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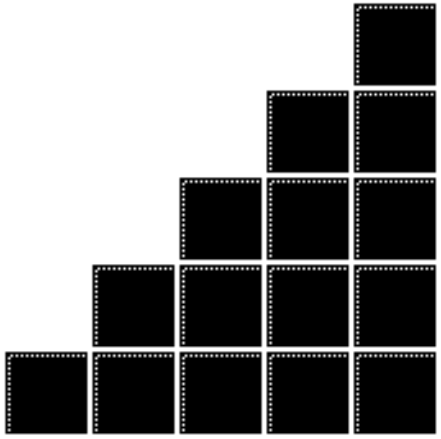
CENTER FOR FEMTOSECOND RESEARCH AND TECHNOLOGY AT HARVARD UNIVERSITY

Eric Mazur
Harvard University

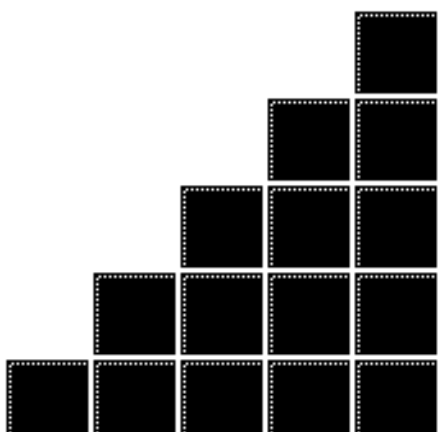
Tokyo
13 March 1995



ハーバード大学
フェムト秒工学研究所

エリック・マズール
ハーバード大学

東京
１９９５年３月１３日



研究分野

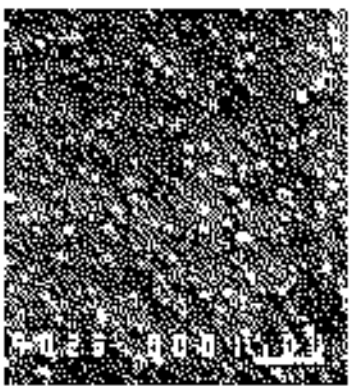
❶ semiconductors

❷ reactions at metal surfaces

❸ monolayers at liquid surfaces

半導体

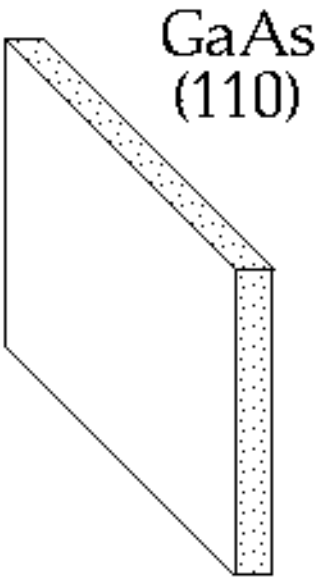
Effect of femtosecond pulses on



SEM picture of GaAs after
femtosecond laser irradiation

- electronic properties
- material properties

半導体



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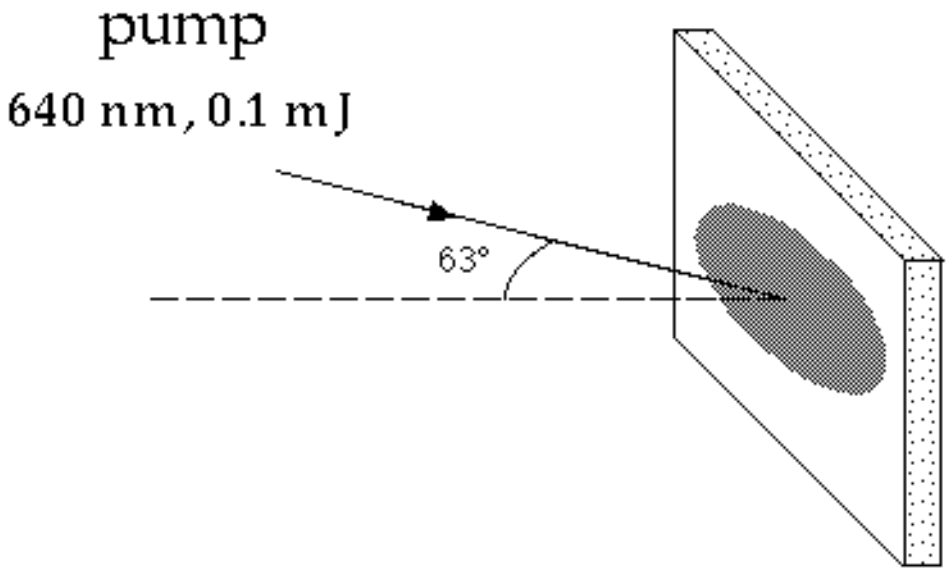

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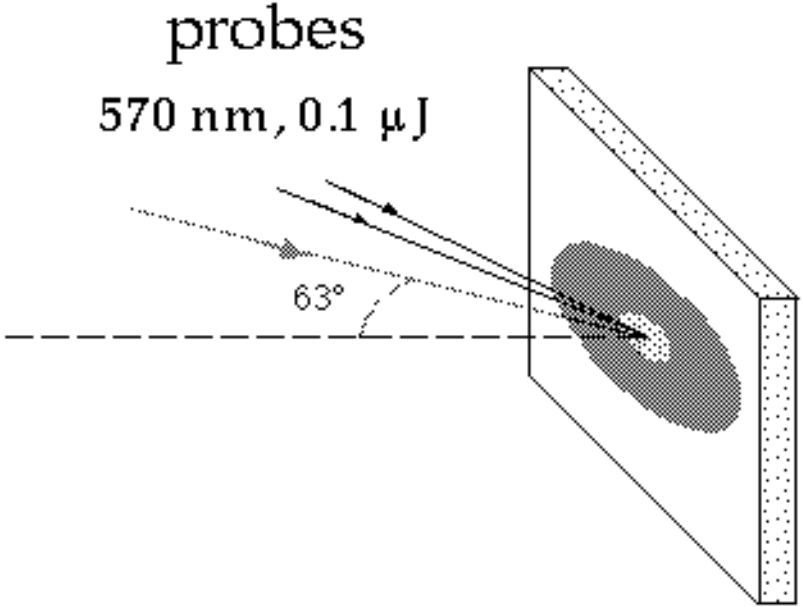
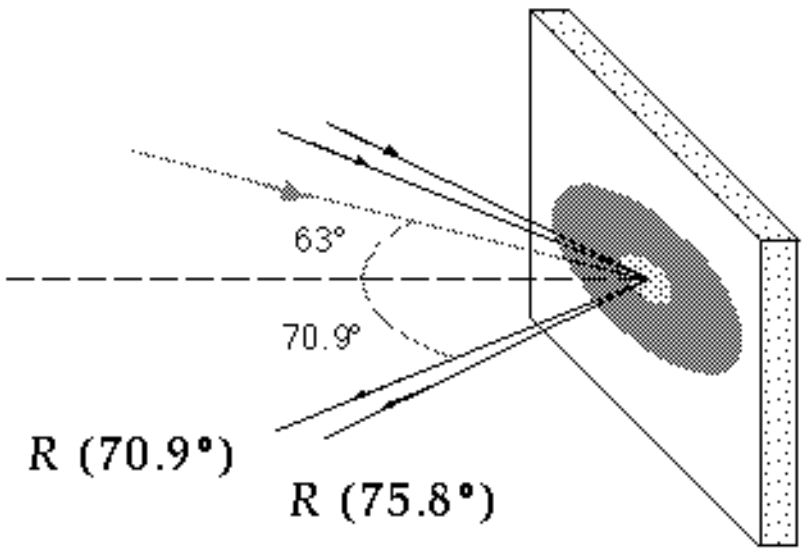


