Investigation of femtosecond laser processing

Femto Process Lab., KIMM

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KOREA INSTITUTE OF MACHINERY & MATERIALS

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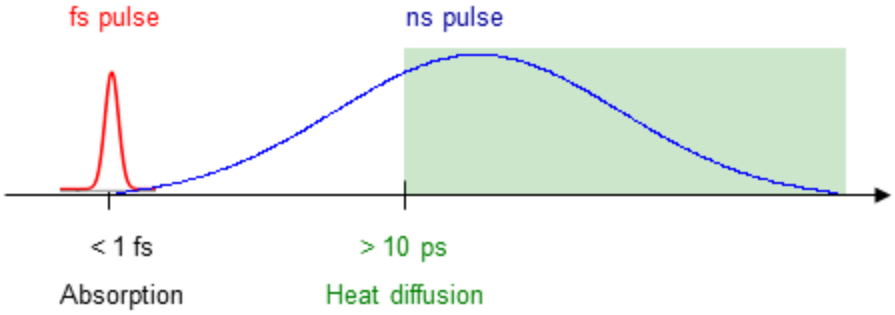
Introduction

❖ *Femtosecond laser processing* used for many applications:

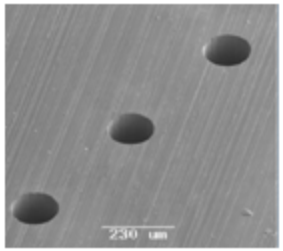
The short laser pulse lengths and high pulse intensities of ultrashort pulsed lasers are the reasons for further advantages:

- ✓ Wide range of machinable materials
- ✓ Minimal thermal and mechanical damage of the material
- ✓ Well-defined ablation thresholds
- ✓ Structure sizes down to the lower sub-micrometer range
- ✓ High-quality machining, burr-free drilling and cutting

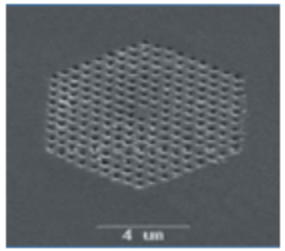
- ✓ 3D volumetric processing in transparent materials
- ✓ Single step fabrication
- ✓ Minimal Heat Affected Zone (HAZ)
- ✓ Ablative and non-ablative fabrication
- ✓ Efficient, fast and localized energy deposition



