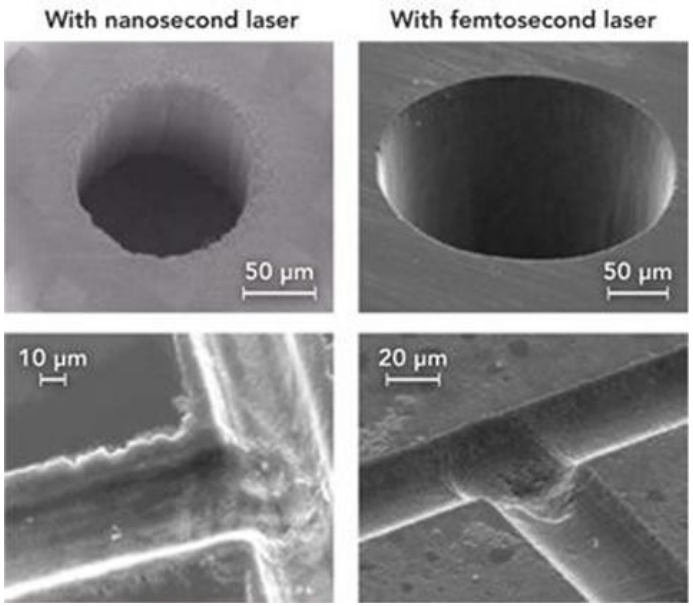


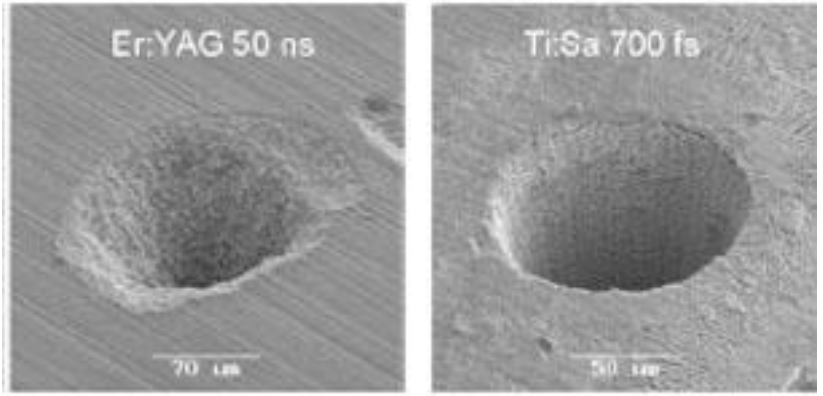
Long pulse



Short pulse







(Vidro)