all beams
70 fs, *p*-pol

半導体



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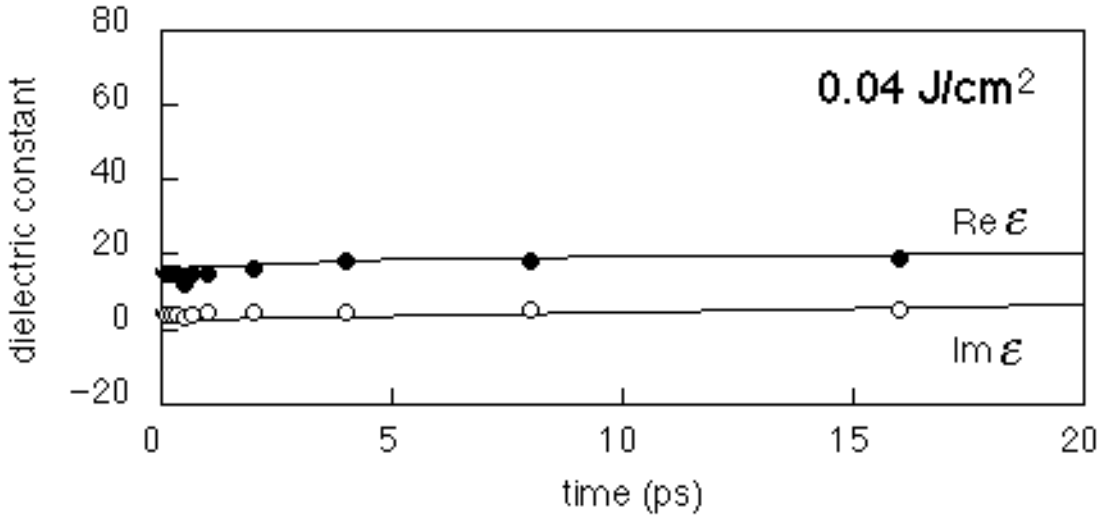
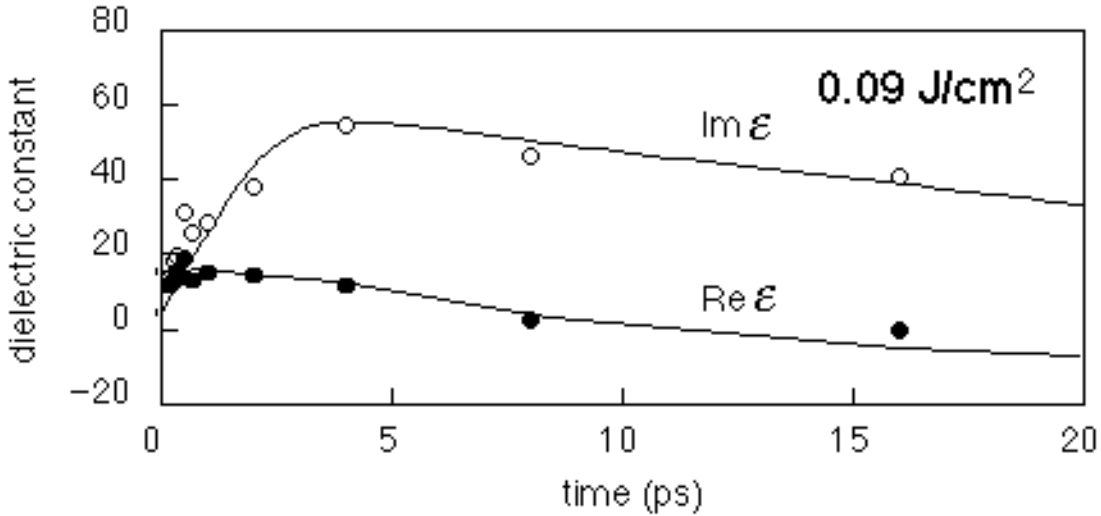


E. Glezer, Y, Siegal, L. Huang, E. Mazur, Phys. Rev. B, March 15 (1995)

半導体



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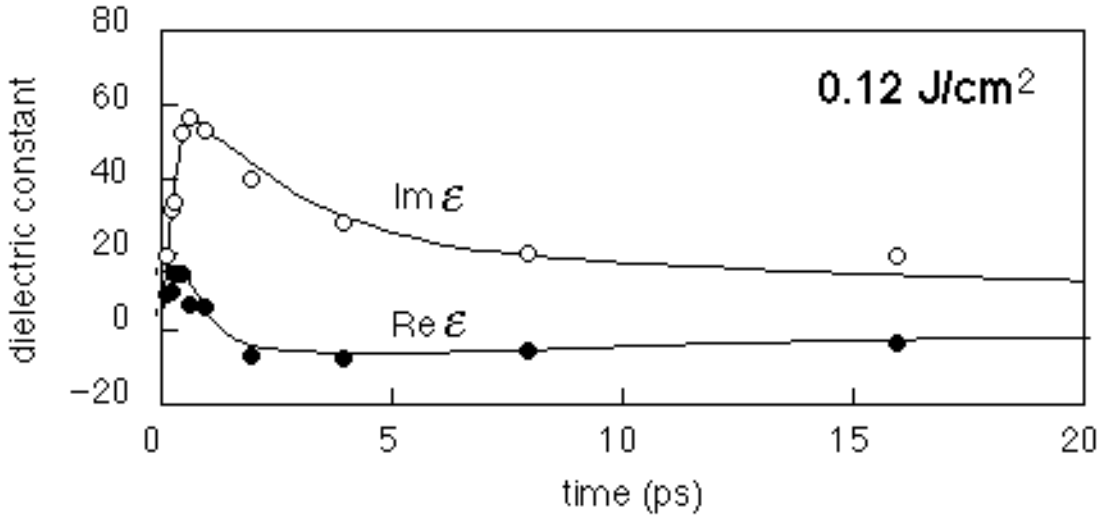

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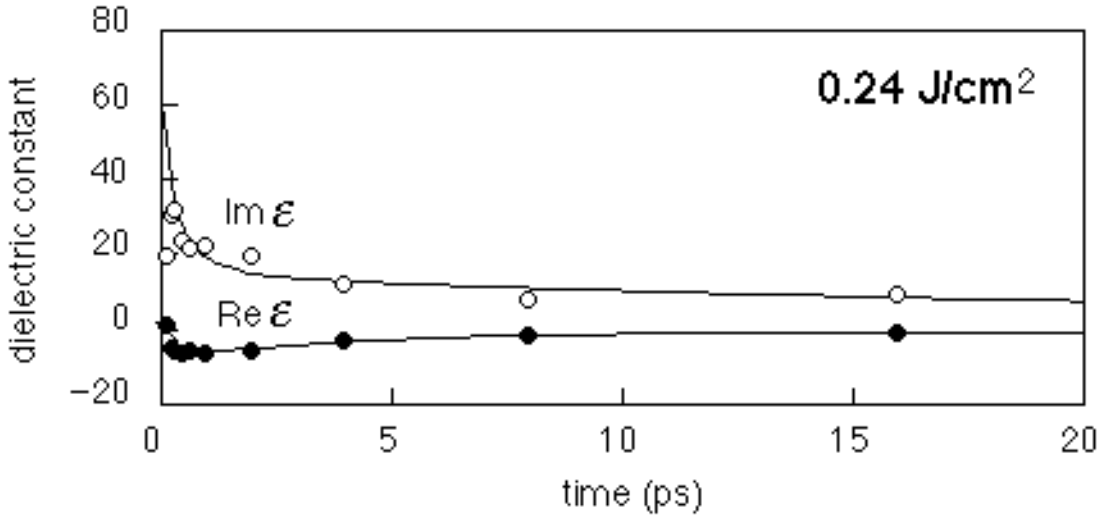

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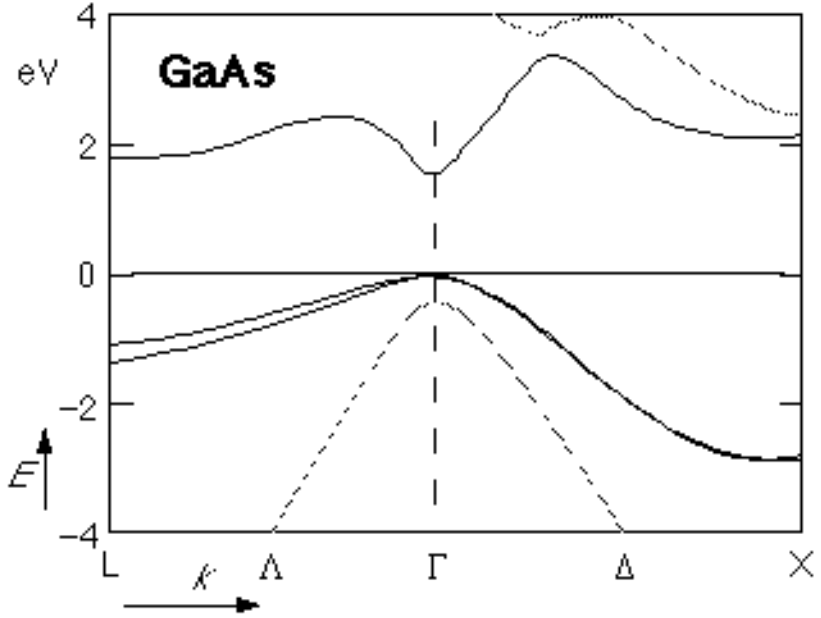