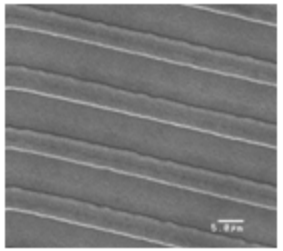
Micro structure



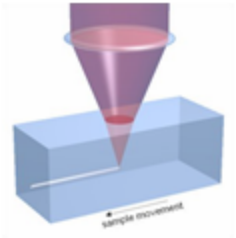
Nano Structure



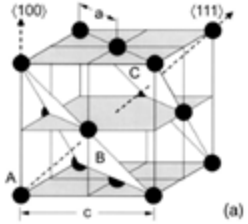
Selective ablation



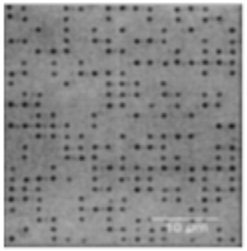
Waveguides



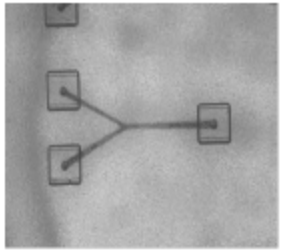
Photonic band gap crystals



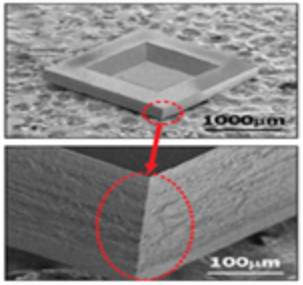
Optical memories



3D micro-channels



Stealth Dicing



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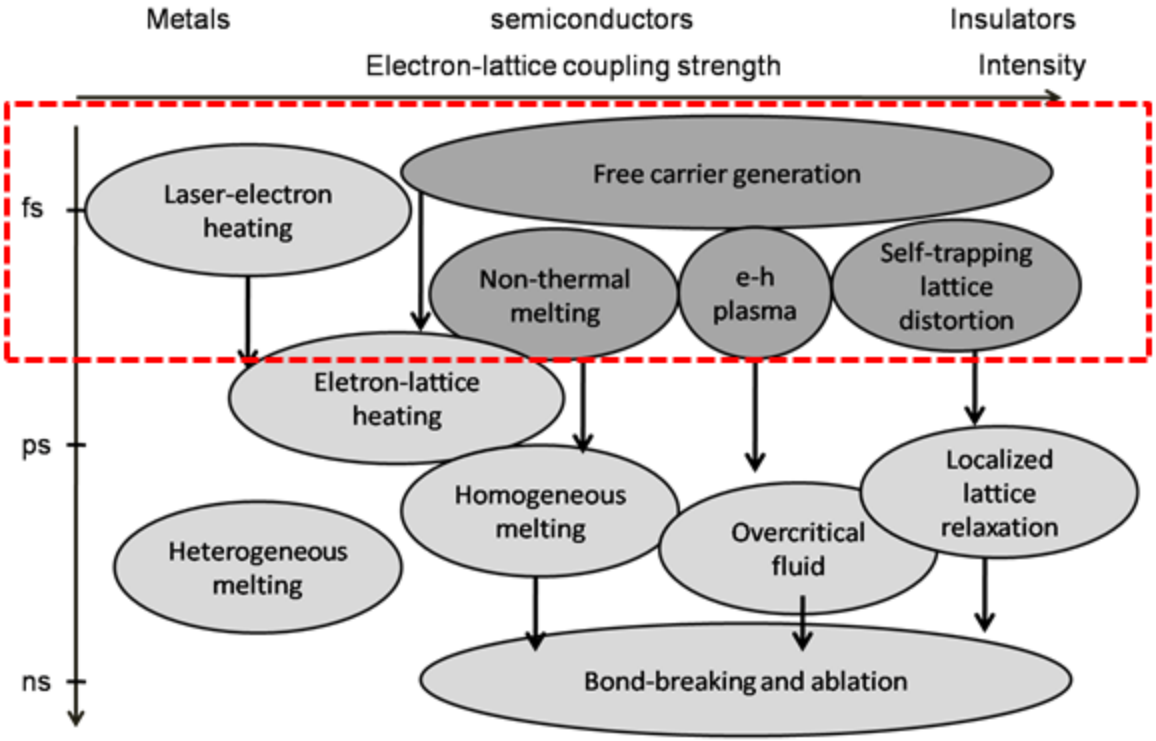
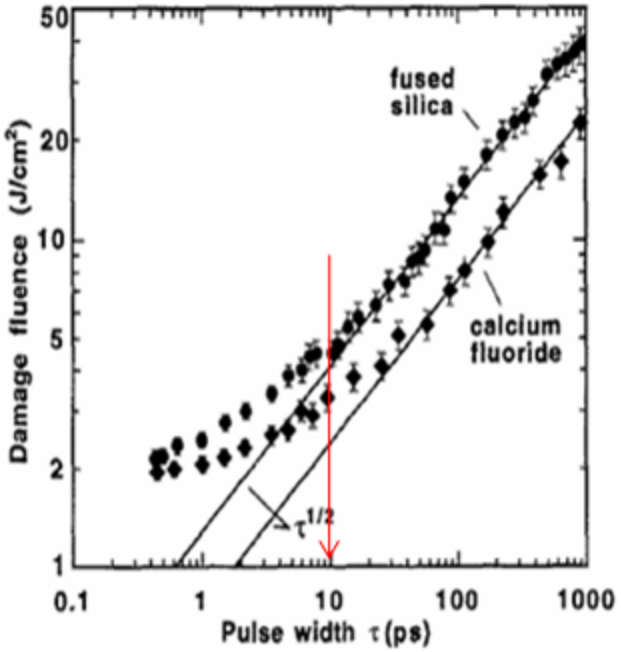
Introduction

Relevant time and intensity scales for laser - matter interaction



Damage threshold vs. pulse width



For short pulse (< 10ps)
- Thermal effect negligible
-Obeys different interaction mechanism

