



# Present Status and Trend of Femtosecond Laser Processing in Next Generation Display,



AMOLED Manufacturing Industry

**페토공정연구실**  
Prof. Dr. SUNG HAK CHO  
[www.femto-kimm.kr](http://www.femto-kimm.kr)  
shcho@kimm.re.kr



Head, Department of Laser & Electron Beam Application  
KIMM (Korea Institute of Machinery & Materials)



Professor, Korea University of Science and Technology

KIMM URL: <http://www.kimm.re.kr>

page 1

[www.femto-kimm.kr](http://www.femto-kimm.kr) (UST-KIMM)

# Keynote Speech & Invited Talks in Recent international Conferences [ 1 ]

- 75<sup>th</sup> International Laser Materials Processing Conference, Dec. 2010, Tokyo Univ  
- Keynote
- 50th Anniversary Memorial Symposium after Laser Invention, Oct. 2010  
- Keynote
- KIMM** 한국기계연구원  
KOREA INSTITUTE OF MACHINERY & MATERIALS
- International R&D Conference 2010, June 2010 Seoul, Korea  
- Keynote
- 펨토공정연구실**  
www.femto-kimm.kr
- NANO KOREA 2010 June 2010  
- Invited
- LPM 2011 (Laser Precision Manufacturing 2011) June 2011  
- Invited
- Photonics West 2012 (Jan, San Francisco)  
- Invited
- Samsung Display Co. Ltd (2010 – Current)  
- Invited Lectures
- Samsung Electronics Co. Ltd (2014 – Current )  
- Invited

# Keynote Speech & Invited Talks in Recent international Conferences [ II ]

Korea Eureka Day ; Korea-Germany Technology Networking Seminar, May. 2015  
- Keynote

NST-FhG Joint Workshop, October 19, 2015, Daejeon, Korea  
- Invited

**KIMM 한국기계연구원**  
OSA ADVANCED SOLID STATE LASERS CONFERENCE AND EXHIBITION,  
KOREA INSTITUTE OF MACHINERY & MATERIALS  
October 4-9, 2015, Adlershof-Berlin, Germany

**펨토공정연구실** - Invited

[www.femto-kimm.kr](http://www.femto-kimm.kr)

Chair & Invited Lecture of Laser Manufacturing Workshop. SIMTOS 2016  
- Invited

International Laser Technology Congress (AKL 2016), Fraunhofer ILT  
Aachen Germany (April 27 - 29, 2016)  
- Invited

Asia Pacific Laser Symposium (APLS 2016) Jeju, Korea (May 2016)  
- Invited

4-th International Academy of Photonics and Laser Engineering (IAPLE)  
Conference, Australia (August 2016)  
- Plenary

# Ultrafast Laser Processing Forum (Korea-Germany)

한국-독일 레이저 생산제조 국제기술교류회

Ultrafast Laser Processing Forum (Korea-Germany) 2015

**KIMM** 한국기계연구원  
KOREA INSTITUTE OF MACHINERY & MATERIALS

Wed. Sept. 16, 2015  
Korea Institute of Machinery & Materials

주최: KIMM  
주관: KIMM, KIST, KADP



300 People attended

Sep. 16. 2016 [at KIMM Korea]

# Outlines



- Introduction
- KIMM Research Activities – fs laser processing
- Need of laser processing in Manufacturing Industry
  - Display, Semiconductor, Mobile phone, LED TV, Medical Devices
  - AMOLED
- Present status and trend of laser application for display, AMOLED in KOREA
  - fs Laser processing for AMOLED panels
  - fs Laser processing for AMOLED components
  - fs Laser processing for advanced products (VR, Wearable devices, Smart Watch, Tablet PC )
- Future Trends



펨토공정연구실  
[www.femto-kimm.kr](http://www.femto-kimm.kr)

# Who am I



INTRODUCTION  
연구실 소개

RESEARCH  
연구 내용

TECHNOLOGY  
보유 기술

EQUIPMENT  
보유 장비

RESULTS  
연구 실적

MEMBER  
구성원

HOME | CONTACT US | BOARD

## 구성원 MEMBER

- 조성학
- 연구원
- 기 연구원

조/성/학 | Leader

• HOME > 구성원 > 조성학

# KIMM

# 한국기계연구원

KOREA INSTITUTE OF MACHINERY & MATERIALS

Tel : +82-42-868-7077 | Fax : +82-42-868-7149 | E\_mail : shcho@kimm.re.kr



조성학, Ph.D., is a senior research scientist in KIMM - The Korea Institute of Machinery and Material.

[www.femto-kimm.kr](http://www.femto-kimm.kr)

## Head, Department of Laser & Electron Beam Application, KIMM

## Professor, Femto Process Lab. [UST-KIMM, Korea Univ. of

He received B.S. degree in electronics from A-Jou Univ, Korea in 1994. And, he received M.E. and Ph.D degrees in electronics form Keio University Japan in 1997 and 2000, respectively. In 2000, he joined RIKEN (The institute of physical and chemical research, Japan) and then he has worked on internal processing and surface modification of transparent materials by using femtosecond lasers,

He also studied on micro-nano processing of hard materials like Diamond, Sapphire by using ultrafast lasers. He moved to KIMM Korea in September, 2003. His current interests are development of advanced laser microprocessing techniques performing surface and 3-D microstructuring of transparent materials for applications.

The diagnosis and nanoprocessing of human live cancer cell using ultrafast laser pulses are also new research topics. He received several awards for his research and inventions in the area of laser microprocessing.

# Where KIMM is ...



**Daejeon (Population of 1.5 million)**

- The city of science and technology
- 7,500 citizens with Ph.D. degrees in the applied sciences and an equal number with M.A.s and other advanced training.

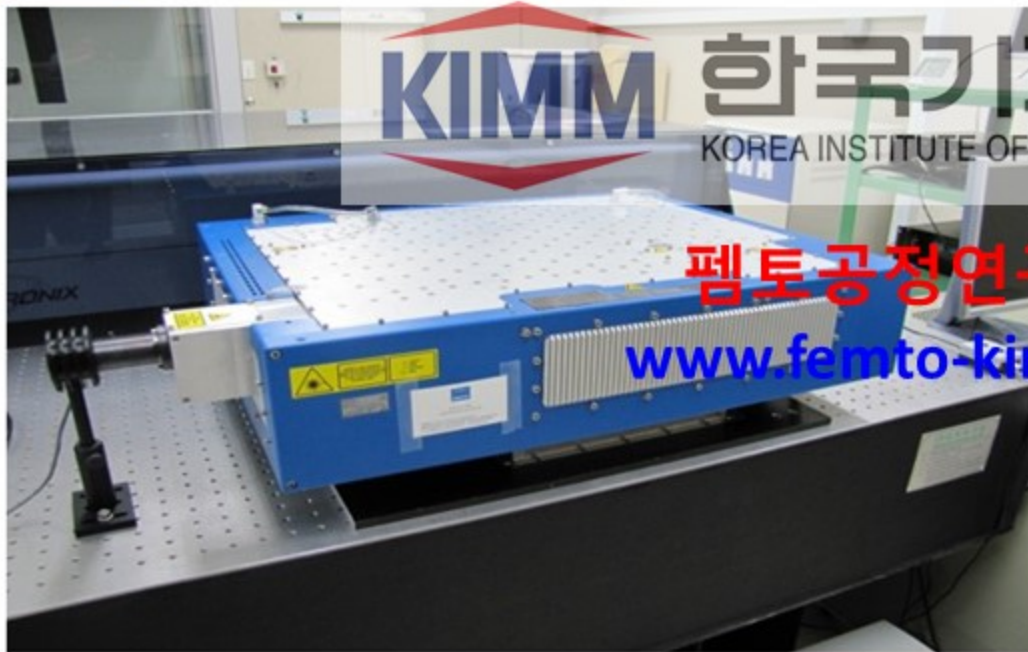
# Femtosecond laser & System in KIMM



System N	KIMM Femto M. I	KIMM Femto M. II	KIMM Femto M. III
Model	RegA™ 9000	Integral I	Solstice
Product c	COHERENT (USA)	QUANTRONIX (USA)	Spectra-Physics (USA)
	<p><b>페토공정연구실</b> <a href="http://www.femto-kimm.kr">www.femto-kimm.kr</a></p>		
Machining system	<ul style="list-style-type: none"> <li>- PMAC based writing software</li> <li>- Motion control</li> <li>- Laser pulse control</li> <li>- Micro Position control</li> <li>- Process parameter database</li> <li>- On-line Monitoring</li> </ul>	<ul style="list-style-type: none"> <li>- CAD based writing software</li> <li>- Motion control</li> <li>- Laser pulse control</li> <li>- Micro Position control</li> <li>- Process parameter database</li> <li>- On-line Monitoring</li> </ul>	<ul style="list-style-type: none"> <li>- CAD based writing software</li> <li>- Motion control</li> <li>- Laser pulse control</li> <li>- Micro Position control</li> <li>- Process parameter database</li> <li>- On-line Monitoring</li> </ul>
Laser Spec.	<p>Working Area: 300 × 300 mm<sup>2</sup> Resolution: 50nm/count Position Accuracy: 2μm Repeatability: ±1μm</p> <p>Wavelength: 800nm Pulse Width: 160fs Repetition Rate: 250kHz Energy: 3μJ/pulse</p>	<p>Working Area: 300 × 300 mm<sup>2</sup> Resolution: 50nm/count Position Accuracy: 2μm Repeatability: ±1μm</p> <p>Wavelength: 790nm Pulse Width: 130fs Repetition Rate: 1kHz Energy: 3.5mJ/pulse</p>	<p>Working Area: 300 × 300 mm<sup>2</sup> Resolution: 50nm/count Position Accuracy: 2μm Repeatability: ±1μm</p> <p>Wavelength: 267nm, 395nm, 790nm Pulse Width: 100fs Rep. Rate: 5kHz Energy: 0.7mJ/pulse</p>

# Femtosecond laser & System in KIMM

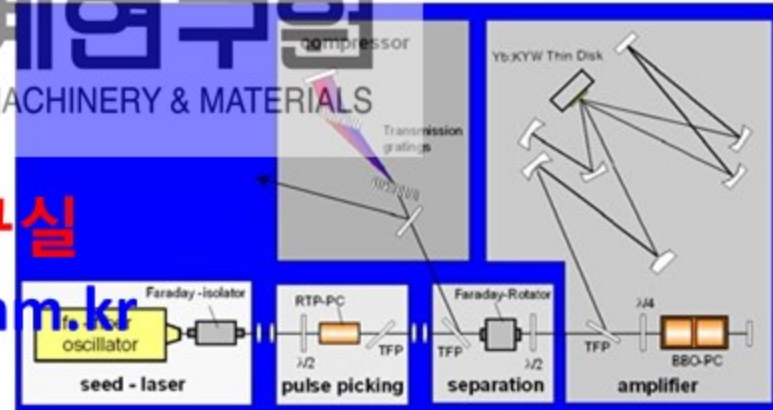
( Jenoptik co. Ltd., Germany )  
[ Jan, 21. 2011 ]



펄소공정연구실

[www.femto-kimm.kr](http://www.femto-kimm.kr)

Model No: JenLas D2.fs



JenLas D2.fs Femtosecond laser  
Pulse energy 40uJ @ 100kHz  
Pulse duration 380fs  
Repetition rate 100kHz  
Beam quality  $M^2 < 1.25$   
Average Output Power 4W  
Wavelength 1027nm, 514nm

<fs laser in KIMM >

SHG, pulse control, First in World.

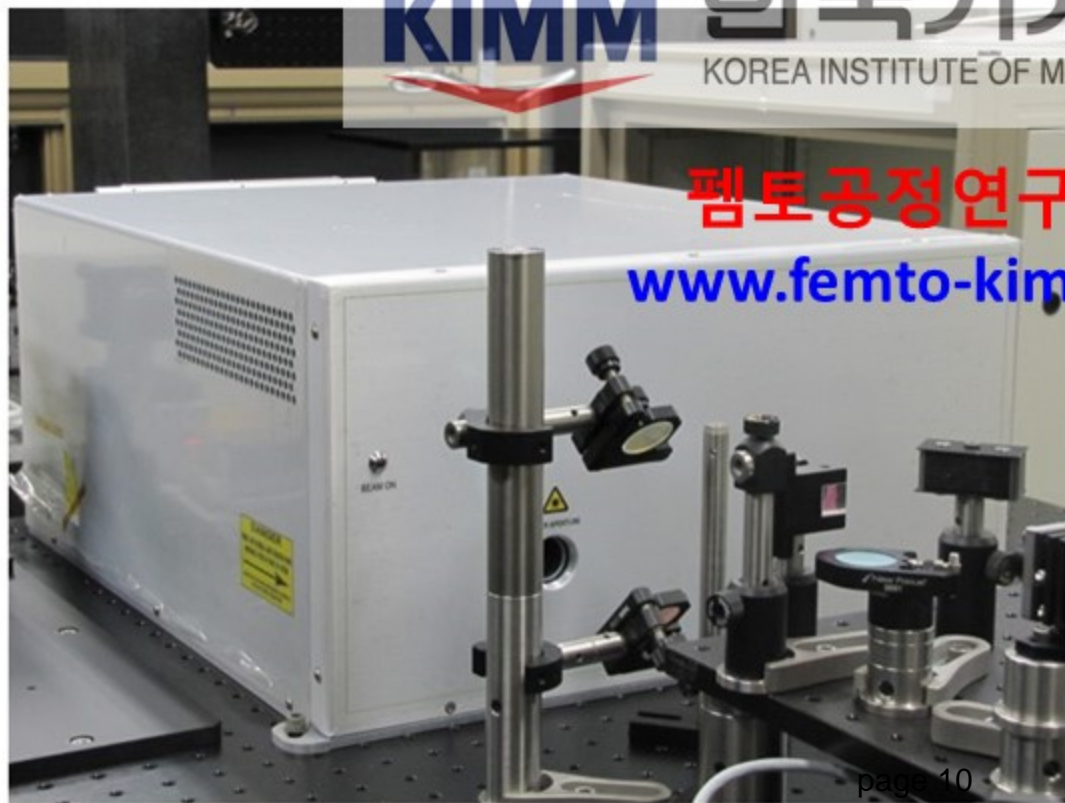
# Femtosecond laser & System in KIMM



고에너지 빔 광원 [fs 레이저]  
[ Raydiance co. Ltd., USA ]  
[ Oct, 7. 2011 ]



Model No.: Smart Light (Full Options)



펄스공정연구실  
[www.femto-kimm.kr](http://www.femto-kimm.kr)

All fiber femtosecond laser  
Raydiance co. (USA)  
Wavelength 1552, 776, 388nm  
Pulse Width 700 fs Repetition  
Rate 1Hz-400kHz [가변]  
Energy 80 uJ / pulse, 6 W

Industrial All fiber fs Laser  
[미국 Raydiance Co.]

page 10

< fs laser in KIMM >

SHG, FHG, Pulse control, First in World

# Femtosecond laser & System in KIMM



극초단 빔 광원 [fs 레이저]  
[ Amplitude systems. Ltd. , France ]  
[ May. 2012 ]



< fs laser in KIMM >

SHG, THG, Pulse control

# Femtosecond laser & System in KIMM



**KIMM** 한국기계연구원  
KOREA INSTITUTE OF MACHINERY & MATERIALS

펨토공정연구실

[www.femto-kimm.kr](http://www.femto-kimm.kr)