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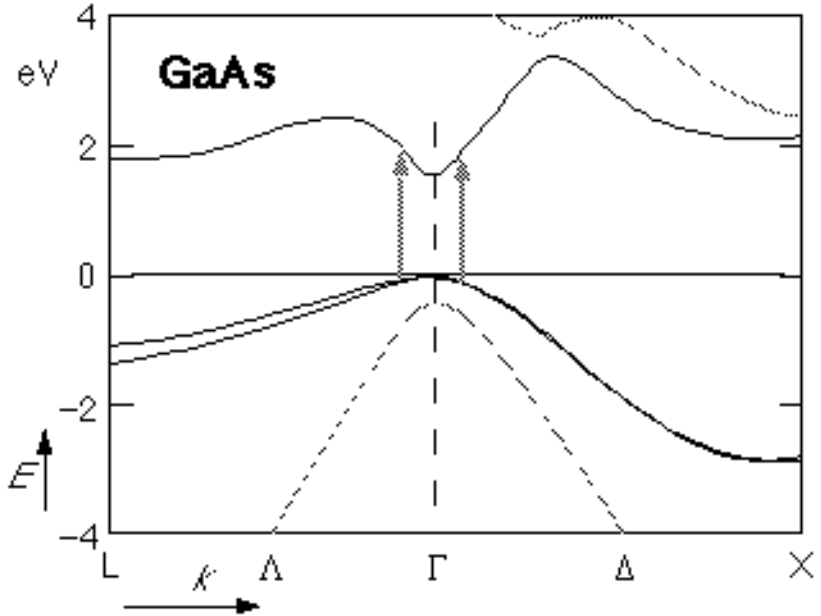

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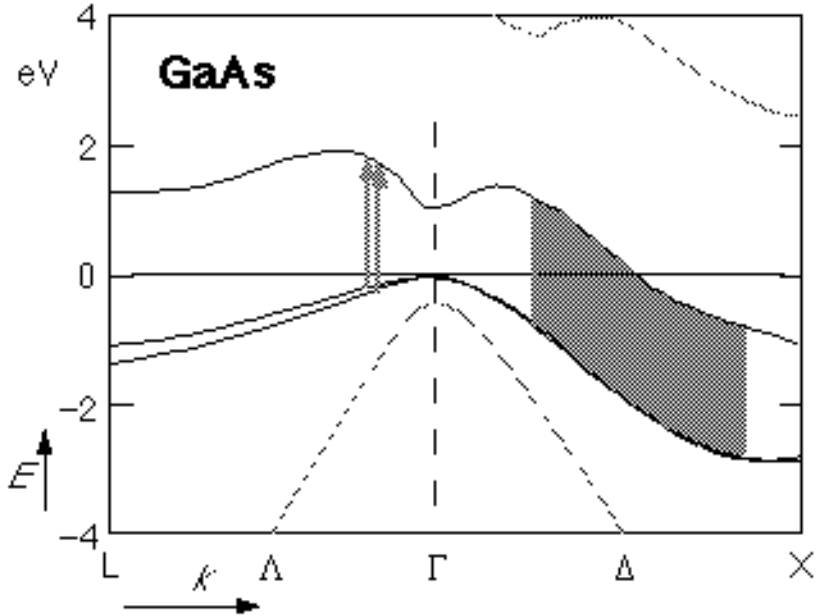


半導体

- ultrafast structural phase transition
- large changes in electronic properties

研究分野

❶ semiconductors

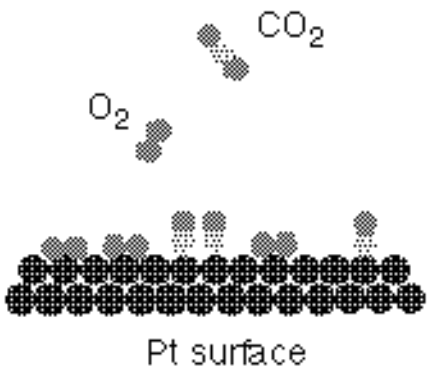
❷ reactions at metal surfaces

❸ monolayers at liquid surfaces

金属表面上の反応

Control molecular processes

- catalysis
- microelectronics
- new materials



金属表面上の反応

Atomically clean platinum surface (90 K)

Pt surface

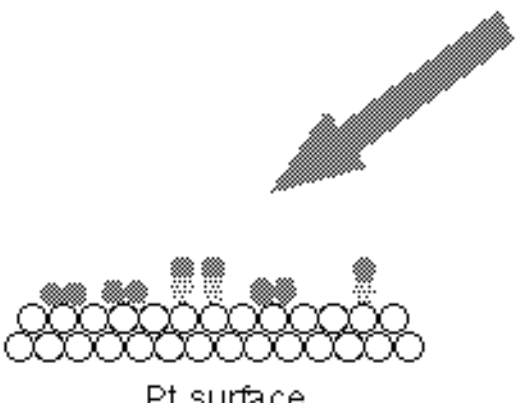
金属表面上の反応

Dose with O_2 and CO

Pt surface

金属表面上の反応

Excite substrate with
femtosecond laser pulse

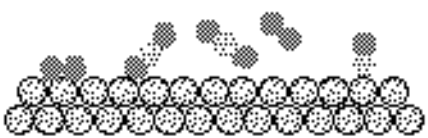


金属表面上の反応

Excited electrons initiate reactions:

O_2 desorption

$2CO + O_2 \rightarrow 2CO_2$

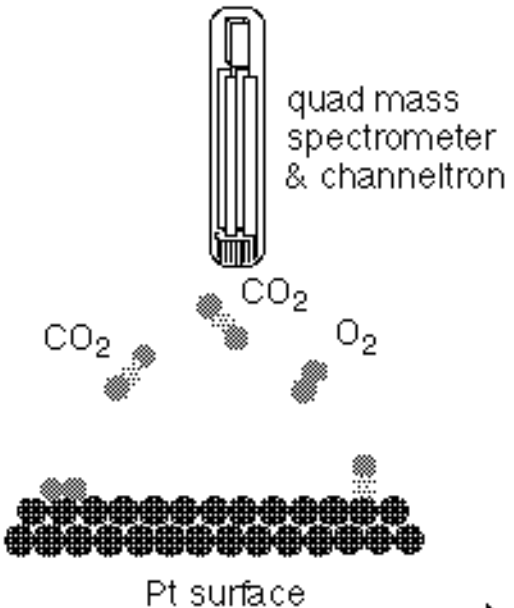


Pt surface

金属表面上の反応

Detect products:

- mass spectrometer
- optically



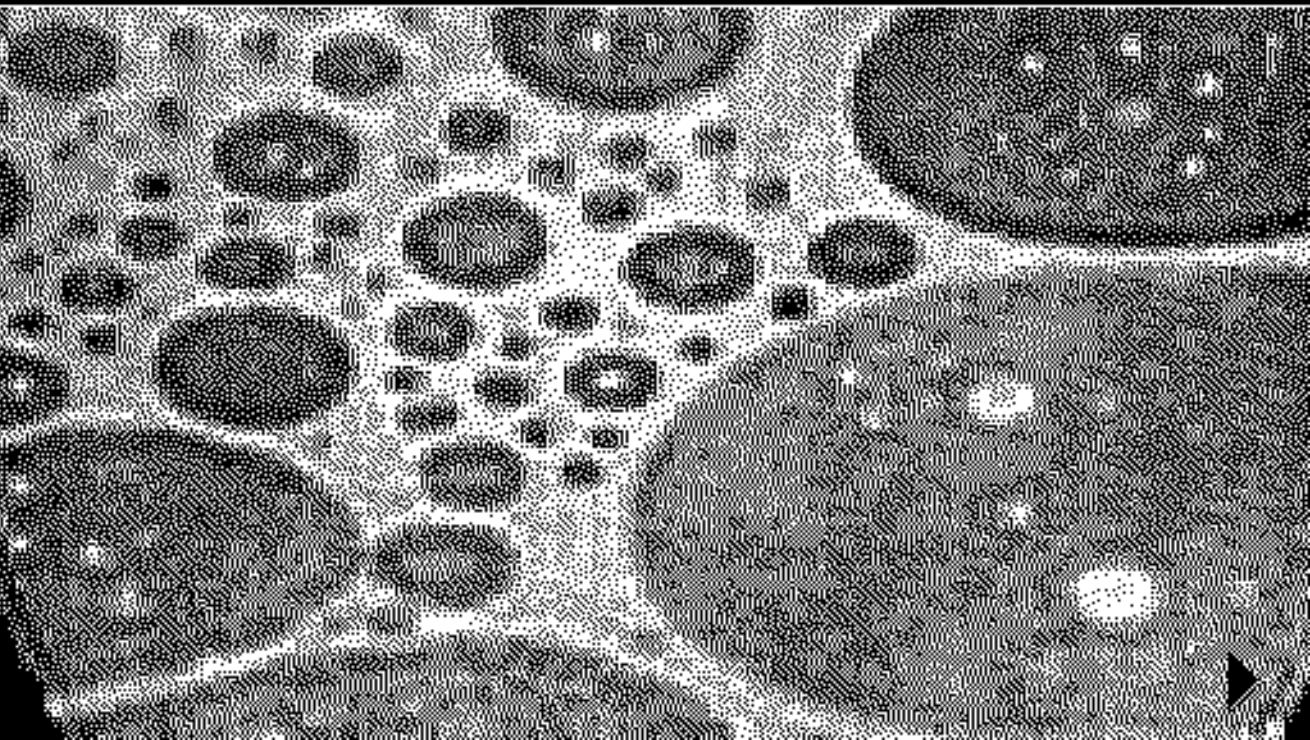
研究分野

❶ semiconductors

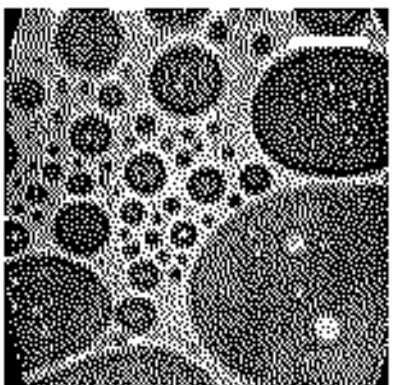
❷ reactions at metal surfaces

❸ monolayers at liquid surfaces

液体表面上の単一層



液体表面上の単一層



Pentadecanoic acid monolayer
on water

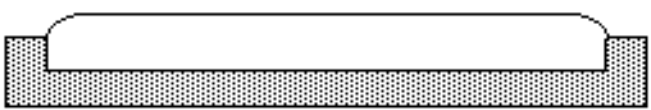
- industrial technology
- physics
- biology

液体表面上の単一層

- heterodyne light scattering
- Brewster angle microscopy
- surface second harmonic generation