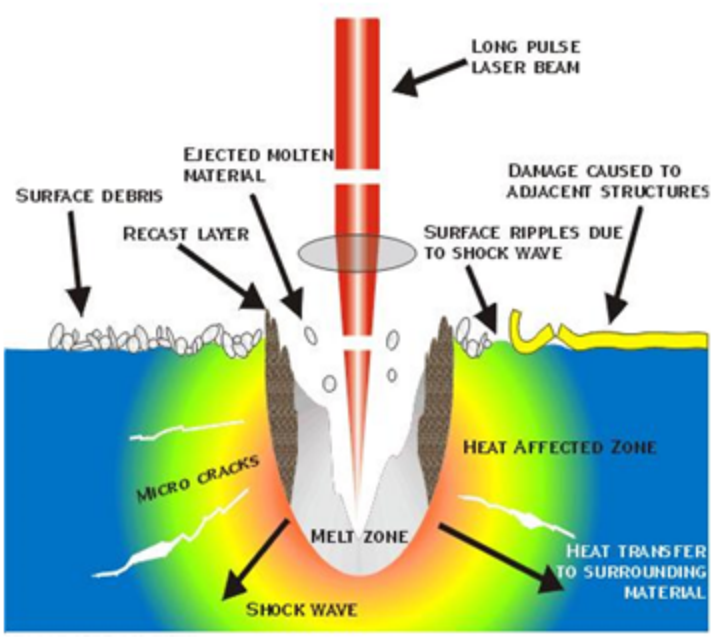
H. Misawa and S. Juodkazis, *3D Laser Microfabrication: Principles and Applications,* Wiley-VCH, 2006
B. C. Stuart et al., Phys. Rev. Lett. vol 74, pp2248-2251, 1995

Introduction

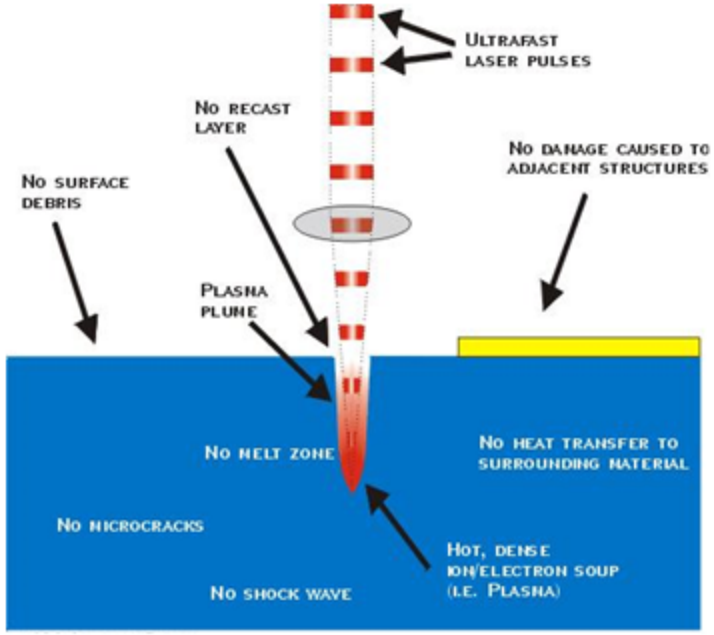
Comparison of femtosecond and nanosecond laser ablation

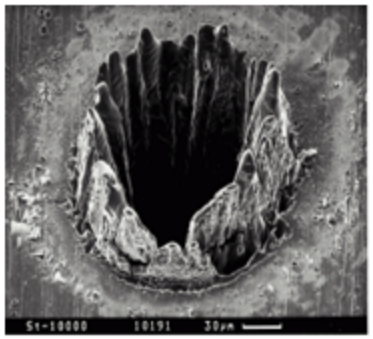
Long- vs. short-pulse micromachining process

Long pulse(nanosecond laser)

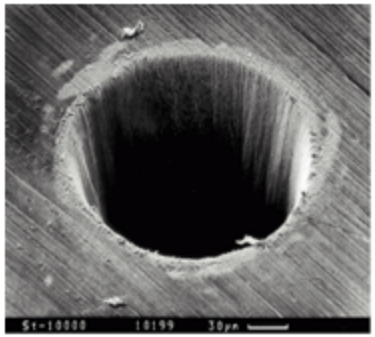


Short pulse(femtosecond laser)





4.2 J/cm^2 @ 3.3 ns



0.5 J/cm^2 @ 200 fs

Steel foil
100 *mm* in thickness

The main **advantages** of femtosecond micro machining are:

- No thermal damage: High machining quality, heat sensitive material machining
- Unmatched accuracy: Down to 100nm (very well defined ablation threshold)
- No wavelength dependence: Any material can be machined with the same laser