6W 190-10,000fs 1030,515, 343nm IR/VIS/UV laser

Pharos (L2K), Light Conversion 사



6W 190-10,000fs  
1030,515, 343nm  
IR/VIS/UV laser



6W 400fs, 1030nm IR laser

# Femtosecond laser & System in KIMM



**KIMM**

**한국기계연구원**

KOREA INSTITUTE OF MACHINERY & MATERIALS

**펨토공정연구실**

[www.femto-kimm.kr](http://www.femto-kimm.kr)

**8W, 10ps, 355nm UV laser**



**50W 300fs 1030nm IR laser**

# New 1 : Samsung invests in Amplitude Systemes[France] (Dec. 1 2015)



SPIE

MY COMPANY | CONTACT US

the business of photonics  
**optics.org**

Daily coverage of the optics & photonics industry and the markets that it serves

**Thales Lasers.**  
**Innovation for industry**  
Wherever safety and security matter, we deliver

**FIND OUT MORE**

**THALES**  
Together • Safer • Everywhere

**KIMM** 한국기계연구원  
KOREA INSTITUTE OF MACHINERY & MATERIALS

Search

HOME NEWSDESK PRESS RELEASES PRODUCTS BUYERS GUIDE JOBS EMPLOYERS EVENTS PUBLICATIONS ADVERTISE

## 펨토공정연구실

[www.femto-kimm.kr](http://www.femto-kimm.kr)

### BUSINESS & FINANCE

PREVIOUS NEXT TABLE OF CONTENTS

## Samsung Ventures invests in Amplitude Laser Group

01 Dec 2015

*French maker of ultrafast solid-state lasers to develop solutions for global consumer electronics giant.*

Ultrafast solid-state laser specialist **Amplitude Laser Group** has announced a financial partnership with **Samsung Venture Investment Corp (SIVC)**, the venture capital arm of Samsung Group. Terms of the investment were not disclosed but Eric Mottay, Amplitude's CEO, told *optics.org*, "We expect this partnership to further strengthen the growth of the company, both in Korea and other



### RELATED LINKS

- Amplitude Laser Group
- Samsung Venture Investment Corp

### RELATED STORIES

- Amplitude Systèmes sets up ultrafast lab in Paris
- Amplitude to snap up GSI's Continuum business
- Biomedical photonics eyes huge potential markets
- French ministers visit booming Amplitude Systèmes

### BUSINESS & FINANCE

Crucial role of large revenue

**WHITE PAPER**  
Epoxies for Optical Applications  
**MASTERBOND**

Messe Stuttgart  
Key to Markets

**THE**

# New 2 : Samsung invests in Raydiance Laser Co. (USA)

(August. 14, 2012)



HOME SERVICES NEWS EDUCATION ABOUT US

Search

- in
- G+
- f
- Twitter
- Envelope
- +

## Raydiance Raises \$20M Growth Financing Led by Samsung Ventures

**KIMM** 한국기계연구원  
KOREA INSTITUTE OF MACHINERY & MATERIALS  
*Company's laser-based solutions poised to enter new markets*

### 펨토공정연구실

August 14, 2012 09:00 AM Eastern Daylight Time

[www.femto-kimm.kr](http://www.femto-kimm.kr)

PETALUMA, Calif.--(BUSINESS WIRE)--Raydiance, Inc., has completed a \$20 million growth financing, led by [Samsung Venture Investment Corporation](#), the investment arm of consumer technology giant Samsung Group. Raydiance says the new funds will be used to accelerate its consumer electronics efforts and to ramp up manufacturing to meet the demand for the company's medical device, automotive, and other manufacturing customers.

"Raydiance offers innovative, disruptive capabilities for manufacturing precise geometries in any material made possible by our femtosecond laser light source"

"The demand for smaller, smarter devices continues to grow," said Jay Chong, investment director at Samsung Ventures. "Raydiance solutions have the potential to significantly improve existing manufacturing processes and to enable exciting new products. We are investing in Raydiance to ensure that these solutions are available for a variety of high volume manufacturing applications."

# KIMM Research of fs laser processing [1]

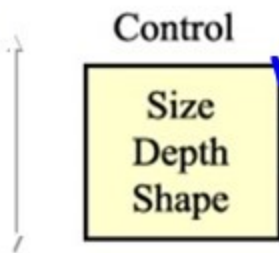


## Mechanism : Ablation (Ultrafast Low-T Plasma) + Ultrasonic V.

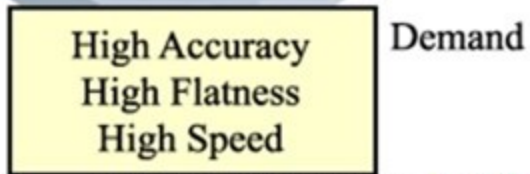
### Concept



Ultrasonic V.



펨토공정연구실  
www.femto-kimm.kr



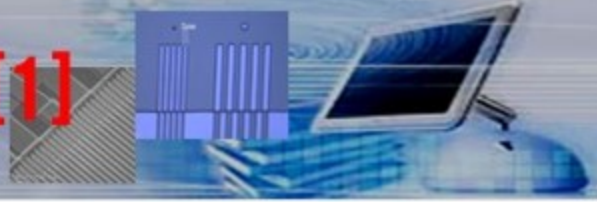
### Target

- Hole Size : < 500 nm
- Line W : < 500 nm
- Depth : > 500 nm
- Resolution: < 100 nm
- Flatness : < 50nm
- Depth, Flatness, A.R.
- Control

### 3D structure

- 특어1: "초음파 진동을 사용하는 하이브리드 레이저 가공 장치" [출원]. [등록]
- 특어10: "LED조명장치의 제조방법" [출원]. [등록]
- 특어2: "외로기관 일체형 LED 패키지를 갖는 LED 조명장치 및 그 제조방법" [출원]. [등록]
- 특어11: "외로기관 일체형 LED 패키지를 갖는 LED 조명장치 및 그 제조방법" [출원]. [등록]
- 특어3: "극초단 펄스 레이저 가공 장치" [출원]. [등록]
- 특어12: "리소그래피 장치 및 리소그래피 방법" [출원]
- 특어4: "레이저를 이용한 위치 검출 장치" [출원]. [등록]
- 특어13: "스텐드" [출원]. [등록]
- 특어5: "펨토초 레이저를 이용한 웨이퍼의 건식세정방법" [출원]. [등록]
- 특어14: "자성을 이용한 가변물드 제작방법 및 이를 이용한 패턴 형성 방법" [출원]. [등록]
- 특어6: "리소그래피장치 및 리소그래피 방법" [출원]. [등록]
- 특어15: "진동자를 이용한 하이브리드 레이저 가공장치" [출원]. [등록]
- 특어7: "투명재료 내부의 컬러영상 가공장치 및 그 가공방법" [출원]
- 특어16: "레이저 가공 기술을 이용한 기관 상 박막의 선택적 제거 장치" [출원]. [등록]
- 특어8: "자석을 이용한 코팅장치" [출원]. [등록]
- 특어17: "극초단 펄스 레이저를 응용한 고중형비 미세영상 가공 장치" [출원]. [등록]
- 특어9: "이방성 진동 가진 장치" [출원]. [등록]

# KIMM Research of fs laser processing [1]



- 특허18: "터치패널, 표시장치 및 터치패널의 제조방법" [출원]
- 특허19: "극초단 펄스 레이저를 이용한 유연 능동형 유기 자체 발광 소자의 비열 리페어 방법 및 장치" [출원]
- 특허20: "극초단 펄스 레이저를 이용한 능동형 유기 자체 발광 소자의 비열 리페어 방법 및 장치" [출원]
- 특허21: "극초단 펄스 레이저를 이용한 투명 능동형 유기 자체 발광 소자의 비열 리페어 방법 및 장치" [출원]
- 특허22: "레이저를 이용한 막대 가공 장치 및 레이저를 이용한 막대 가공 방법" [출원], [등록]
- 특허23: "극초단 펄스 레이저를 이용한 대면적 능동형 유기 자체 발광 소자의 비열 리페어 방법 및 장치" [출원]
- 특허24: "진동자가 결합된 하이브리드 극초단 펄스 레이저 절단 장치" [출원]
- 특허25: "능동형 유기 자체 발광 소자의 열적 및 비열적 복합 리페어 장치" [출원], [등록]
- 특허26: "탑 연마 장치 및 이를 이용한 탑 연마 방법" [출원], [등록]
- 특허27: "스텐트 및 이의 제조방법" [출원], [등록]
- 특허28: "절삭가공기구 및 절삭가공방법" [출원]
- 특허29: "탑가공장치, 이에 의해 제작된 탑, 및 탑을 이용한 열처리장치" [출원]
- 특허30: "하이브리드 펄스 레이저 가공장치" [출원]
- 특허31: "복합 펄스 레이저 가공 장치" [출원]
- 특허32: "선택적 펄스 폭 가변형 레이저를 이용한 능동형 유기 자체 발광 소자의 비열 리페어 방법 및 장치" [출원]
- 특허33: "Full HD급 고해상도 모바일 능동형 유기 자체 발광 소자의 비열 리페어 방법 및 장치" [출원]
- 특허34: "진동자가 결합된 하이브리드 극초단 펄스 레이저 장치를 이용한 투명 재료 접합 방법" [출원]
- 특허35: "레이저를 이용한 선택적 박리장치 및 이를 이용한 박리 방법" [출원], [등록]
- 특허36: "레이저를 이용한 기관 결정화 장치 및 이를 이용한 기관 결정화 방법" [출원], [등록]
- 특허37: "튜브 홀더 및 튜브 홀더를 갖는 튜브 연마 장치" [출원]
- 특허38: "레이저 가공용 진동 장치" [출원]
- 특허39: "고중형비 홀 가공용 베셀 빔 레이저 가공 장치" [출원]
- 특허40: "멀티 모달 레이저 가공 장치" [출원]
- 특허41: "빔 웨이핑 및 펄스 횡수 조절을 이용하여 박막 가공 깊이를 제어하는 레이저 가공 방법" [출원]
- 특허42: "교류전장원을 이용한 레이저 가공 장치 및 방법" [출원]
- 특허43: "레이저를 이용한 증착 및 결정화 장치 및 이를 이용한 증착 및 결정화 방법" [출원]
- 특허44: "선택적 전사 장치 및 방법" [출원]
- 특허45: "튜브부재 가공장치" [출원]
- 특허46: "나노가공 기술기반 플랫탑 빔을 이용한 내장형 안테나 초미세 패턴 제작 방법" [출원]
- 특허47: "나노 홀 가공 기술" [출원]
- 특허48: "나노가공 기반 다광자 흡수 현상을 응용한 차세대 모바일 폰 안테나 제작 방법" [출원]
- 특허49: "투명 능동형 유기자체발광소자 디스플레이 펌토초 레이저 비열 리페어 공정기술 및 리페어장치" [출원]
- 특허50: "나노가공 기반 모바일 폰 안테나 제작을 위한 열가소성 소재 가공 방법" [출원]
- 특허51: "나노 하이브리드 초음파 진동자 시스템을 이용한 유리 미세 접합 기술" [출원]
- 특허52: "온나노와이어 레이저 패턴닝시 황변완화 방법" [출원]

**KIMM 한국기계연구원**

Korea Research Institute of Machinery & Materials

**펄스 레이저 연구실**

[www.femto-kimm.kr](http://www.femto-kimm.kr)

# KIMM Research of fs laser processing [2]



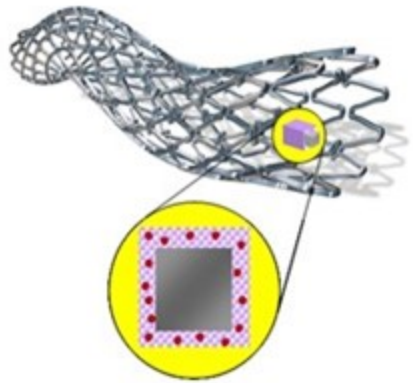
## fs laser processing for Drug Delivery Stent (DDS)



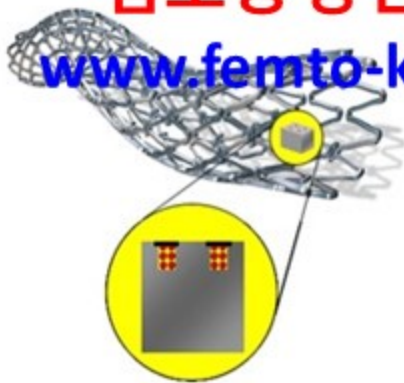
**KIMM 한국기계연구원**  
KOREA INSTITUTE OF MACHINERY & MATERIALS

**펨토공정연구실**

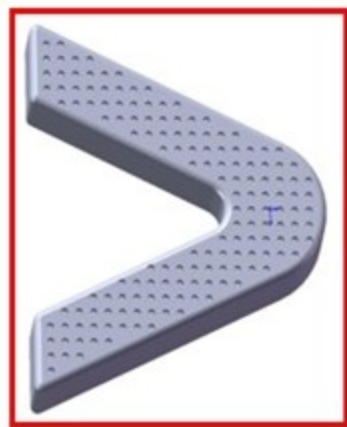
[www.femto-kimm.kr](http://www.femto-kimm.kr)



Conventional  
[Polymer+Drug]



New concept  
[Drug]



**No Polymer Use, Hot Issue**

**Korea National Project**



## Precise nano-machining with a femtosecond laser

(Hole and Surface Relief structure)

Precise nano-machining on polished metal surface

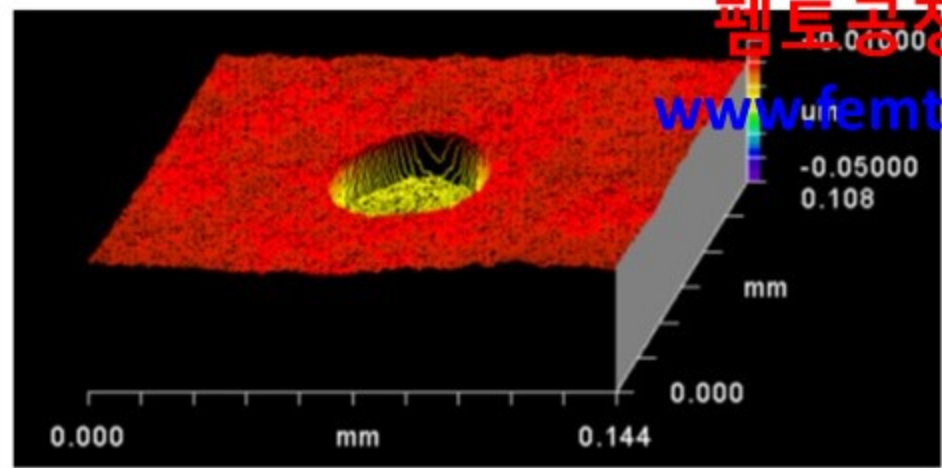


한국기계연구원  
KOREA INSTITUTE OF MACHINERY & MATERIALS

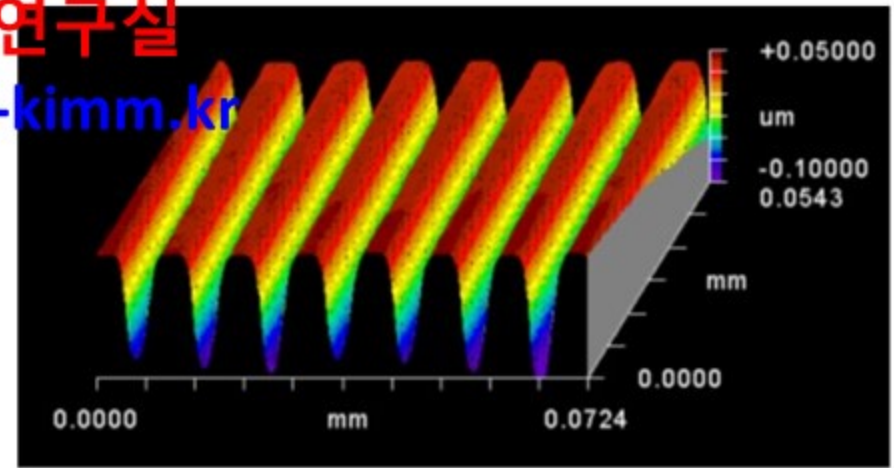
$\phi 40\mu\text{m}$  , 30 nm Depth

10  $\mu\text{m}$  Pitch , 110 nm Depth

펄초공정연구실  
[www.femto-kimm.kr](http://www.femto-kimm.kr)