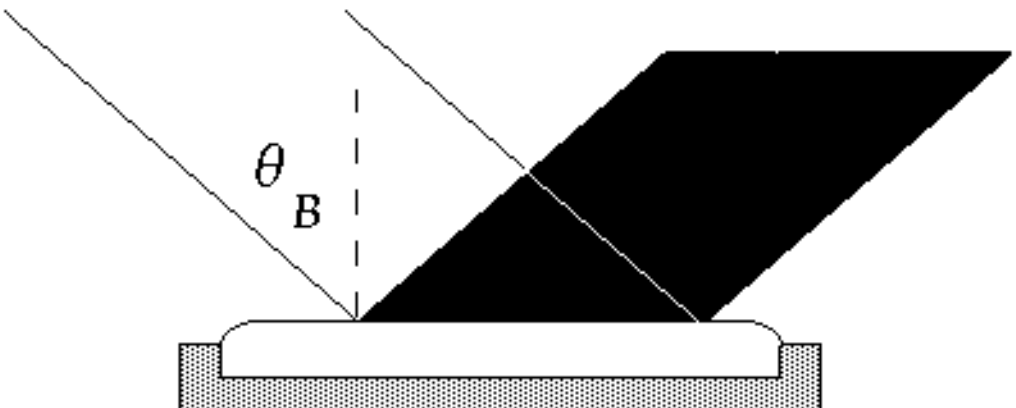
ブルースター角顕微鏡法

clean water surface



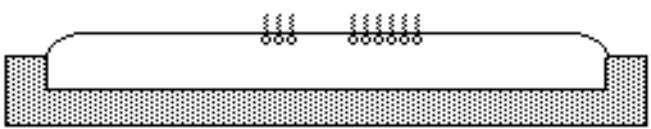
ブルースター角顕微鏡法

no reflection at Brewster angle



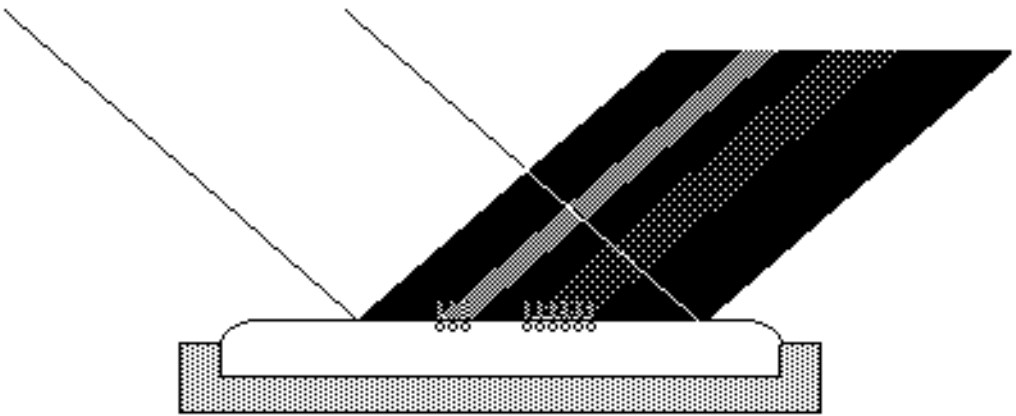
ブルースター角顕微鏡法

Add surfactant monolayer

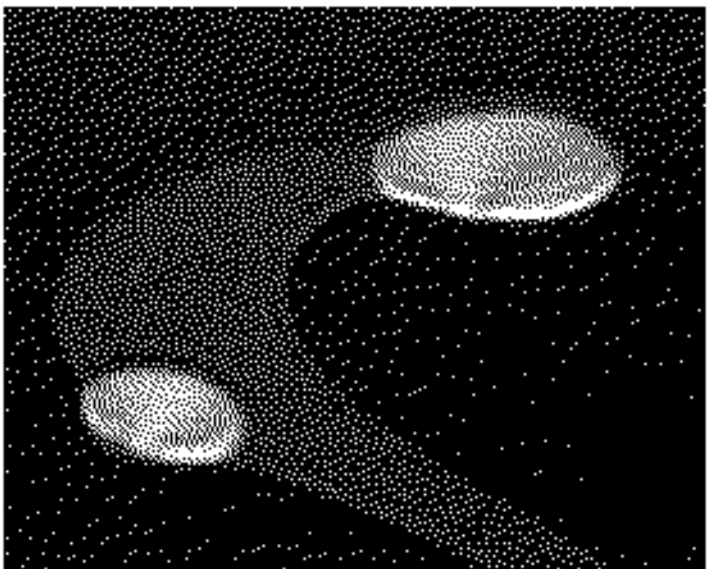


ブルースター角顕微鏡法

reflection due to changes in index

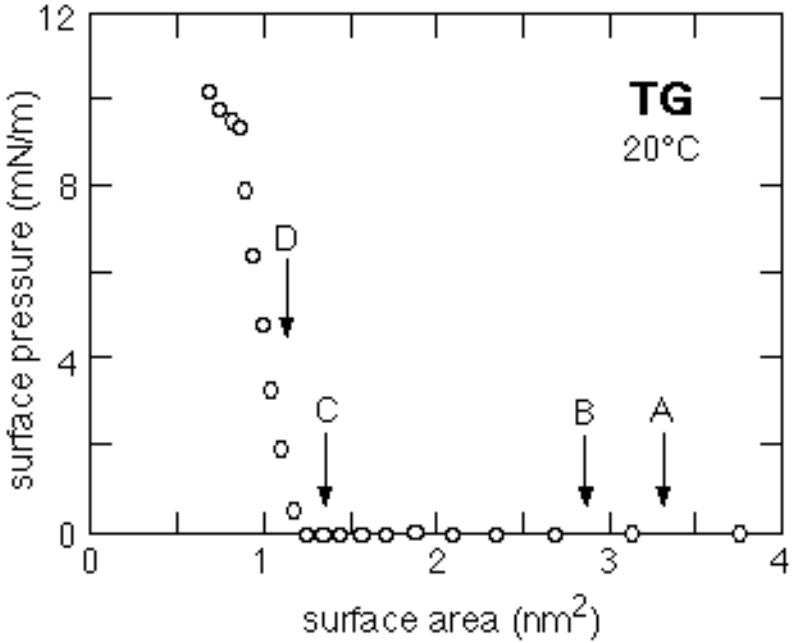


ブルースター角顕微鏡法

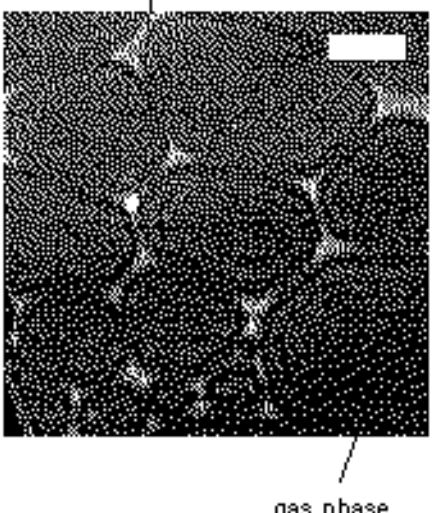


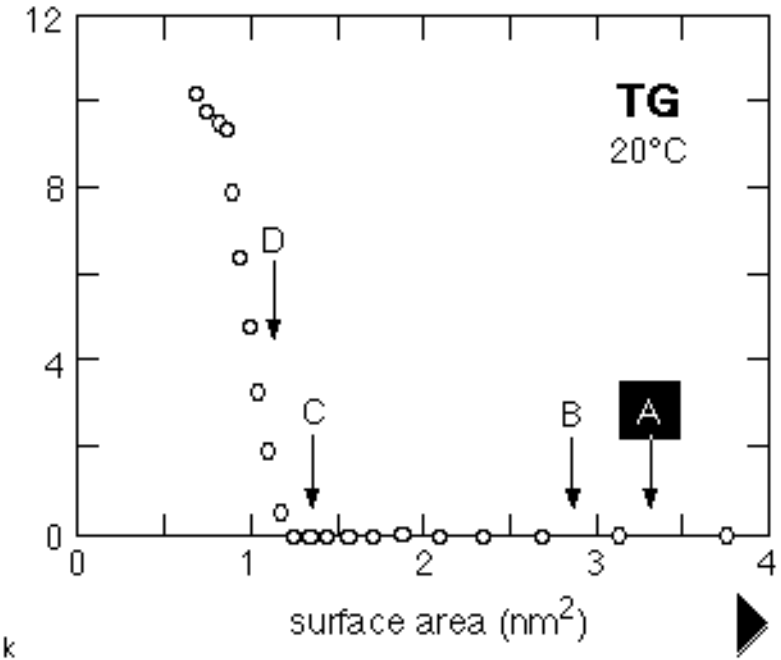
ブルースター角顕微鏡法

isotherm



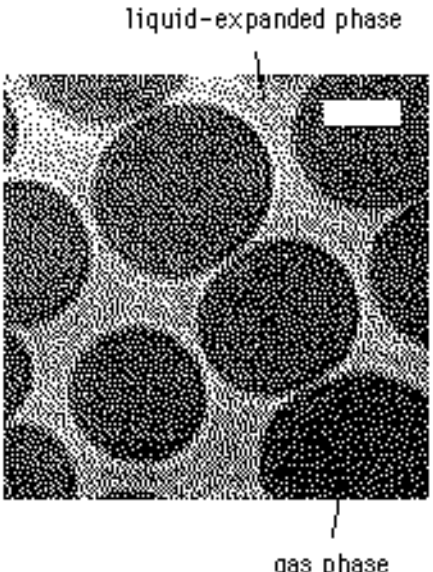
ブルースター角顕微鏡法

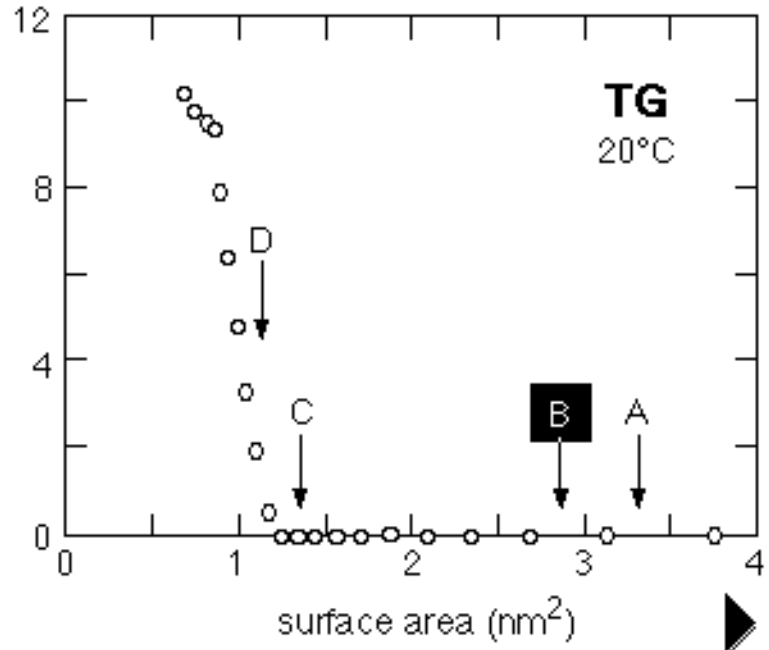




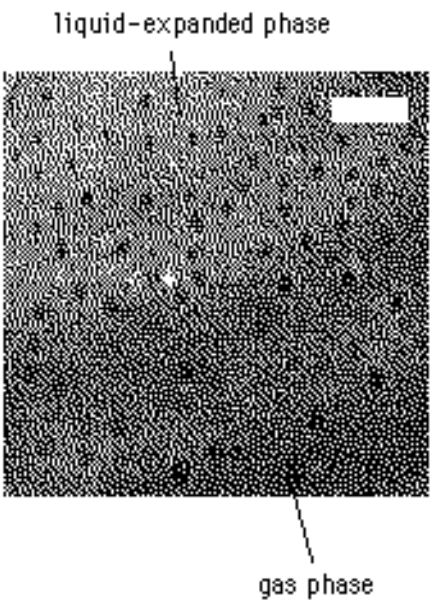
reference to our own work