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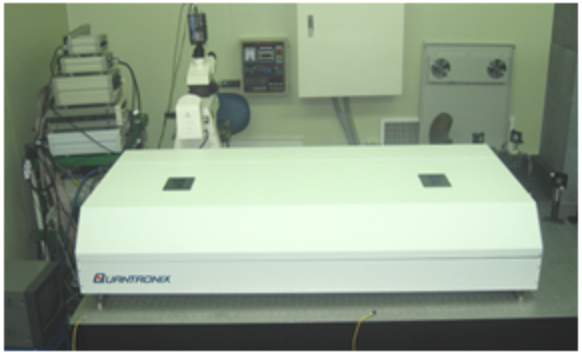
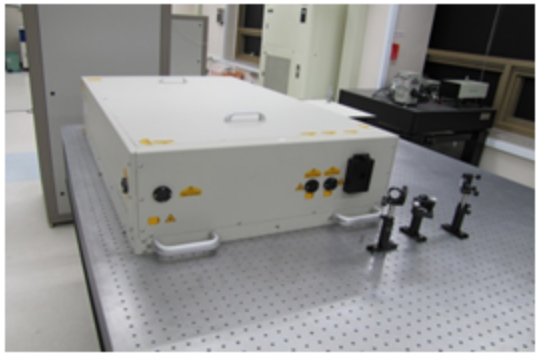
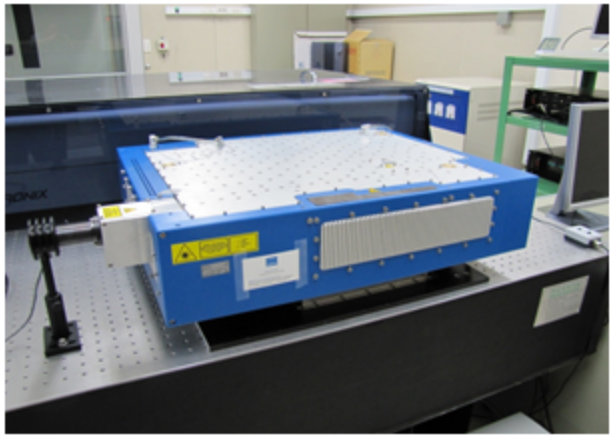
Experimental setup



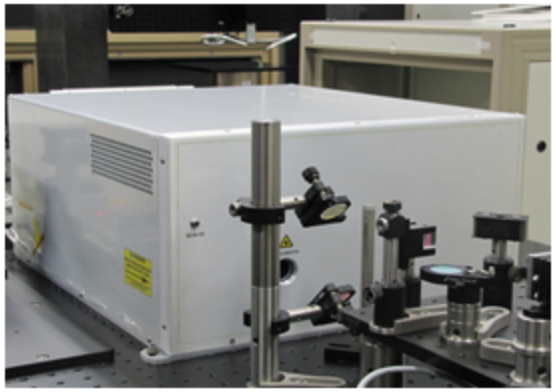
QUANTRONIX (USA)
Model: Integra I
120fs, 795nm, 3.5W



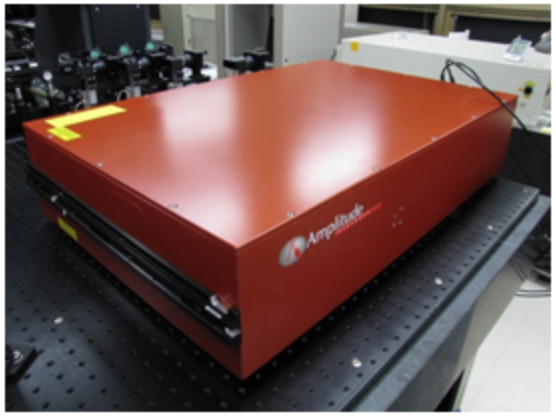
Spectra-Physics (USA)
Model: Solstice
90fs, 795nm, 3.5W



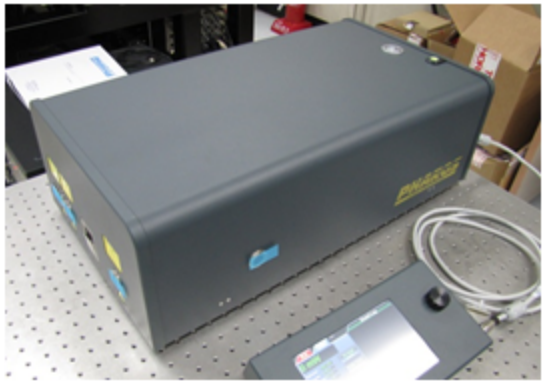
JENOPTIK Model : Jen Las D2.fs
Germany, 산업용레이저