Hole (Flat Top) Structure



Surface Relief Structure



## fs internal processing of flexible transparent materials

### Optics Communications

Optics Communications 282 (2009) 1317–1321

Femtosecond laser embedded grating micromachining of flexible PDMS plates

Sung-Hak Cho<sup>a,c</sup>, Won-Seok Chang<sup>a</sup>, Kwang-Ryul Kim<sup>b</sup>, Jong Wook Hong<sup>c</sup>

<sup>a</sup>Nano Machining Laboratory, KIMM (Korea Institute of Machinery & Materials), P.O. Box 57, Yusong, Taejeon 305-380, Republic of Korea  
<sup>b</sup>Department of Electronics and Computer Engineering, Hanyang University, Seoul 133-791, Republic of Korea  
<sup>c</sup>Materials Research and Education Center, Department of Mechanical Engineering, Auburn University, 275 Wilmore Laboratories, Auburn University, Auburn, AL 36849, USA



펨토공정연구실

[www.femto-kimm.kr](http://www.femto-kimm.kr)

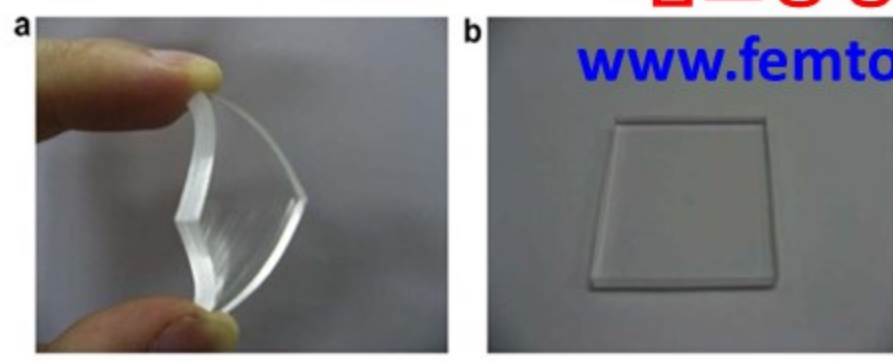


Fig. 2. Sample views of planar flexible PDMS plates: (a) side view and (b) front view.

First report of flexible materials in the world

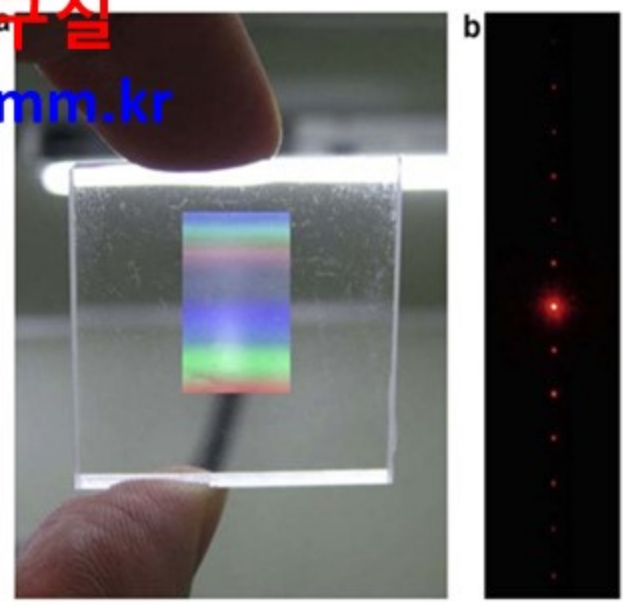


Fig. 7. Diffraction images of the fabricated embedded diffraction grating with refractive index modification using (a) white light source and (b) He-Ne laser (633 nm).

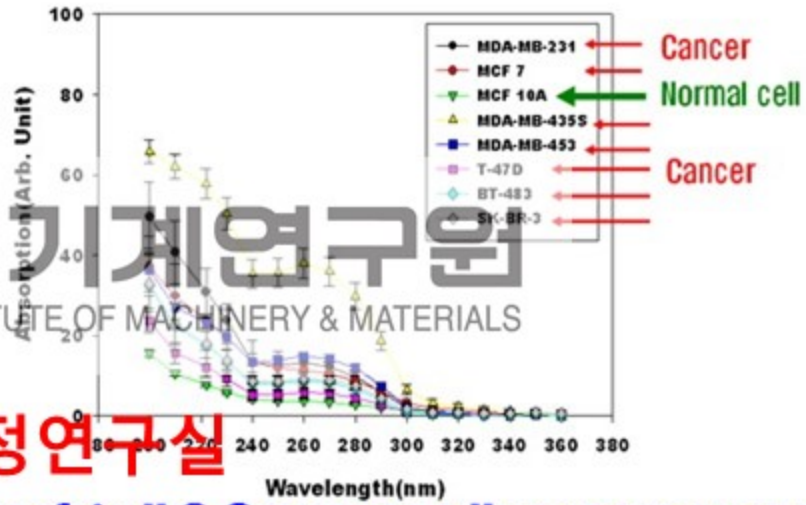
# KIMM Research of fs laser processing [5]



## Single living cell manipulation using fs laser

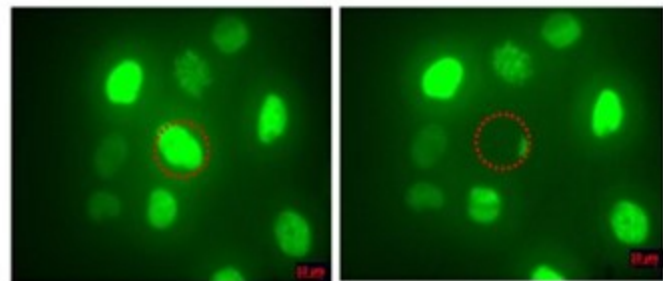
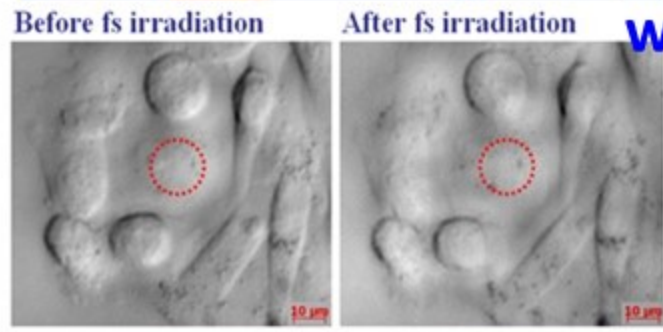


한국기계연구원  
KOREA INSTITUTE OF MACHINERY & MATERIALS



펄스 공정 연구실

## www.femto.kim.ac.kr Cancer cell measurement using cells natural Physical Properties



Cancer cell (MDA-MB-231)  
Histone H2B GFP transfection

1. Patent : SH CHO, UV광 흡수스펙트럼을 이용한 세포의 정상세포, 암 세포 진단장치 및 방법 [10-2007-0006232]
2. Sung-Hak Cho, " Measurement of UV absorption of single living cell for cell manipulation using NIR femtosecond laser" Applied Surface Science 255, 4974-4978 (2009)
3. Sung-Hak Cho, "in situ Observation of photo-bleaching in human single living cell excited by a NIR femtosecond laser " Applied Surface Science. 254, 3370-3375 (2008)

# KIMM Research of fs laser processing [6]



Optics and Lasers in Engineering 84 (2016) 44–50



Contents lists available at ScienceDirect  
**Optics and Lasers in Engineering**  
 journal homepage: [www.elsevier.com/locate/optlaseng](http://www.elsevier.com/locate/optlaseng)



## 40nm Machining

## Resolution for AMOLED

**[World First & Best]**

Ablation depth control with 40 nm resolution on ITO thin films using a square, flat top beam shaped femtosecond NIR laser



Hoon-Young Kim<sup>a,b</sup>, Ji-Wook Yoon<sup>a,b</sup>, Won-Suk Choi<sup>a,b</sup>, Kwang-Ryul Kim<sup>c</sup>,  
 Sung-Hak Cho<sup>a,b,\*</sup>

<sup>a</sup> Nano Machining Laboratory, Korea Institute of Machinery & Material (KIMM), 171 Jangjeon 1-ro, Yusong-gu, Daejeon 305-380, South Korea  
<sup>b</sup> Department of Nano-Mechatronics, Korea University of Science & Technology (UST), 170 Cheongrye-ro, Yuseong-gu, Daejeon 305-341, South Korea  
<sup>c</sup> Department of Electronic and Electrical Engineering, Sungkyunkwan University, 300 Chunchi-dong, Jangjeon-gu, Suwon 440-746, South Korea

[www.femto-kimm.kr](http://www.femto-kimm.kr)

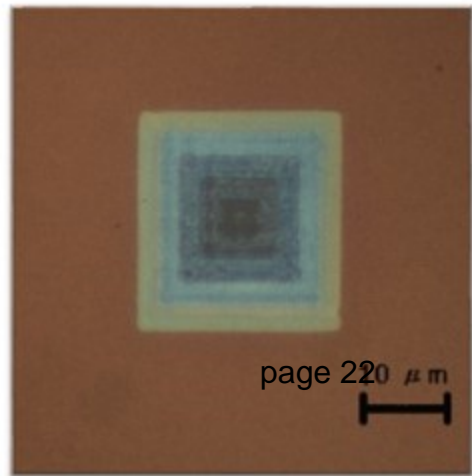
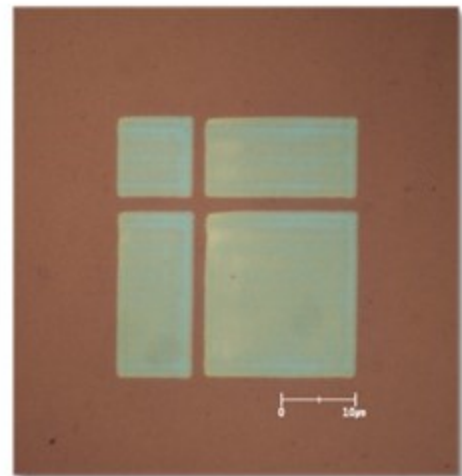
OLEN, April. 12. 2016

ARTICLE INFO

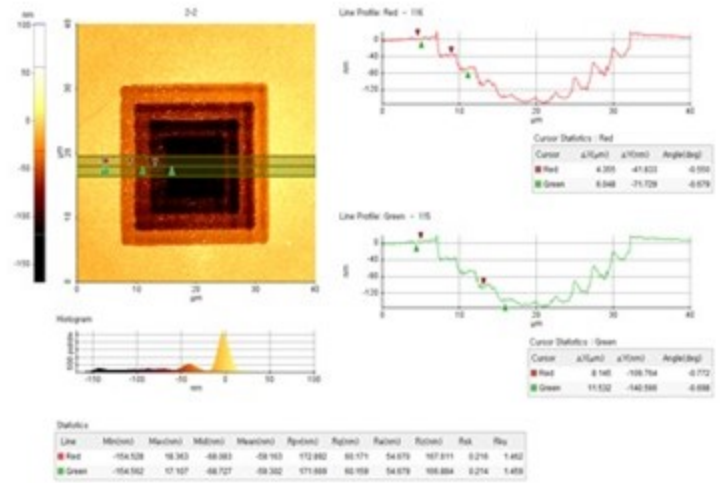
Article history:  
 Received 30 June 2015

ABSTRACT

We reported on the ablation depth control with a resolution of 40 nm on indium tin oxide (ITO) thin film using a square beam shaped femtosecond (100 fs) laser ( $\lambda = 1030$  nm). A slit is used to control the cross-



page 220  $\mu\text{m}$





한국기계연구원

KOREA INSTITUTE OF MACHINERY & MATERIALS

펨토공정연구실

[www.femto-kimm.kr](http://www.femto-kimm.kr)

# KIMM Research of fs laser processing [6]



## KIMM's fs processing Network in KOREA



Laser Process Lab



Annual Meeting  
[Technical, 2times]

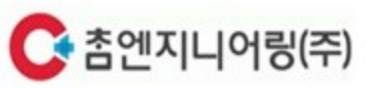
Annual Meeting  
[Technical, 2times]

펨토공정연구실

[www.femto.kimm.kr](http://www.femto.kimm.kr)

Femtosecond laser Process Lab

70 patents  
of fs laser processing



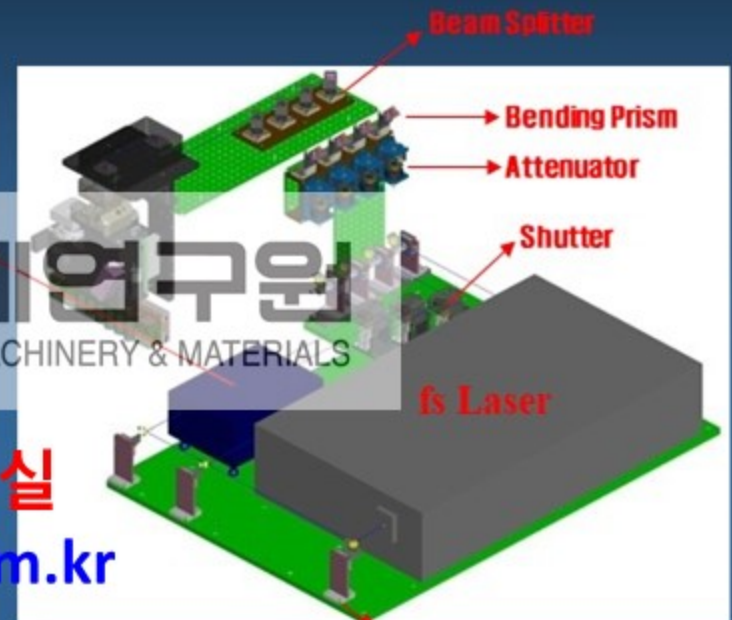
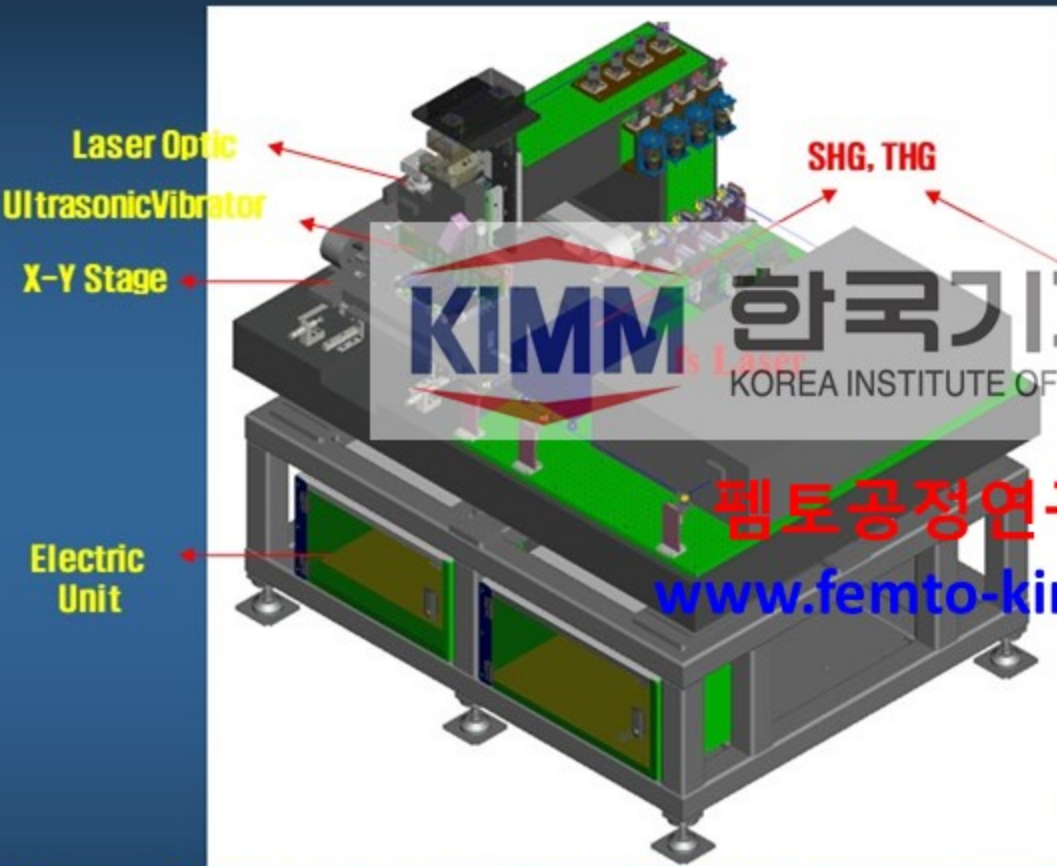
IMT Co.