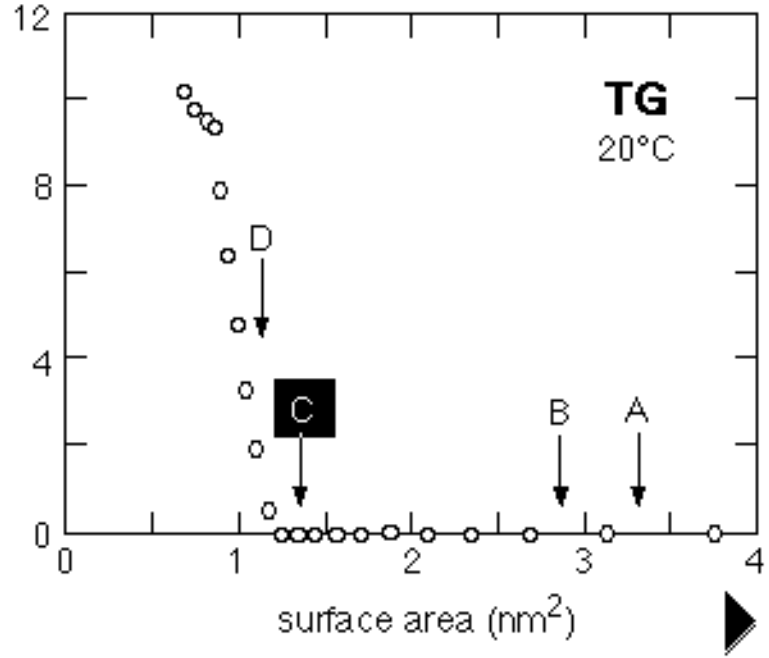
ブルースター角顕微鏡法



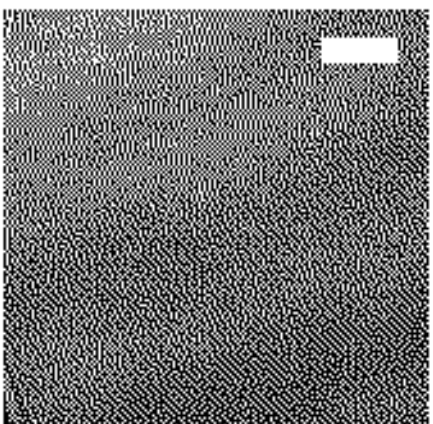


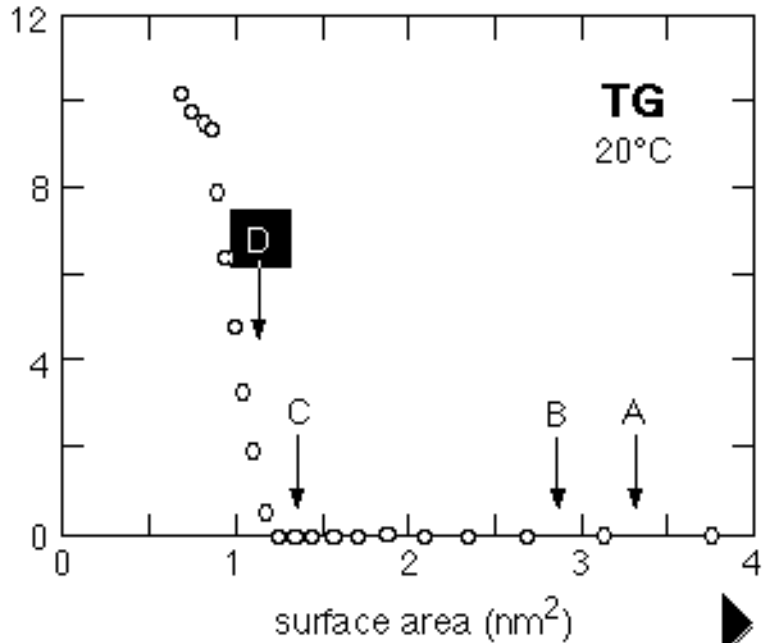
ブルースター角顕微鏡法





ブルースター角顕微鏡法





研究分野

❶ semiconductors

❷ reactions at metal surfaces

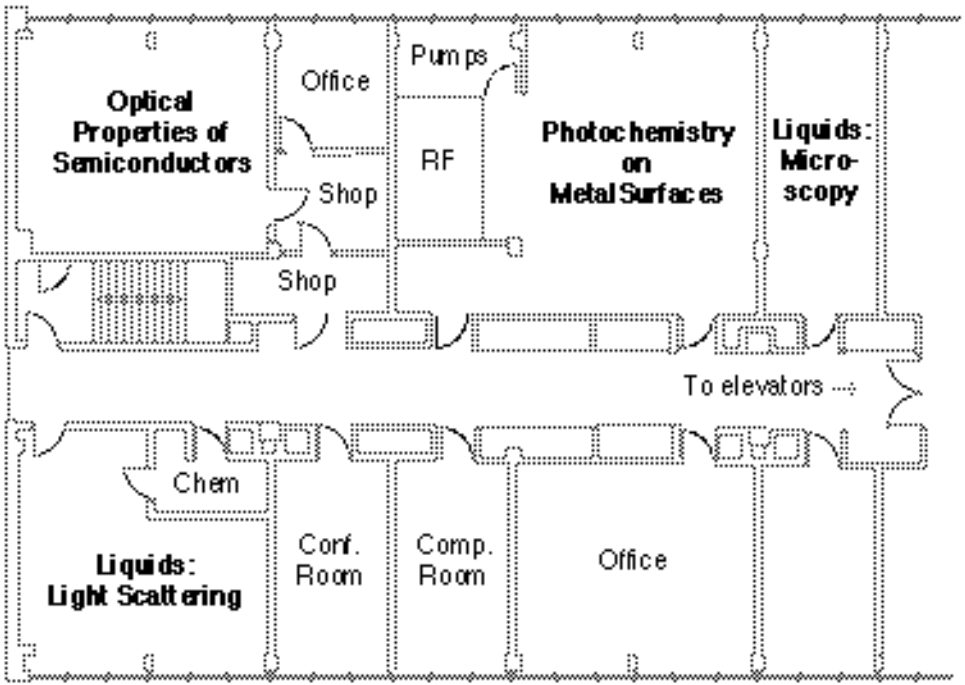
❸ monolayers at liquid surfaces

machining 化との関係

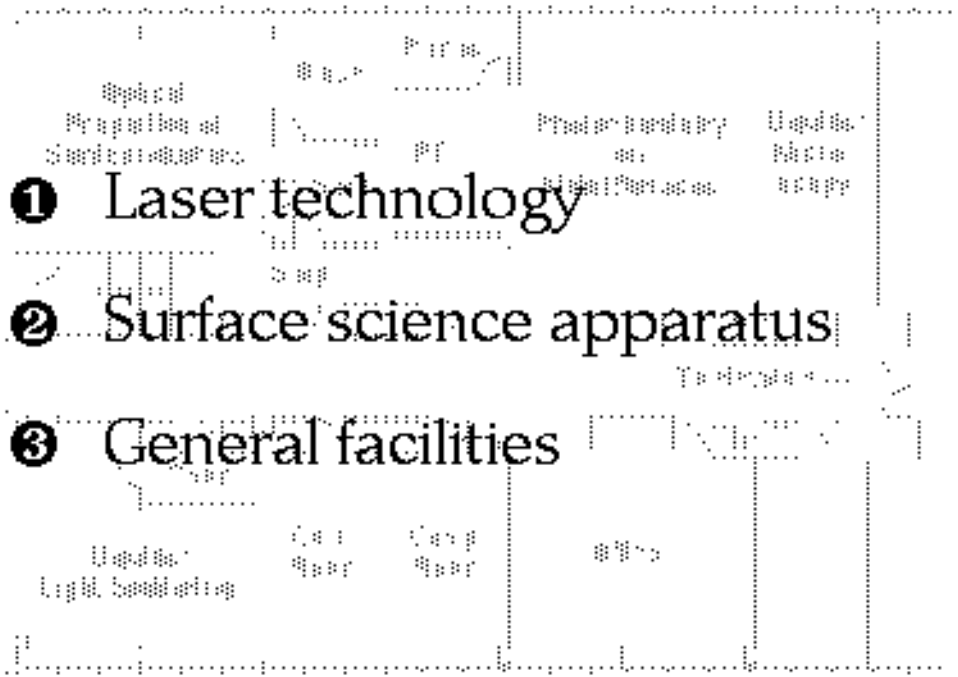
Knowledge of the dynamics of

- nonequilibrium lattice/electrons
- plasma effects
- lattice and surface bonding
- photoinduced reactions

設備


Optical Properties of Semiconductors
Office
Shop
Shop
Pumps
RF
Photochemistry on Metal Surfaces
Liquids: Micro-scopy
To elevators
Chem
Liquids: Light Scattering
Conf. Room
Comp. Room
Office