RAYDIANCE Model : Smart Light,
USA

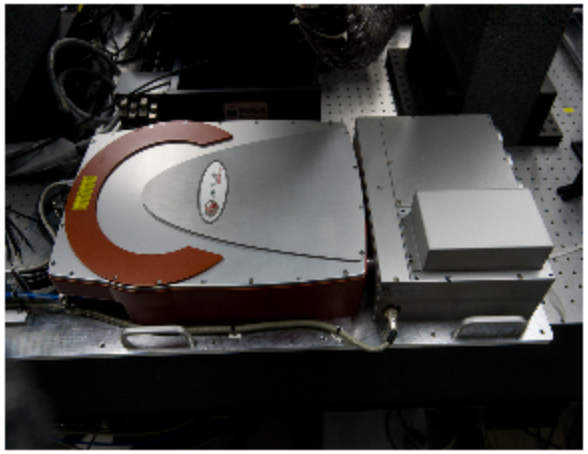


Amplitude Model : S-Pulse HR,
France



LIGHT CONVERSION Model : Pharos ,
Lithuania

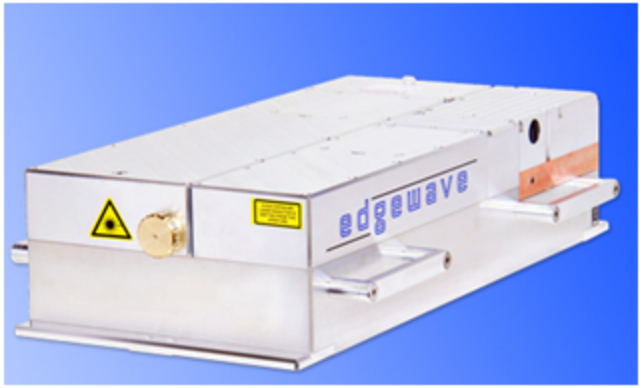
Experimental setup



Amplitude Model : Satsuma-Customized, France

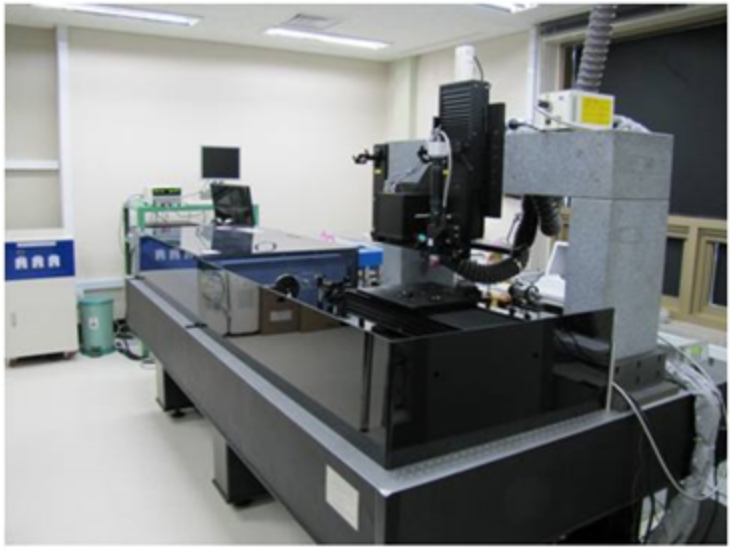
Amplitude Model : Satsuma HP2, France

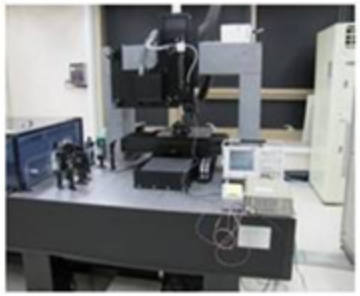
NKT Photonics Model : Origami XP, Denmark