EO Technics co.

# Next Generation Repair System for AMOLED, Next Generation Display

[Flexible or Transparent or AMOLED Display]

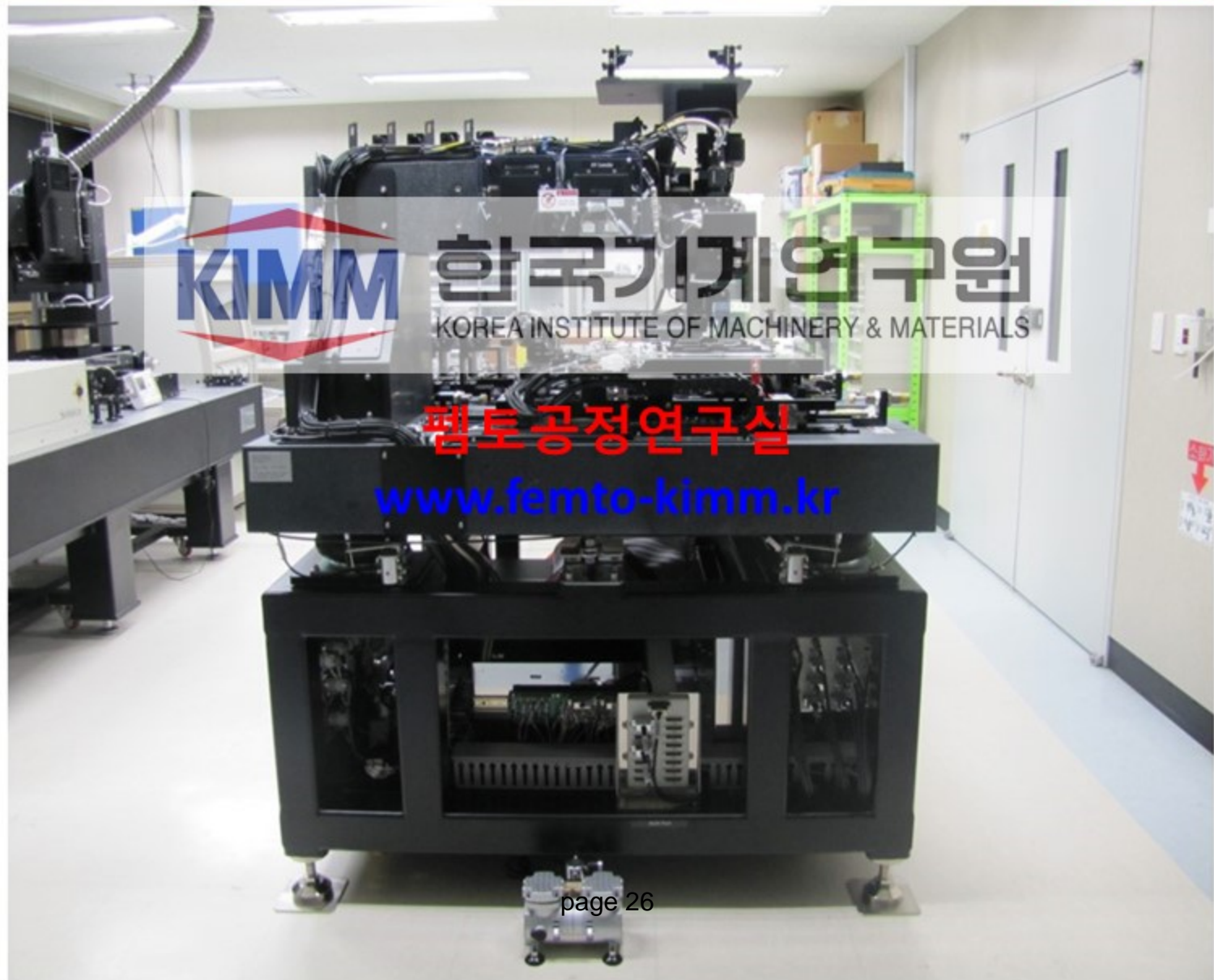


**KIMM** 한국기계연구원  
KOREA INSTITUTE OF MACHINERY & MATERIALS

펨토공정연구실  
[www.femto-kimm.kr](http://www.femto-kimm.kr)

- 5 파장 fs 고에너지 빔 8 초음파진동 기반 하이브리드 초정밀 가공 시스템 개발 [세계 최초]
- fs(펨토초) IR, NIR, VIS, UV, DUV 5개 파장 동시 발진 및 공정적용 [세계 최초, 90fs 3개 파장, 400fs 2개 파장 hybrid화]
- 이중물리량 [고에너지빔+진동] 기반 고품위 가공기술
- 나노기반 초정밀 하이브리드 가공 시스템 기술 확보
- 가공선폭 Sub-um, 홀폭 Sub-um, 가공정밀도 <250nm, 재료무의존성

# Next Generation Repair System for AMOLED ( Next Generation Display )



**KIMM** 한국기계연구원  
KOREA INSTITUTE OF MACHINERY & MATERIALS

펨토공정연구실

[www.femto-kimm.kr](http://www.femto-kimm.kr)

**First in  
the World**

# Outlines



- Introduction
- KIMM Research Activities – fs laser processing
- **Need of laser processing in Display Manufacturing Industry**
  - Display, Semiconductor, Mobile phone, LED TV, Medical Devices
  - AMOLED
- Present status and trends of femto laser application for display, AMOLED, Mobile phone, Semiconductor in KOREA
  - fs Laser Cleaning for Semiconductor
  - LGP (Light Guide Panel) for LED TV
  - Laser processing for AMOLED
  - Laser processing for Other products
- Future Trends



한국기계연구원  
KOREA INSTITUTE OF MACHINERY & MATERIALS

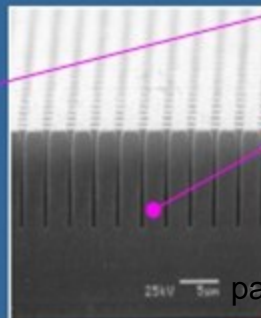
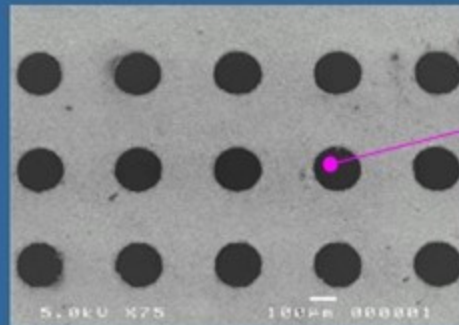
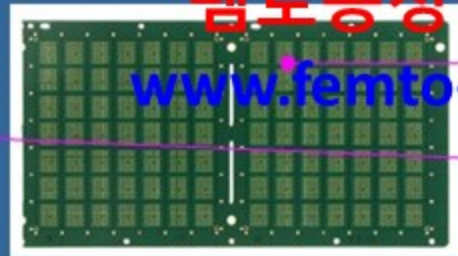
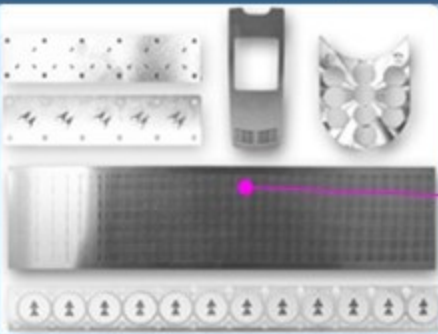
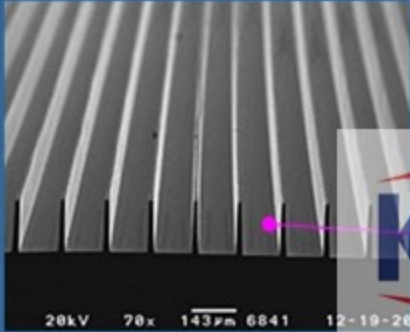
펨토공정연구실

[www.femto-kimm.kr](http://www.femto-kimm.kr)

# Needs = Laser process tech.



## Needed company and products



(주)신진엔지니어링  
(주)에스엠텍  
(주)뮤텍코리아  
한국원자력연구원  
(주)나노전광

## Need companies

(주)엘지전자  
(주)엘지이노텍  
(주)토펙  
(주)삼성SDI  
중앙연구소  
(주)엘엠에스  
(주)에닉스  
(주)맥스필름  
(주)마이크로홀  
(주)제이피이  
(주)피엔티  
(주)나노솔루션  
(주)케이메트로  
(주)오토파워  
한독기계(주)  
소닉스코리아  
(주)LG화학  
(주)덕유  
휴메드 주식회사  
조폐공사  
(주)AP시스템

페토공정연구실

[www.femto-kimm.kr](http://www.femto-kimm.kr)

EMI 필터

PCB/FPCB 기판

휴대폰부품, 케이스

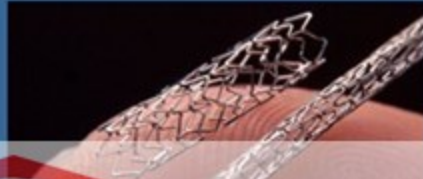
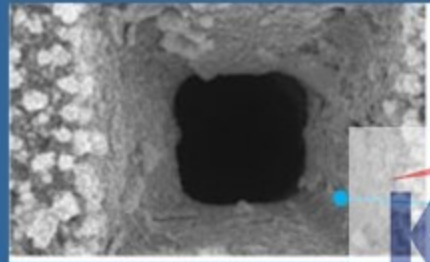
X-ray 형광판

바이오칩 미세홀

(주)엘티에스  
한국국방과학연구소  
(주)삼익THK  
한국표준과학연구원

# Needs = Laser process tech.

## Needed company and products



- (주) 휴메드
- (주) 삼성SMD
- (주) LG디스플레이
- (주) 룩스이엔지
- (주) 성경포토닉스
- (주) 신한다이아몬드

## Needed companies

- 이피코리아
- 하나 마이크로
- 삼성전기
- 샤프정밀
- 엘지 마이크로
- 동산금형
- (주) 세진
- (주) 원플러스투
- KDS intech
- 진영정밀금속
- (주) 애경화학
- 연백정공
- 도양엔지니어링(주)
- (주) 유비프리시전
- (주) 네온테크
- 블루플래닛
- 삼성전자
- 생산기술연구소
- 재영솔루텍
- 대산정밀
- 삼도프레스(주)
- (주) HPK
- (주) 호나
- (주) 빛기술

약물전달 스텐트

펄토 공정 연구실

디스플레이용 광학부품

[www.femto-kimm.kr](http://www.femto-kimm.kr)

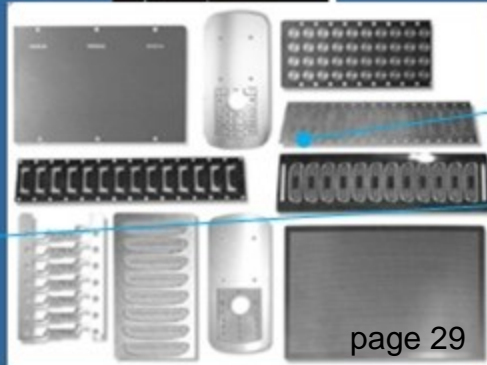
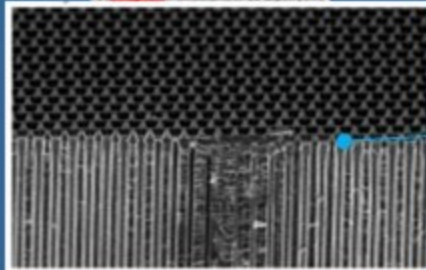
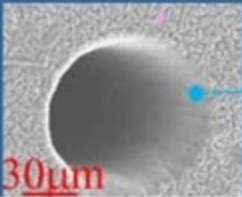
초정밀 공작기계 부품

각종 valve

금형부품

연료전지

디스플레이 리페어



# Needs = Laser process tech.



## Needed company and products

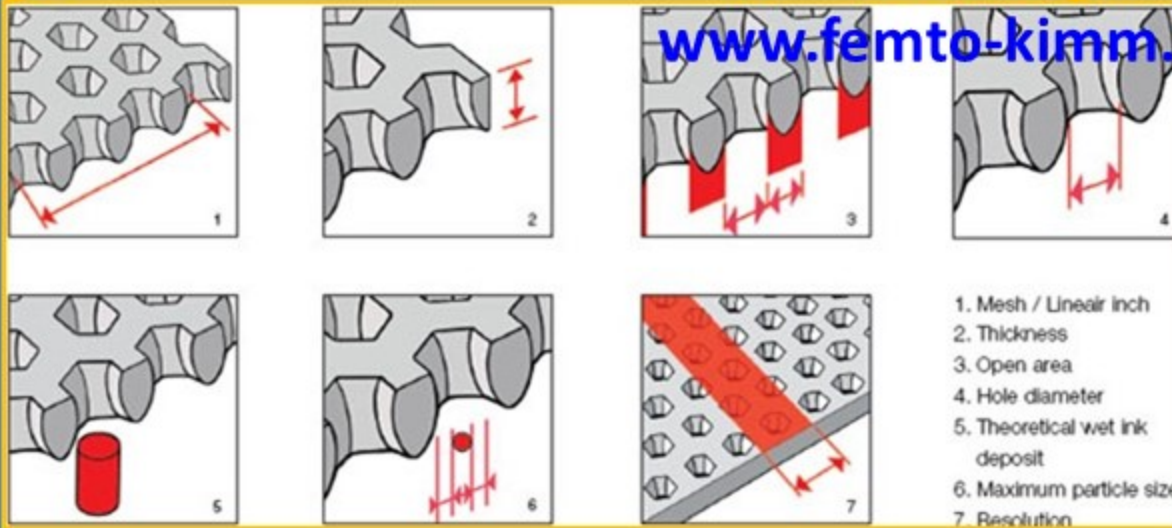


고품질 롤 인쇄를 위한  
High aspect ratio mesh  
type 노즐 형상  
공정 기술 요청

### 펨토공정연구실

[www.femto-kimm.kr](http://www.femto-kimm.kr)