設備



❶ Laser technology

❷ Surface science apparatus

❸ General facilities

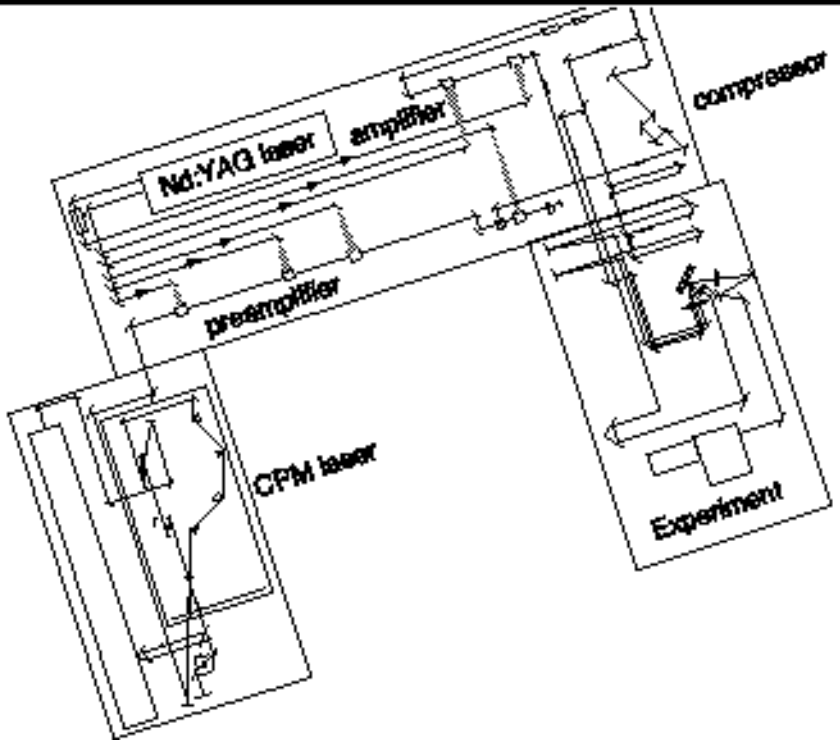
レーザー技術

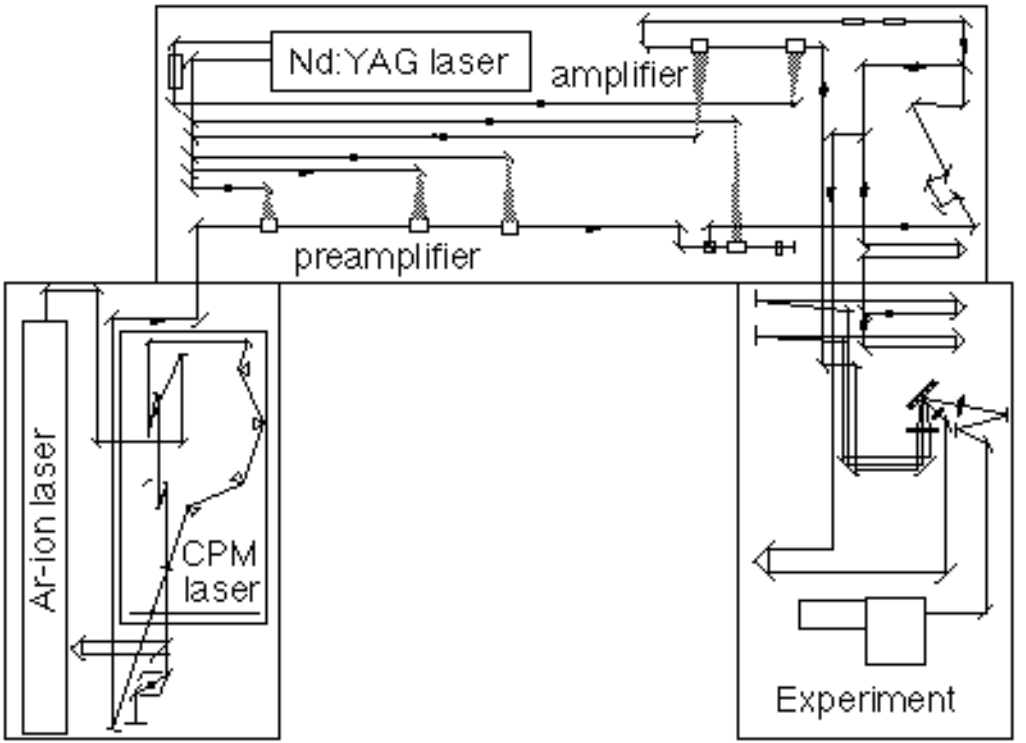
❶ CPM femtosecond facility

❷ Ti:Sap femtosecond facility

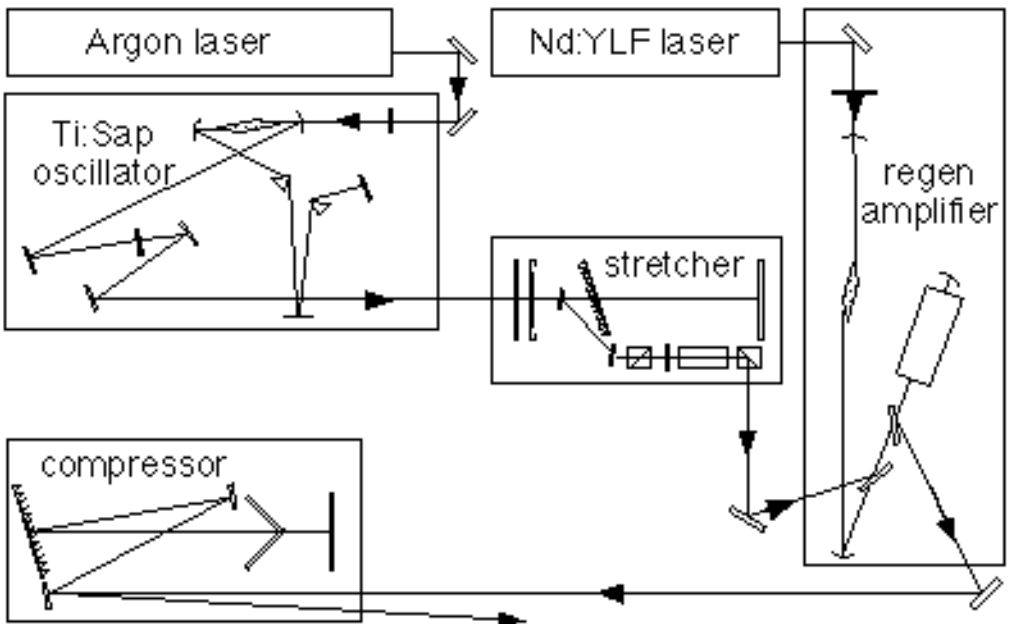
❸ other...

CPMフェムト秒レーザー技術



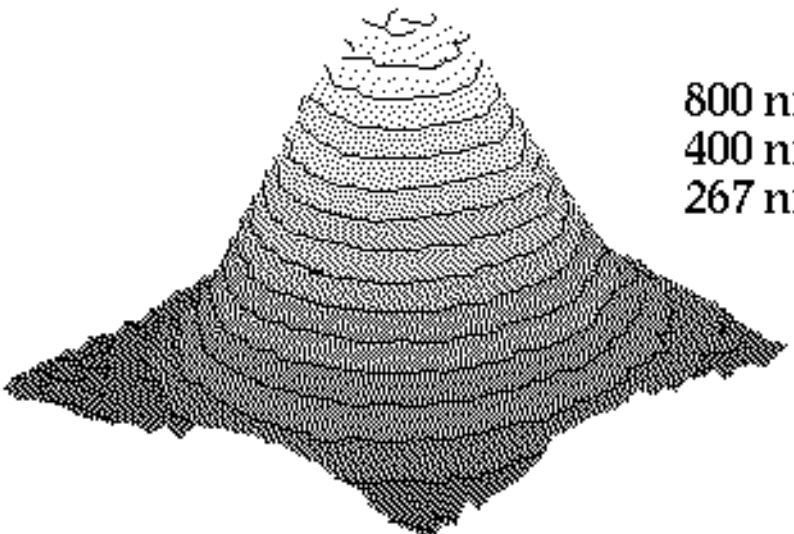

Nd:YAG laser
amplifier
preamplifier
Ar-ion laser
CPM
laser
Experiment

Ti:Sapフェムト秒レーザー設備



Ti:Sapフェムト秒レーザー設備

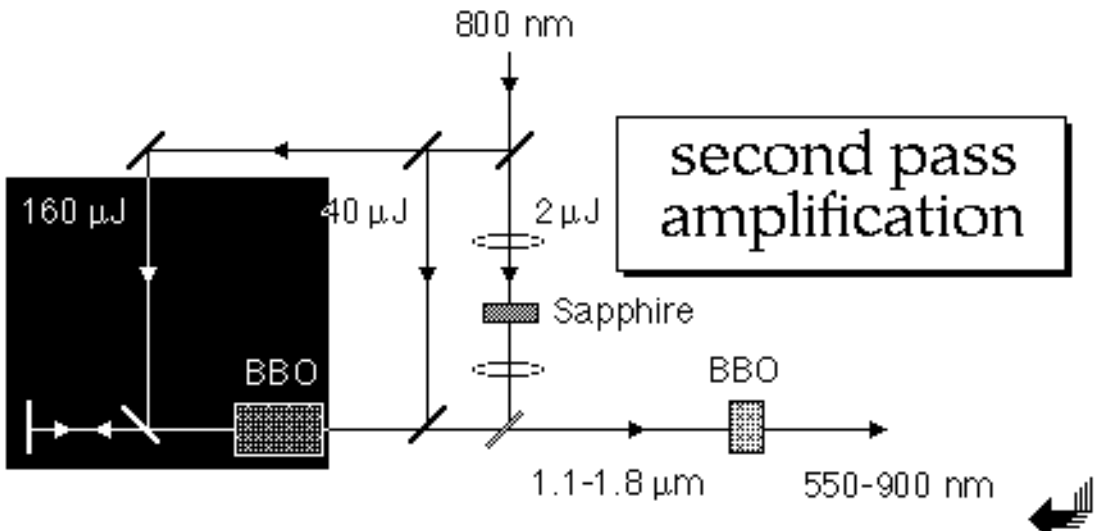
Pure Gaussian profile



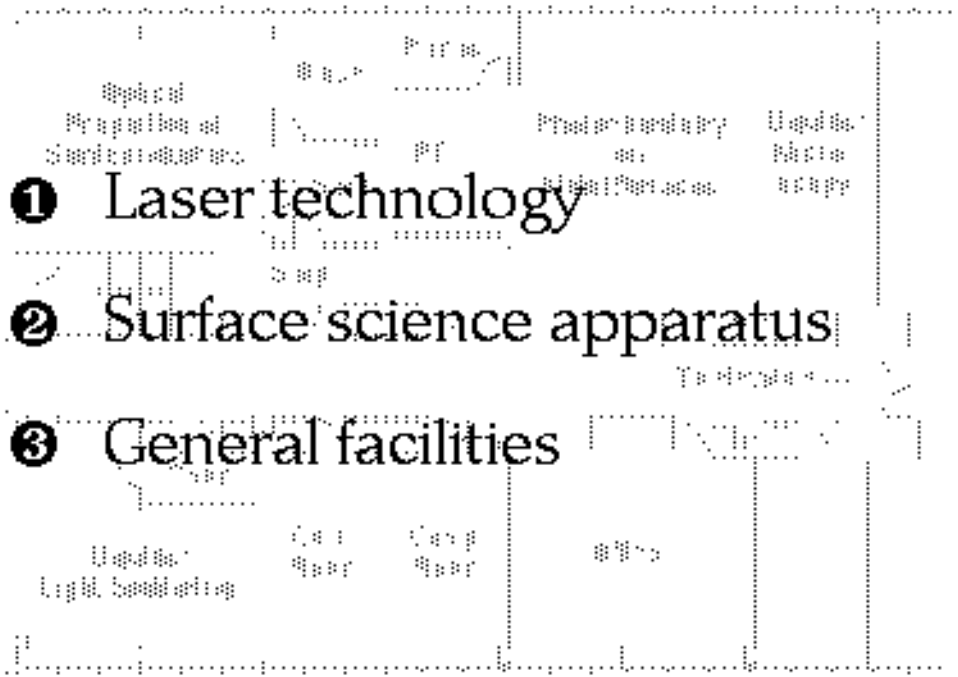
1 kHz
800 nm: 70 fs, 500 μJ
400 nm: 200 fs, 100 μJ
267 nm: 250 fs, 15 μJ