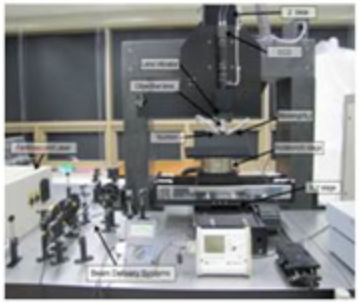


edgewave Model :MXp50-3-GM, Germany

Experimental setup





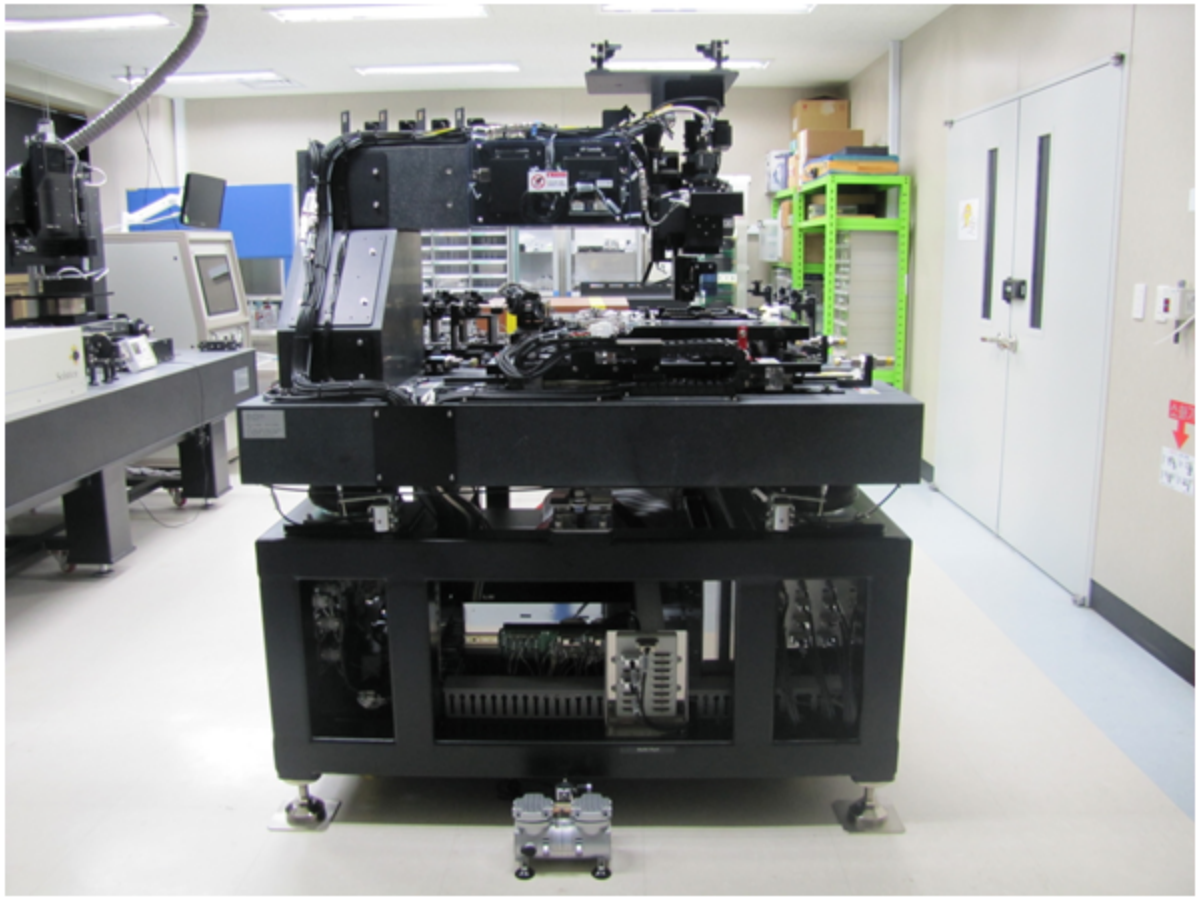


- Wavelength: 790nm (NIR)
- Pulse width: 130 fs (femtosecond,10^{-15})
- Pulse energy : 3 mJ/pulse (@1kHz)
- Average power : 3 W
- Repetition rate: 1kHz

- Wavelength : 1027nm (NIR)
- Pulse width : 380 fs (femtosecond,10^{-15})
- Pulse energy : 3 mJ/pulse (@1kHz)
- Average power : 3 W
- Repetition rate : 1kHz

- Wavelength : 790nm (NIR), 395nm, 264nm
- Pulse width : 90 fs (femtosecond,10^{-15})
- Pulse energy : 0.7 mJ/pulse (@5kHz)
- Average power : 3.5 W
- Repetition rate : 1kHz, 5kHz, 10kHz

Experimental setup



Femtosecond laser OLED display repair system

- **Wavelength: 1027, 513, 343, 790 nm**
- **Mechanical slit: 1 – 50 μm**
- **Linear revolver: 5x, 10x, 20x, 50x, 100x (automated)**
- **Auto focusing**
- **Single system (included electronic parts)**

Thank you for your attention

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