+ 비밀 암호 형상 제작 가능성 의뢰  
[ Sub 10 um Non-thermal process ]



# Needs - Laser process tech



- **LGP (Light guide panel) for LED TV, 3D LED TV,**



**KIMM**

**한국기계연구원**

KOREA INSTITUTE OF MACHINERY & MATERIALS

**펨토공정연구실**

[www.femto-kimm.kr](http://www.femto-kimm.kr)

**3D LED LCD,  
LED TV**



**LED mobile Phone**

**Needs from SAMSUNG**



# Needs - fs Laser process tech.



## NEED companies



**KIMM**

**한국기계연구원**  
KOREA INSTITUTE OF MACHINERY & MATERIALS

AMOLED

**SAMSUNG**



SAMSUNG  
Electronics Co

SMD  
(Samsung  
Mobile Display)



**펨토공정연구실**

[www.femto-kimm.kr](http://www.femto-kimm.kr)

**LG electronics**



**3D LED LCD,  
LED TV**

**LG display**



# Needs - Laser process tech for AMOLED



한국기계연구원  
KOREA INSTITUTE OF MACHINERY & MATERIALS

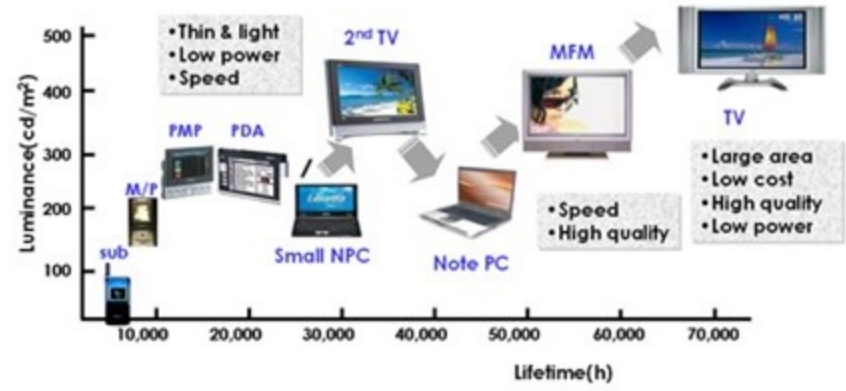
AMOLED substrate [삼성 SMD 제공]

## 페토공정연구실

[www.femto-kimm.kr](http://www.femto-kimm.kr)

### Display Applications for AMOLED

- Mobile → Small TV → Middle size → HDTV
- Key issues for large area is life time and image sticking



# Super AMOLED



SAMSUNG Electron. co  
Smart phone Galaxy S  
(2010.6.9)



페토공정연구실  
[www.femto-kimm.kr](http://www.femto-kimm.kr)

SUPER AMOLED  
(AMOLED) employed



**50,000,000 sold in world**

# GALAXY S VS iPhone Ultra 4G



**GALAXY S**



**iPhone 4**

	Iphone 4	Galaxy S
<p><b>Retina LCD</b>                      ( LG Display Co. Korea )                      한국기계연구원                      KOREA INSTITUTE OF MACHINERY &amp; MATERIALS</p>	<p>8.9cm (대각선) 와이드 스크린                      960*640 해상도</p>	<p><b>WVGA Super AMOLED PANEL</b>                      SAMSUNG MOBILE DISPLAY</p>
<p><b>페토공정연구실</b>  <a href="http://www.femto-kimm.kr">www.femto-kimm.kr</a>                      800:1 명암비 (일반)</p>	<p>2.54cm 당 326 픽셀인                      960*640 해상도</p>	<p>4.0" WVGA(480*800) 16M SUPER AMOLED                      mDNle(Mobile Digital Natural Image engine)</p>
<p><b>Display</b></p>	<p>앞면과 뒷면에 지문 및 기름 방지 코팅</p> <p>여러 언어와 글자 동시 표현 지원</p> <p>3.5 inch (8.9cm) 화면</p> <p>960*640 해상도 (326ppi)</p> <p>Retina IPS LCD Panel</p>	<p>4 inch (10.16cm) 화면</p> <p>800*400 해상도(233ppi)</p>

# TabletPC [Galaxy Tab VS iPad]



**GALAXY TAB (Samsung)**



**iPad (Apple)**

	Samsung	Apple
구분	GALAXY TAB	iPAD
갤럭시탭과 아이패드 비교		
운영체제	안드로이드 2.2(프로요)	iOS 3.2
CPU	SH01 (삼성 자체개발 1GHz)	A4 (애플 자체개발 1GHz)
Display	7인치 LCD(16:10)	9.7인치 LCD(4:3)
메모리	내장 16GB/확장슬롯 제공	16GB, 32GB, 64GB
통신망	와이파이+3G	와이파이, 와이파이+3G
터치	지원	지원
이러바시	터치 지판 이용한 삼성키패드, 모아키, 스와이프	터치자판 이용
통화기능	지원	미지원
카메라	300만화소 후면카메라, 전면 영상 통화용 제공, 플래시탑재	미지원
애플리케이션 마켓	안드로이드마켓, 삼성앱스(예상), 티스토어(예상) 이용가능	애플 앱스토어, 아이튠스스토어, 아이북스 스토어 이용가능
기타	국내모델 지상파 DMB 지원	두터운 이용자층과 풍부한 콘텐츠

한국기계연구원

Display

KOREA INSTITUTE OF MACHINERY & MATERIALS

페토공정연구실

www.femto-kimm.kr

Samsung LCD



Galaxy S4



Galaxy Note3



Galaxy Gear



Galaxy Round

**KIMM**

**한국기계연구원**

KOREA INSTITUTE OF MACHINERY & MATERIALS

**페토공정연구실**  
**AMOLED panel adopted Products**  
[www.femto-kimm.kr](http://www.femto-kimm.kr)



**AMOLEd TV**



**Flexible AMOLEd**



**Transparent AMOLEd**

- Present status and trend of laser application



한국기계연구원

KOREA INSTITUTE OF MACHINERY & MATERIALS

fs Laser processing for AMOLED  
펨토공정연구실

[www.femto-kimm.kr](http://www.femto-kimm.kr)



AMOLED is the next generation display

Samsung display (SDC) is single provider in the world

# Introduction **AMOLED**



## Full HD AMOLED display



### Smart Phone



### Tablet PC

Ex)  
Galaxy TAB

Ex)  
Galaxy S1-S7  
Galaxy Note  
KORREAN INSTITUTE OF MACHINERY & MATERIALS



## Next generation AMOLED **페토공정** 연구실

[www.femto-kimm.kr](http://www.femto-kimm.kr)



[Transparent Display]



[Flexible Display]



[Foldable Display]



[Dual Display]



[3D TV Display]



[Paper Thin Display]

# Trend of AMOLED [1]



## Various applications of OLEDs



**KIMM 한국기계연구원**  
 KOREA INSTITUTE OF MACHINERY & MATERIALS

**페토공정연구실**  
[www.femto-kimm.kr](http://www.femto-kimm.kr)



Samsung "AMOLED" 4.0" Mobile phone



Samsung "AMOLED" TV" 40 inch



Samsung SDI 1.1" PMOLED



Pioneer PMOLED



UDC, Transparent lighting



Sony 'CLIE' PDA 3.8" Full-color AMOLED



LG "AMOLED" TV" 15 inch



RIOE(Japan), OLED lighting GE, OLED Chandelier

# Trend of AMOLED [1]



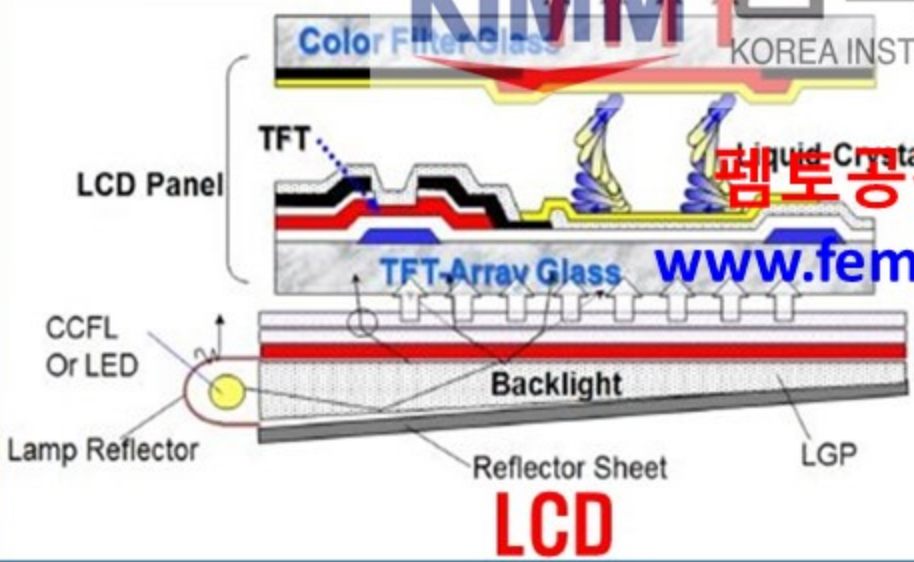
## LCD vs. AMOLED

### Structures of TFT-LCD

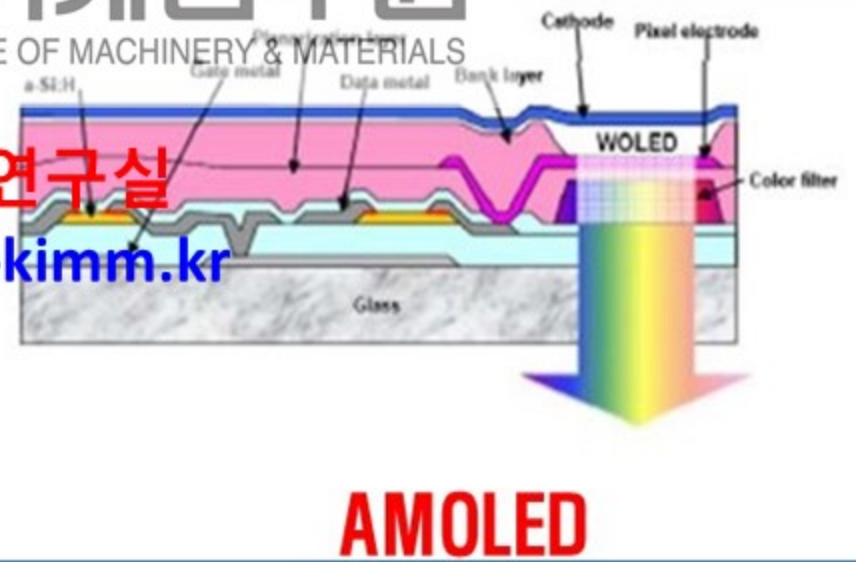
### Structures of AMOLED

KIMM 한국기계연구원

KOREA INSTITUTE OF MACHINERY & MATERIALS



**LCD**



**AMOLED**

페미토공정연구실  
www.femto-kimm.kr

**LCD**: Liquid Crystal Display

**AMOLED**: Active Matrix Organic Light-Emitting Diode

# Manufacturing Cost (LCD vs AMOLED)

## Manufacturing Cost – One Full HD Display Panel (5 inch) for Smart Phone

LCD : 14.6 US Dollar

AMOLED : 14.3 US Dollar



Chosun Biz  
 한국기계연구원 RX  
 KOREA INSTITUTE OF MACHINERY & MATERIALS  
 Lexus LADIES LONG DRIVE CH...  
 총상금 1000만원의 주인공

Manufacturing Cost :  
AMOLED < LCD

at 1/4 Quarter, 2016

페토공정연구실  
www.femto-kimm.kr

스마트폰용 AMOLED 제조원가, LCD보다 낮아졌다...AMOLED로 대체될까

정용창 기자

기사 100자평(0)

입력 : 2016.03.24 15:44 | 수정 : 2016.03.24 16:07

### Turning Point from LCD to AMOLED

스마트폰용 능동형 유기발광다이오드(AMOLED) 패널의 제조원가가 처음으로 스마트폰용 액정표시장치(LCD) 패널의 제조 원가보다 낮아졌다. 이에 따라 AMOLED가 스마트폰 디스플레이 시장에서 LCD를 대체해 나갈 것이라는 전망이 나온다.

시장조사기관 IHS는 24일 올해 1분기 5인치 풀HD 스마트폰에 탑재되는 AMOLED의 제조원가가 14.3달러로 같은크기의 LTPS LCD(14.6달러)의 제조원가보다 낮아졌다고 밝혔다.

New 1

# Manufacturing Cost (LCD vs AMOLED)

## Manufacturing Cost – One Full HD Display Panel (5 inch) for Smart Phone

LCD : 14.6 US Dollar

AMOLED : 14.3 US Dollar



Manufacturing Cost :  
AMOLED < LCD

at 1/4 Quarter, 2016

Chosun Biz  
한국기계연구원 RX  
KOREA INSTITUTE OF MACHINERY & MATERIALS  
LADIES LONG DRIVE CH  
총상금 1000만원의 주인공

뉴스 증권 부동산 정책·금융 기업 Weekly Biz 오피니언

페토공정연구실  
www.femto-kimm.kr

스마트폰용 AMOLED 제조원가, LCD보다 낮아졌다...AMOLED로 대체될까

정용창 기자

기사 100자평(0)

다운로드 +크게 -작게

입력 : 2016.03.24 15:44 | 수정 : 2016.03.24 16:07

## Turning Point from LCD to AMOLED

스마트폰용 능동형 유기발광다이오드(AMOLED) 패널의 제조원가가 처음으로 스마트폰용 액정표시장치(LCD) 패널의 제조 원가보다 낮아졌다. 이에 따라 AMOLED가 스마트폰 디스플레이 시장에서 LCD를 대체해 나갈 것이라는 전망이 나온다.

시장조사기관 IHS는 24일 올해 1분기 5인치 풀HD 스마트폰에 탑재되는 AMOLED의 제조원가가 14.3달러로 같은크기의 LTPS LCD(14.6달러)의 제조원가보다 낮아졌다고 밝혔다.

New 2

# Samsung Display supply AMOLED to Apple Co. Ltd.

2016-April-18 Ref. SBS. Korea

3 billion USD for 3 Years

삼성, 아이폰용 OLED패널 공급  
삼성 투자확대...업계 판도변화 촉각



한국기계연구원

KOREA INSTITUTE OF MACHINERY & MATERIALS

펨토공정연구실

[www.femto-kimm.kr](http://www.femto-kimm.kr)



LG

경제이슈 이슈

삼성-애플, 3조원대 올레드 패널 공급 계약

# World Market Share (Small – Medium OLED Panel)

## 중소형 OLED 패널 시장 점유율

2016년 1분기 기준, 단위:%

소니 0.4

LG디스플레이 1.2

AUO 0.4

eMagin 0.1



한국기계연구원  
KOREA INSTITUTE OF MACHINERY & MATERIALS



페토공정연구실  
[www.femto-kimm.kr](http://www.femto-kimm.kr)

삼성디스플레이  
97.9

자료:IHS

그래픽:유정수 디자이너

2016. 1/4 Quarter

SAMSUNG Display	: 97.9%
LG Display	: 1.2%
Sony	: 0.4%
AUO	: 0.4%
eMagin	: 0.1%

# AMOLED (Introduction, Korean)



SMD PR 2011



**한국기계연구원**  
KOREA INSTITUTE OF MACHINERY & MATERIALS

**펨토공정연구실**

[www.femto-kimm.kr](http://www.femto-kimm.kr)

# Transparent AMOLED



**한국기계연구원**  
KOREA INSTITUTE OF MACHINERY & MATERIALS

**펨토공정연구실**

[www.femto-kimm.kr](http://www.femto-kimm.kr)

# AMOLED Market Size [ I ]



(billion dollars)



**KIMM** 한국기계연구원  
KOREA INSTITUTE OF MACHINERY & MATERIALS

**페토공정연구실**  
[www.femto-kimm.kr](http://www.femto-kimm.kr)

(billion dollars)



Display Bank (2011)

Display Bank (2011)

# AMOLED Market Size [ II ]



## AMOLED Market Prospect

Grow up about 110% every year

## AMOLED World Market Growth



- Forecast of rapid growth \$2.4billion in 2015 to \$30billion in 2020
- Territory expansion to large area display from small and medium area display

- Flexible display market growth in earnest since 2014
- Prospect for steady growth of flexible display market

The sales figures of SAMSUNG DISPLAY(2013) : \$250billion  
The sales figures of LG DISPLAY(2013) : \$210billion

➔ Expectation of new market caused by development of flexible AMOLED display

# Technical Issues



Rapid increase on demand for AMOLED display-related technology based laser

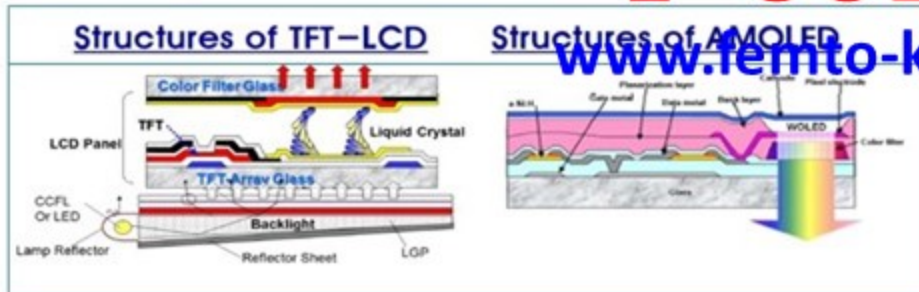


**KIMM** 한국기계연구원  
KOREA INSTITUTE OF MACHINERY & MATERIALS



펄토공정연구실

[www.femto-kimm.kr](http://www.femto-kimm.kr)



**SAMSUNG ELECTRONICS :**  
Waste panel \$700M/year (2013)

**SAMSUNG DISPLAY :**  
Waste panel \$300M/year (2013)

**AMOLED ( Active Matrix Organic LED )**

**Discard in case of defect in AMOLED (Can not use thermal laser based nanosecond laser**

**No solution with non-thermal micromachining for repair mobile AMOLED panel**

# AMOLED



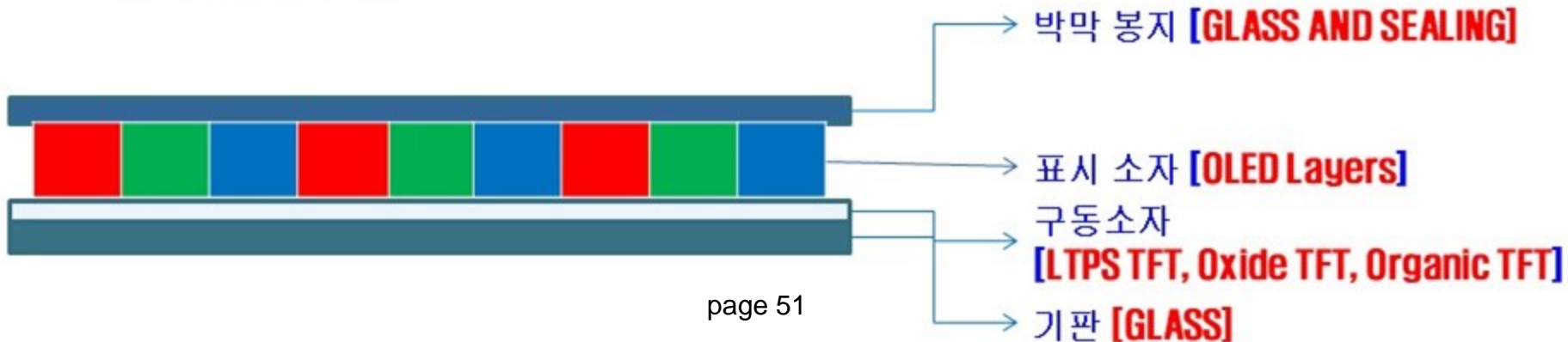
## KIMM

### 한국기계연구원

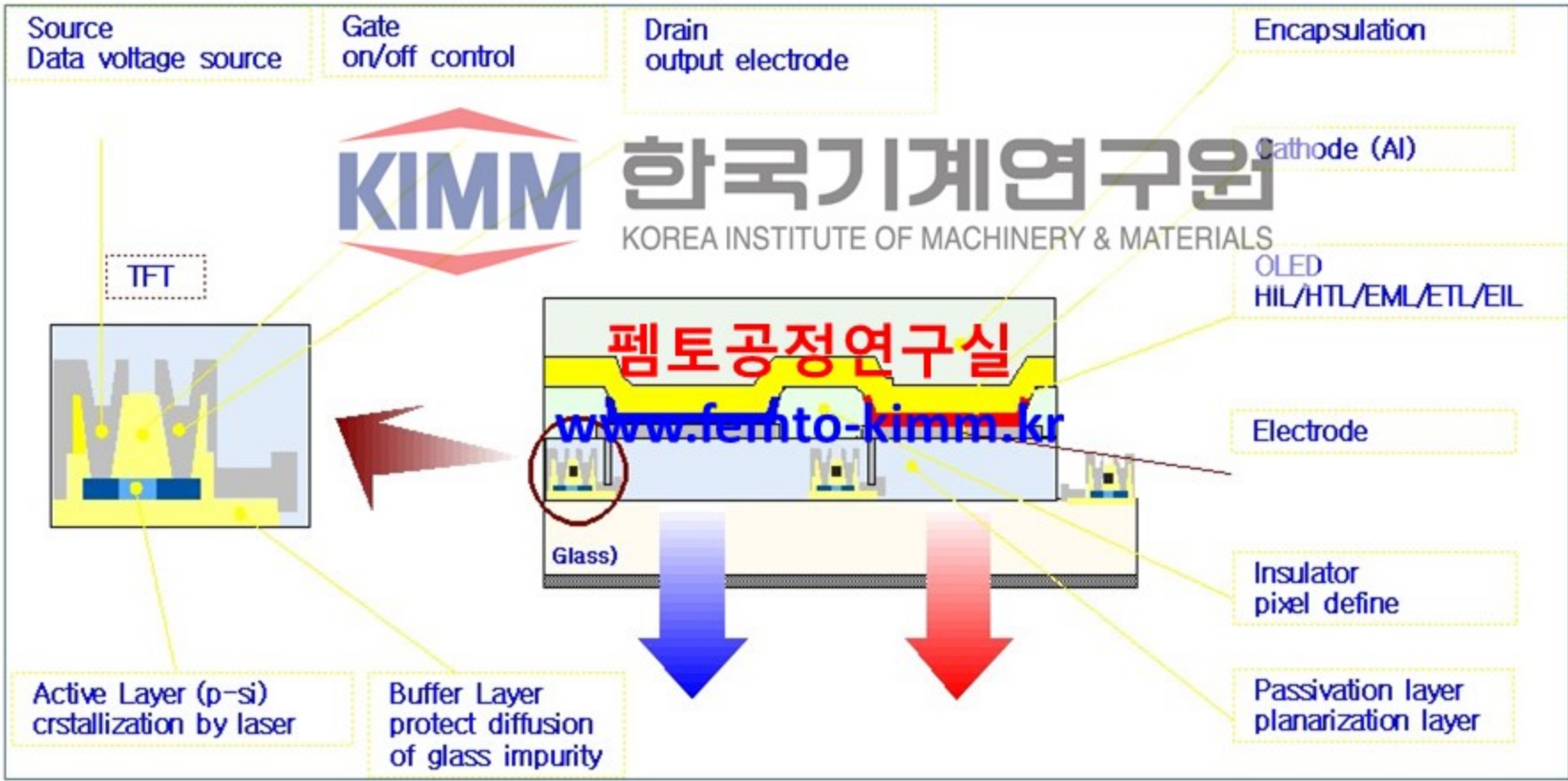
KOREA INSTITUTE OF MACHINERY & MATERIALS

### 펨토공정연구실

[www.femto-kimm.kr](http://www.femto-kimm.kr)



# Device structure of AMOLED



# Classification of AMOLED by emitting direction

	Bottom-emitting OLED	Top-emitting OLED
Emission direction	<p>Emission to TFT side</p>	<p>Emission to transparent cathode side</p>
Structure	<p>Transparent anode Reflective cathode</p>	<p>Reflective anode Semi-transparent cathode</p>
Characteristics	<p>Simple structure and process Low aperture ratio (&lt;40%) Short lifetime and low resolution</p>	<p>Complicated structure and manufacturing High aperture ratio (40~70%) Long lifetime and high resolution Wide color gamut</p>

# Non-thermal fs processing for AMOLED

ns, ps laser

fs laser



한국기계연구원  
KOREA INSTITUTE OF MACHINERY & MATERIALS

펨토초 펄스 레이저 (Femtosecond Pulse Laser)

펨토공정연구실 (Femtosecond Processing Research Lab)

[www.femto-kimm.kr](http://www.femto-kimm.kr)



NO USE



?

# AMOLED PIXEL (RGB)



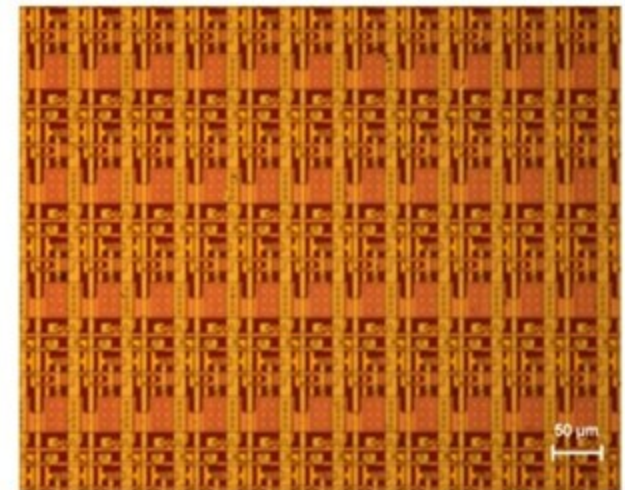
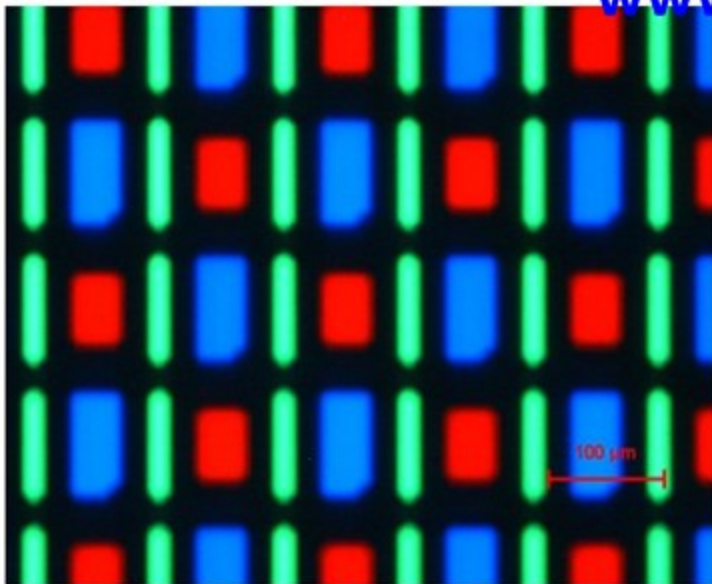
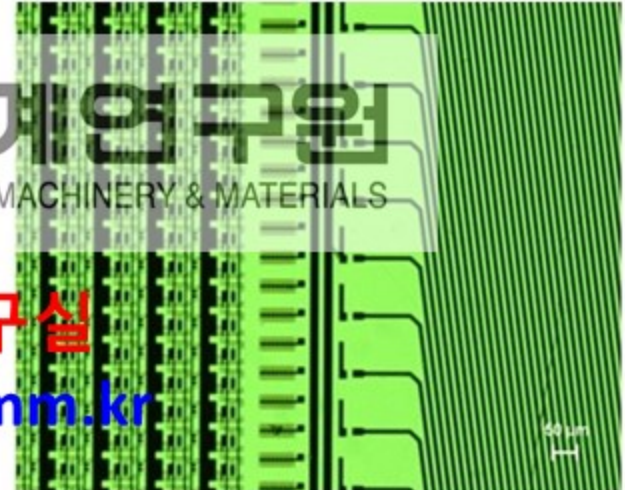
Super AMOLED in Galaxy S  
217ppi



한국기계연구원  
KOREA INSTITUTE OF MACHINERY & MATERIALS

펨토공정연구실

[www.femto-kimm.kr](http://www.femto-kimm.kr)



# AMOLED Display [Galaxy series]



## Galaxy S

**Super AMOLED**

4.3 inch (800 × 480)

217ppi  
June 25, 2010



## Galaxy S2

**Super AMOLED Plus**

4.3 inch (800 × 480)

217ppi  
April 29, 2011

페토공정연구실

[www.femto-kimm.kr](http://www.femto-kimm.kr)



## Galaxy S2 HD LTE

**Super AMOLED**

4.65 inch (1280 × 720)

316ppi  
Oct. 27, 2011



## Galaxy Note

**Super AMOLED**

5.3 inch (1280 × 800)

316ppi  
Nov. 29, 2011

# AMOLED Display [Galaxy series]



Not yet release

Galaxy Tab 7.7	
Size/Weight	133 × 196.7 × 7.89 mm, 335g
Display	7.7 inch (12.1 cm) Super AMOLED Plus, 197ppi
OS	Android 3.2
Battery	5100 mAh
Release date	Not yet. At 2012

**KIMM 한국기계연구원**  
KOREA INSTITUTE OF MACHINERY & MATERIALS

페토공정연구실

[www.femto-kimm.kr](http://www.femto-kimm.kr)

Not yet release



AMOLED TV	
Display	55 inch
Company	SMD, LGD
Release date	The second half of 2012

# AMOLED Flexible Display [Galaxy Skin]



Not yet release

Release date : 2012

GALAXY Skin

**KIMM** 한국기계연구원  
FLEXIBLE AMOLED  
Supreme Flexible AMOLED  
Skin Phone with Challenge of AMOLED  
Natural User Interface

AMOLED

www.femto-kimm.kr



Natural User Interface



# OLED TV 3D (55 inch)



**KIMM**

**한국기계연구원**

KOREA INSTITUTE OF MACHINERY & MATERIALS

**펨토공정연구실**

[www.femto-kimm.kr](http://www.femto-kimm.kr)

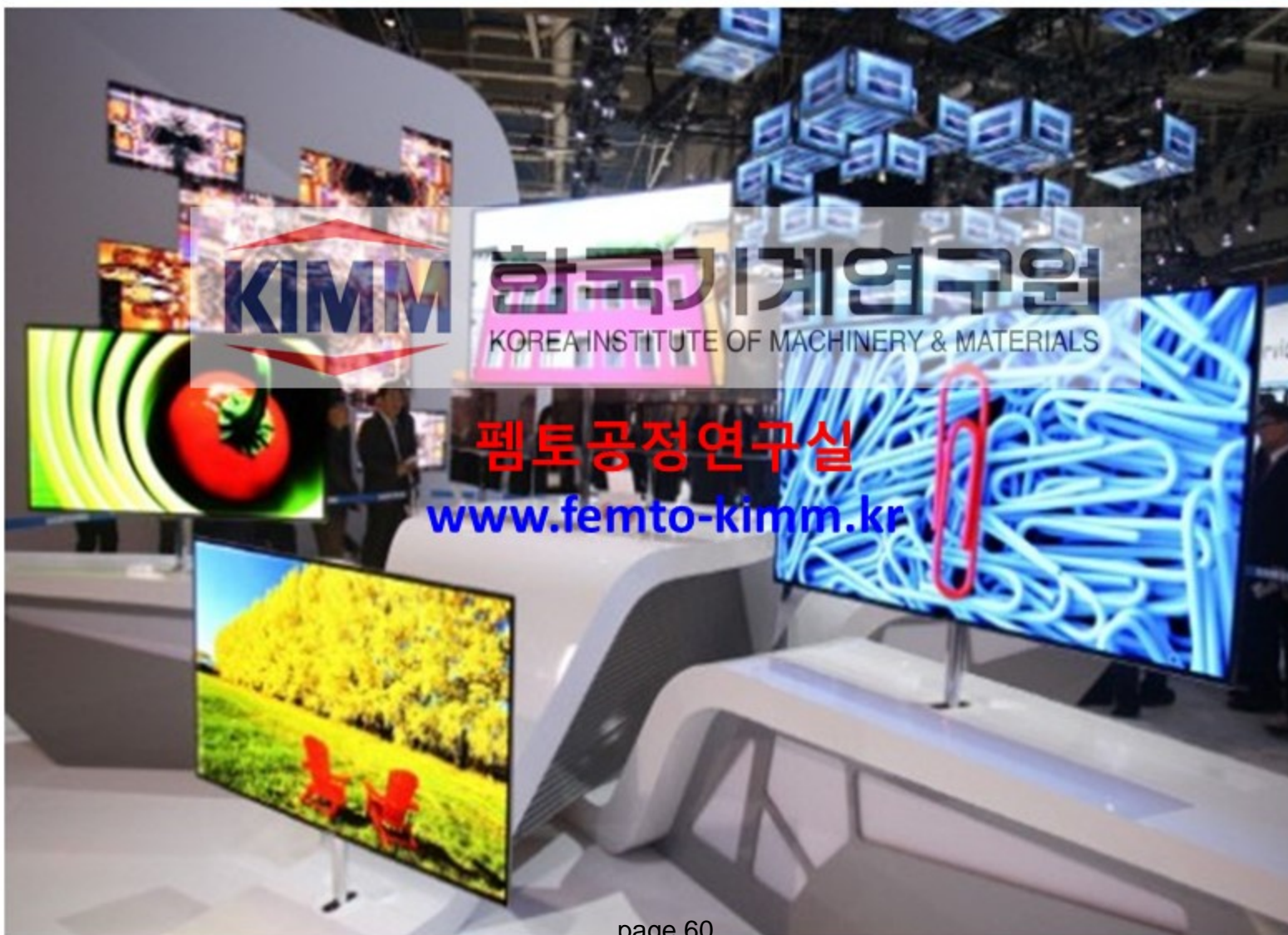
page 59

**White OLED + Color Filter, (No AMOLED)**

**Thickness: 4mm, Weight: 7kg**

**LG Electron., CES 2012 (2012. 1)**

# SAMSUNG Super AMOLED TV (55 inch)



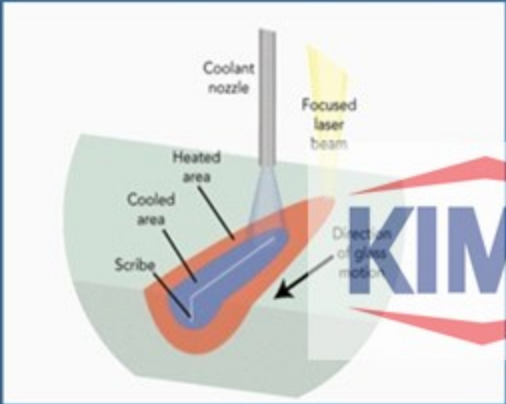
page 60

**SAMSUNG Electron., CES 2012 (2012.1)**

# Trend of AMOLED



## ◆ Laser process technology in AMOLED (Current, near future)



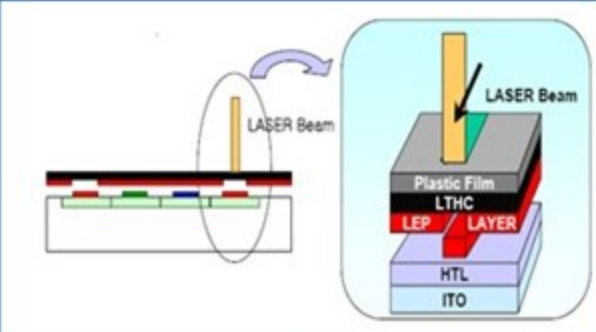
[Laser Substrate Cutting]



[Laser Annealing, LTPS]  
[www.femto-kimm.kr](http://www.femto-kimm.kr)



[Laser Frit Sealing]



[ LITI ]



[Laser Repairing]



[Laser In-Glass Marking]

# AMOLED Test (KIMM)



Pulse energy (50  $\mu$ J) fixed  
Objective lens : x 20 (NA: 0.28)  
Wavelength : 776 nm  
Laser delay time : 1000 ms ~ 4000 ms

**KIMM** 한국기계연구원  
KOREAN INSTITUTE OF MACHINERY & MATERIALS



# AMOLED Test (KIMM)

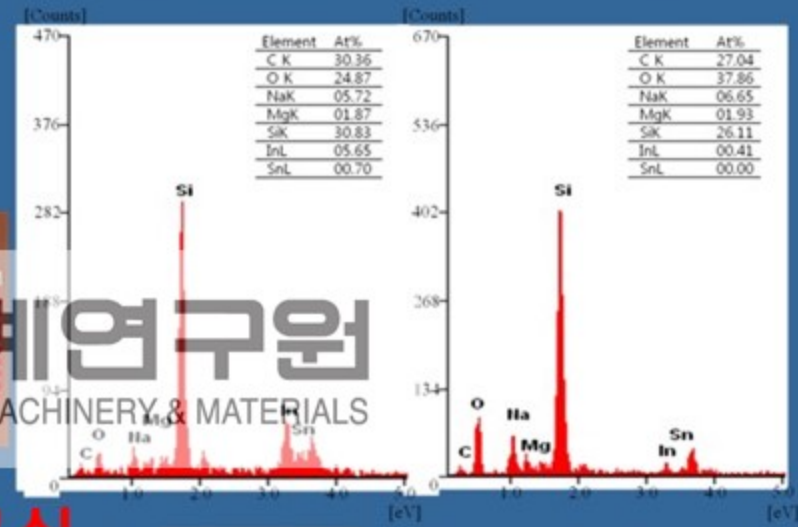


## ❖ Micromachining with femtosecond laser

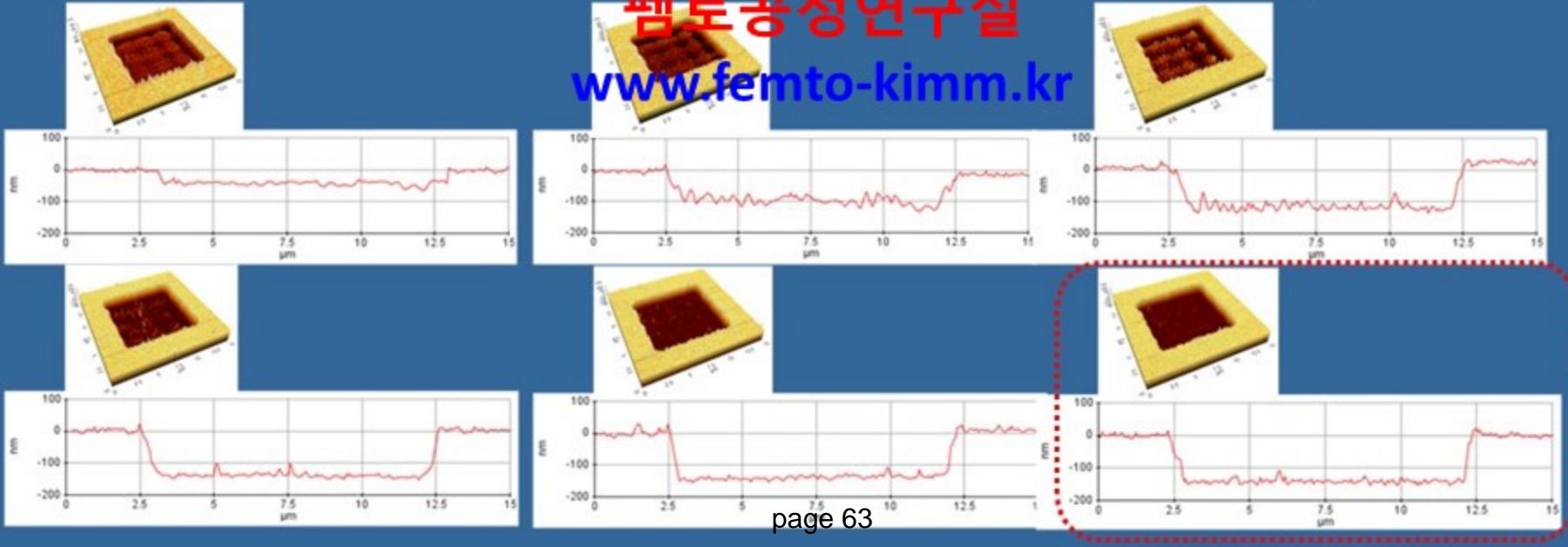
### ➤ ITO-Glass depth control test



**KIMM** 한국기계연구원  
KOREA INSTITUTE OF MACHINERY & MATERIALS



펨토공정연구실  
[www.femto-kimm.kr](http://www.femto-kimm.kr)

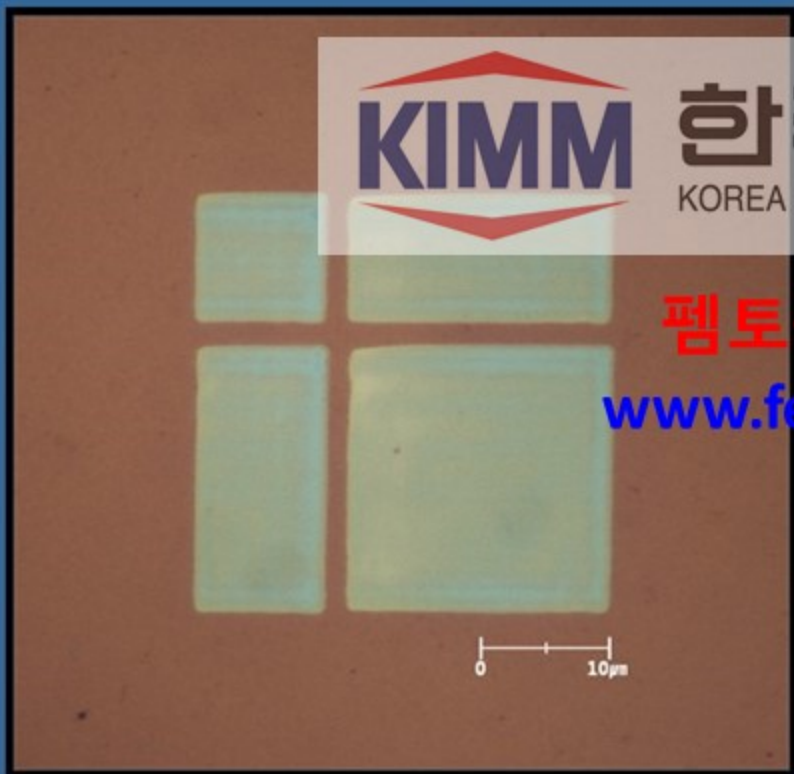


# AMOLED Test (KIMM)



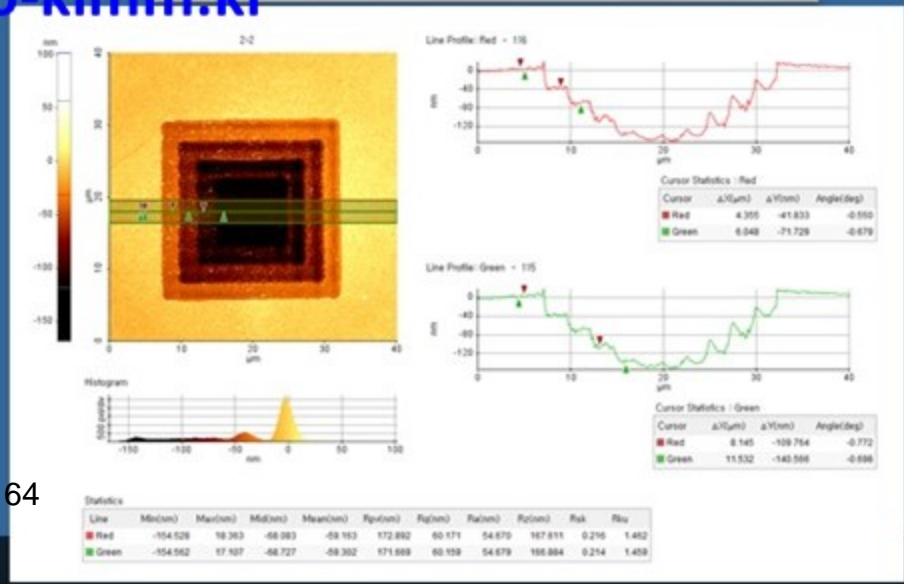
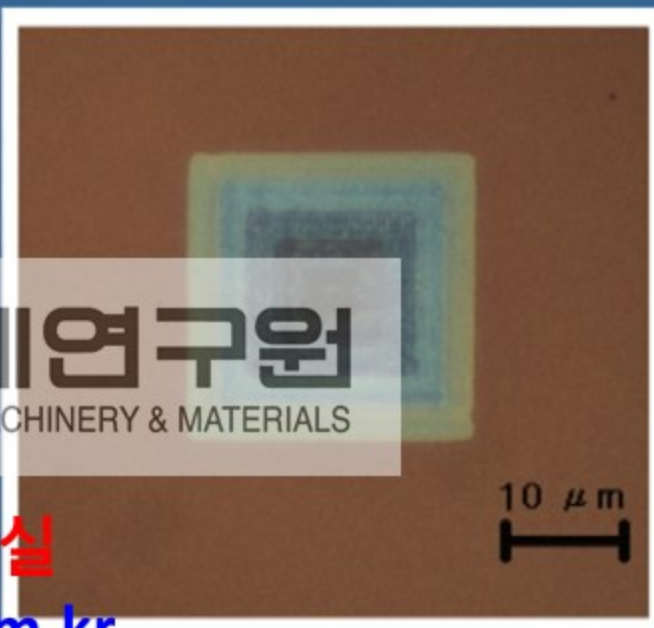
## ❖ Micromachining with femtosecond laser

### ➤ ITO-Glass depth control test



**KIMM** 한국기계연구원  
KOREA INSTITUTE OF MACHINERY & MATERIALS

펨토공정연구실  
[www.femto-kimm.kr](http://www.femto-kimm.kr)



# AMOLED Test (KIMM)



## ❖ AMOLED/LCD electrode pattern repair test

- Flat panel display test
  - Metal electrode ablation test

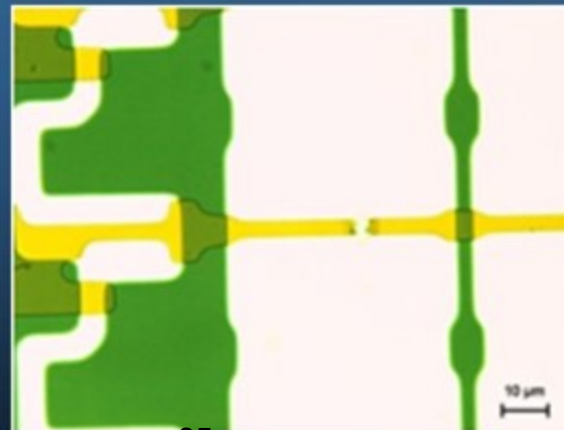
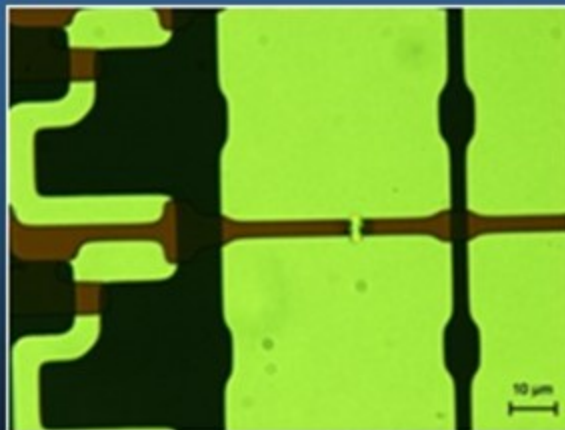


한국기계연구원  
KOREA INSTITUTE OF MACHINERY & MATERIALS

펨토공정연구실

[www.femto-kimm.kr](http://www.femto-kimm.kr)

Repair target : electrode



Average power : 0.32 W  
Pulse energy : 3.2  $\mu$ J  
Repetition rate : 100 kHz  
Laser delay time : 80 msec  
Pulse width : 380 fs

# AMOLED Test (KIMM)



## ❖ AMOLED/LCD electrode pattern repair test

- Flat panel display patterning test
  - Beam Shaping technology

Pulse energy : 1.3 uJ  
Pulse number control  
Pulse width : 380 fs

No damage



한국기계연구원  
KOREA INSTITUTE OF MACHINERY & MATERIALS

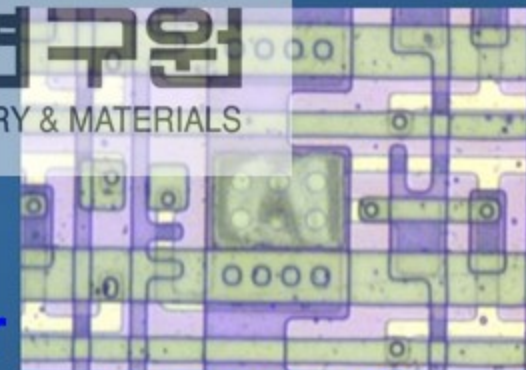
펄토공정연구실  
[www.femto-kimm.kr](http://www.femto-kimm.kr)



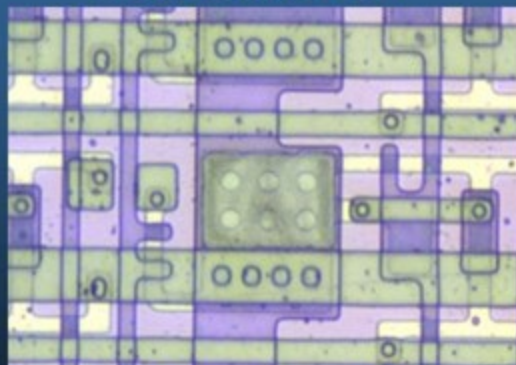
Pulse number : 0



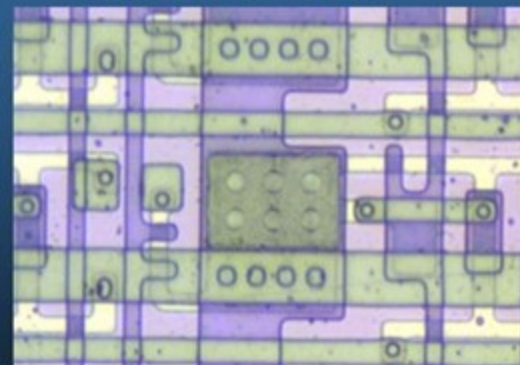
Pulse number : 6



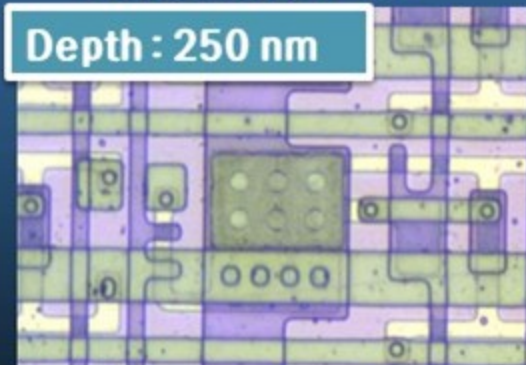
Pulse number : 12



Pulse number : 18



Pulse number : 24



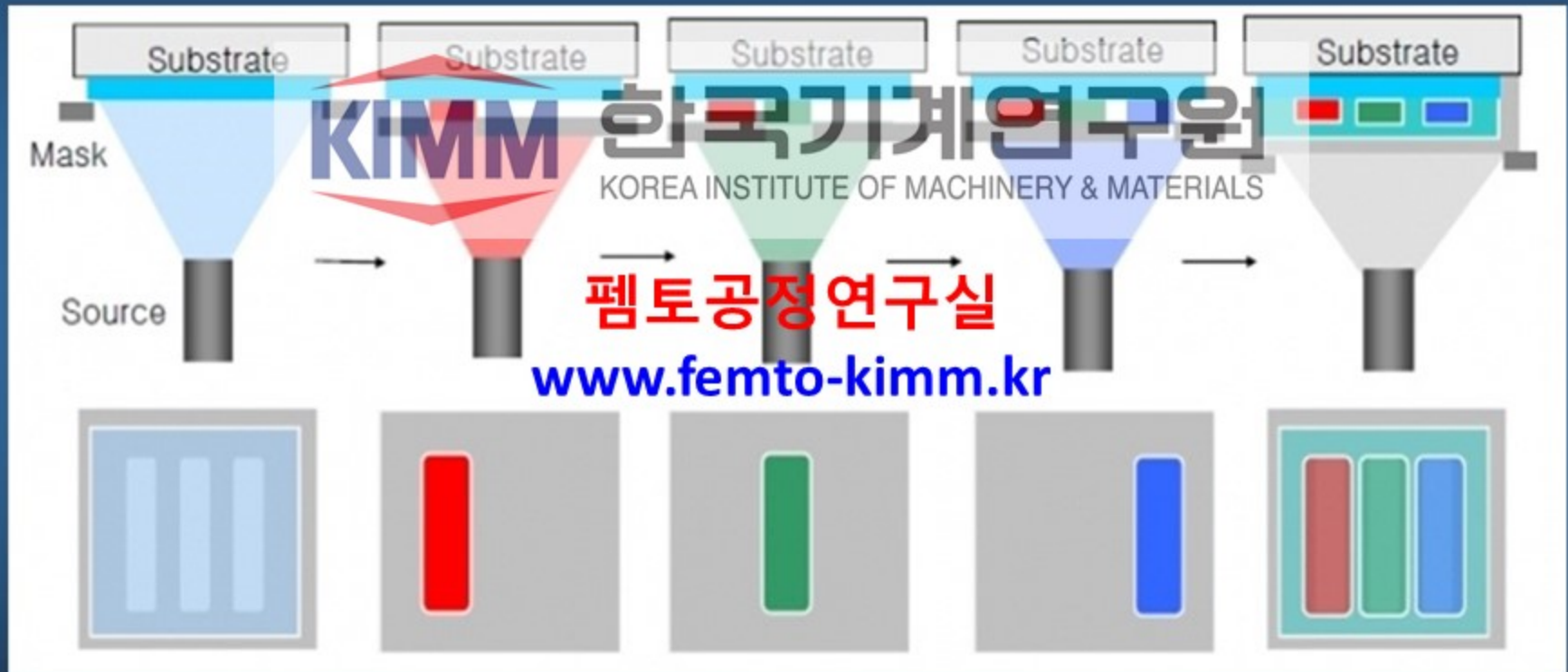
Depth : 250 nm

Pulse number : 30

# AMOLED Test (KIMM)



## ❖ AMOLED MASK pattern test



# AMOLED Test (KIMM)



## ❖ AMOLED MASK pattern test



Entrance dia. 20.376  $\mu\text{m}$



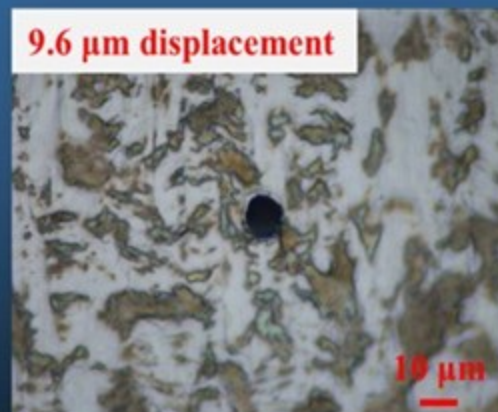
www.femto-kimm.kr



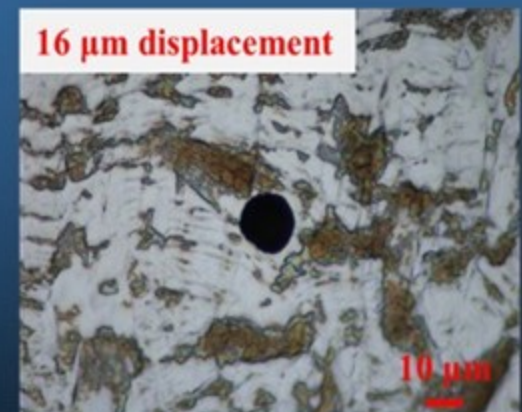
Entrance dia. 24.001  $\mu\text{m}$



Exit dia. 4.506  $\mu\text{m}$



Exit dia. 8.628  $\mu\text{m}$



Exit dia. 13.910  $\mu\text{m}$

# Next-Generation AMOLED Display



[Transparent Display]



[Flexible Display]



[Foldable Display]

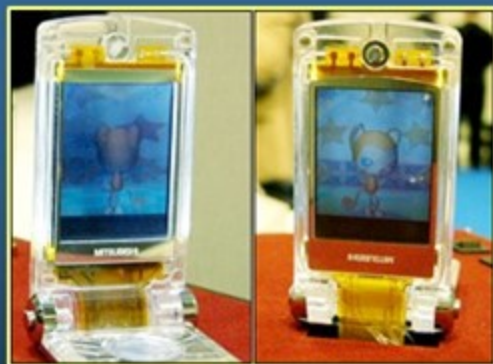
**KIMM**

**한국기계연구원**

KOREA INSTITUTE OF MACHINERY & MATERIALS

**펨토공정연구실**

[www.femto-kimm.kr](http://www.femto-kimm.kr)



[Dual Display]



[3D Display]



[Paper Thin Display]

# Summary : Statue and Trend in fs laser processing KOREA



1. We expect **1,000 femtosecond lasers** are needed in AMOLED within 5 years

2. SAMSUNG, LG in KOREA ?



KOREA INSTITUTE OF MACHINERY & MATERIALS

3. Strong information network and human relationship

Big company (SAMSUNG, LG) - Small laser equipment companies - National institutes → many technical demands

**펄스공정연구실**

[www.femto-kimm.kr](http://www.femto-kimm.kr)

4. Some advanced products are single produced in the world.

5. Some item (system) World Leading  
Korea Export to Japan, China, Taiwan

6. Self development of laser source

7. Strong Laser processing community in small laser processing

# KOREA MARKET OF LASER PROCESSING ?



**KIMM** 한국기계연구원  
KOREA INSTITUTE OF MACHINERY & MATERIALS

**펨토공정연구실**

[www.femto-kimm.kr](http://www.femto-kimm.kr)



**Name: David A. Belforte**  
**Position: Publisher & Editor-in-Chief**  
**Division: Industrial Laser Solutions**  
**Company: Penn Well Corp.**

**Current market scale**

**July, 2010.**

**KOREA Market of laser processing is equal to or bigger than that of JAPAN**

# Thank You !!

shcho@kimm.re.kr  
**KIMM** 한국기계연구원  
Lab URL: <http://femto-kimm.kr>  
KOREA INSTITUTE OF MACHINERY & MATERIALS

UST KIMM 펨토 공정 연구실  
Femto Process Lab.

INTRODUCTION 연구실 소개 RESEARCH 연구 내용 TECHNOLOGY 보유 기술 EQUIPMENT 보유 장비 RESULTS 연구 실적 MEMBER 구성원

## 펨토공정연구실

펨토초 레이저의 미세 가공  
& 바이오 융합 연구의 산실

[www.femto-kimm.kr](http://www.femto-kimm.kr)

한국과학기술연합대학원 (UST) 나노메카트로닉스전공 KIMM 캠퍼스

Welcome to Femto Process Laboratory, UST-KIMM

### NEWS & EVENT

- 공지사항
- 최근 소식
- 국내외 레이저가공연구동향
- 미세가공 애로사항 문의
- UST 대학원생 채용 안내



국내 학술 회의  
Domestic Conference

국제 학술 회의  
International Conference

Photo Gallery  
모토갤러리

Related Site  
관련사이트

Korea Institute of  
Machinery & Material  
한국기계연구원  
자세히 보기

Media-Award  
연구실  
연론홍보-수상내역  
자세히 보기

펨토 공정 연구실  
Femto Process Lab.

과학기술연합대학원 나노메카트로닉스전공 펨토공정연구실 전임교수 조성학  
한국기계연구원 나노융합기계연구본부 나노공정연구실 펨토공정팀  
Tel : +82-42-868-7077 | Fax : +82-42-868-7149 | Email : shcho@kimm.re.kr

KIMM 한국기계연구원