Ti:Sapフェムト秒レーザー設備

Optical Parametric Amplifier



設備



❶ Laser technology

❷ Surface science apparatus

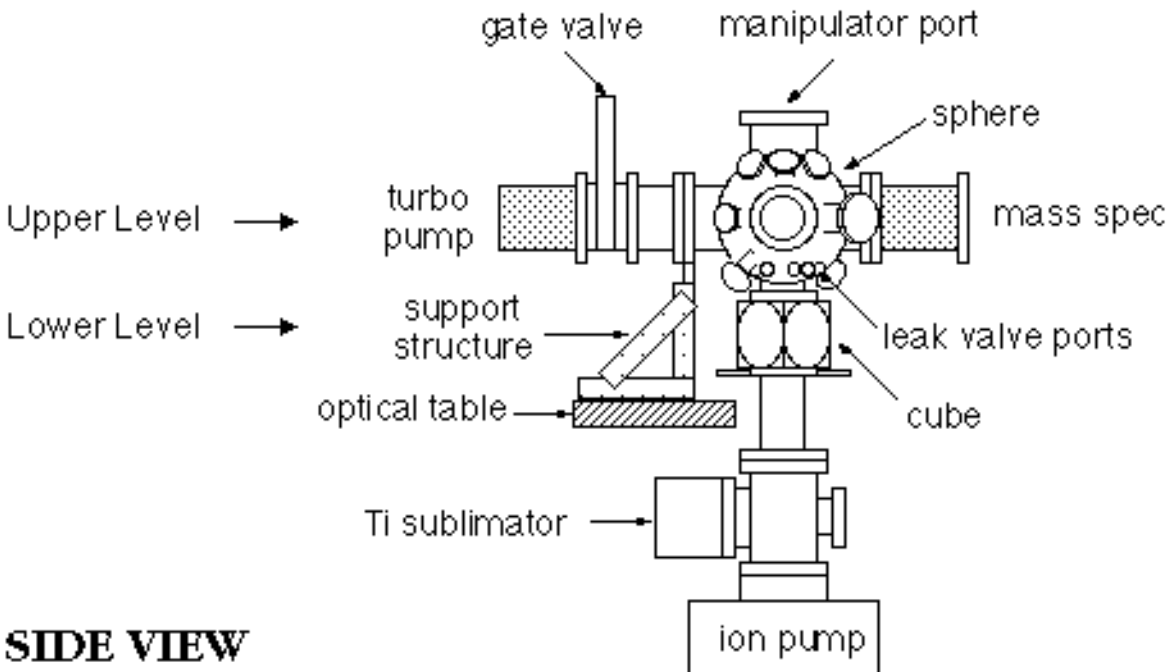
❸ General facilities

表面科学装置

❶ UHV surface science chamber

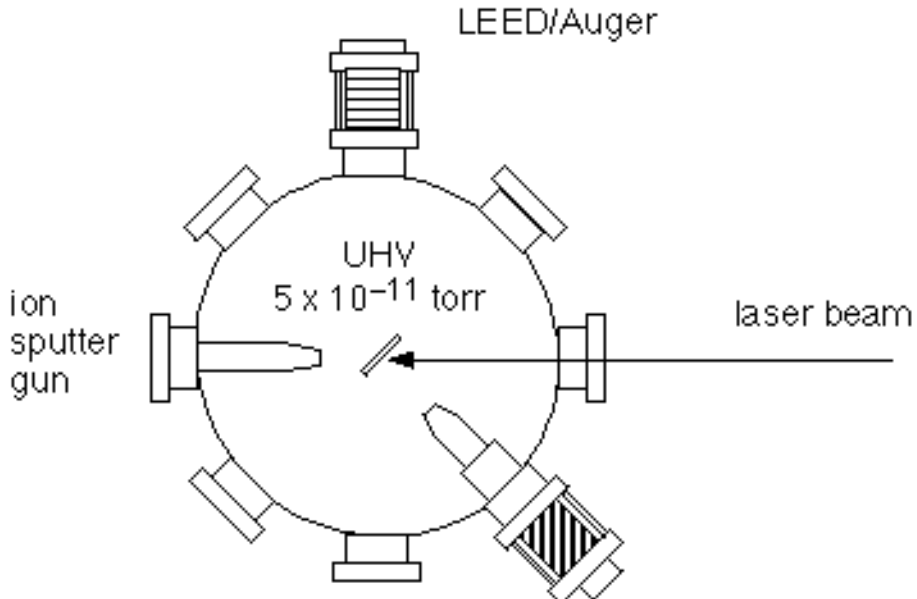
❷ Langmuir troughs

UHV表面科学室



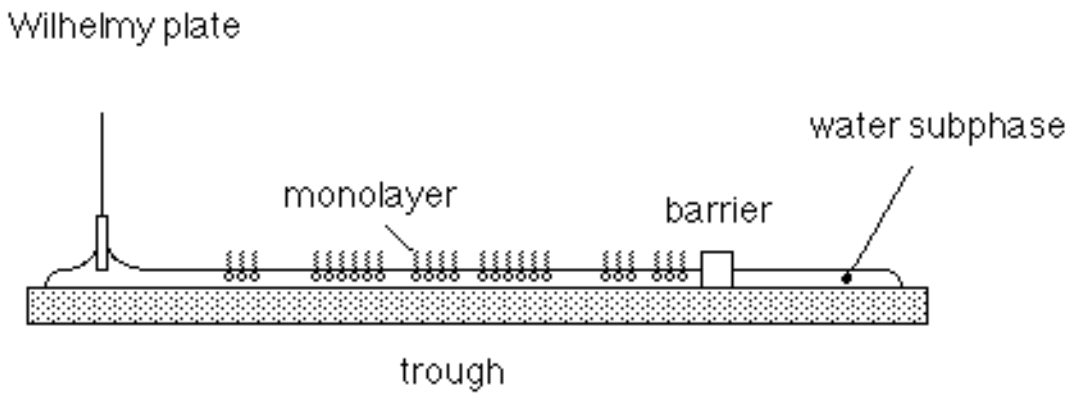
SIDE VIEW

UHV表面科学室



TOP VIEW

ラングミュア谷



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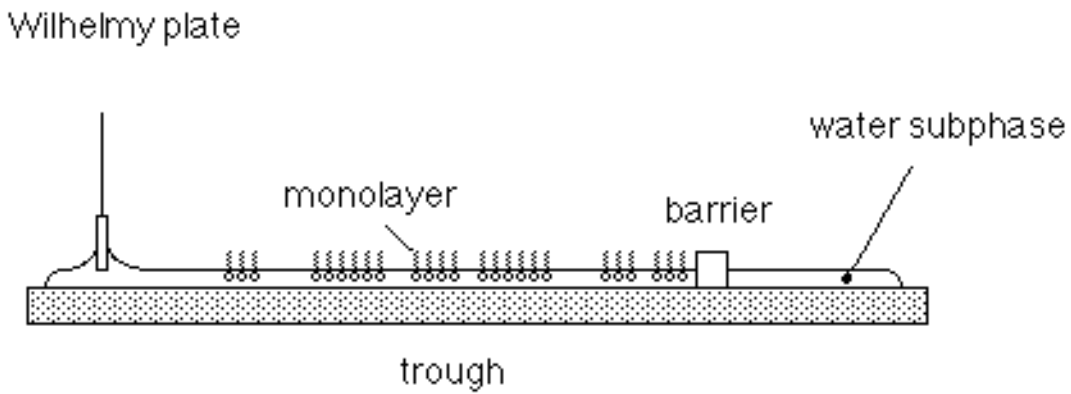

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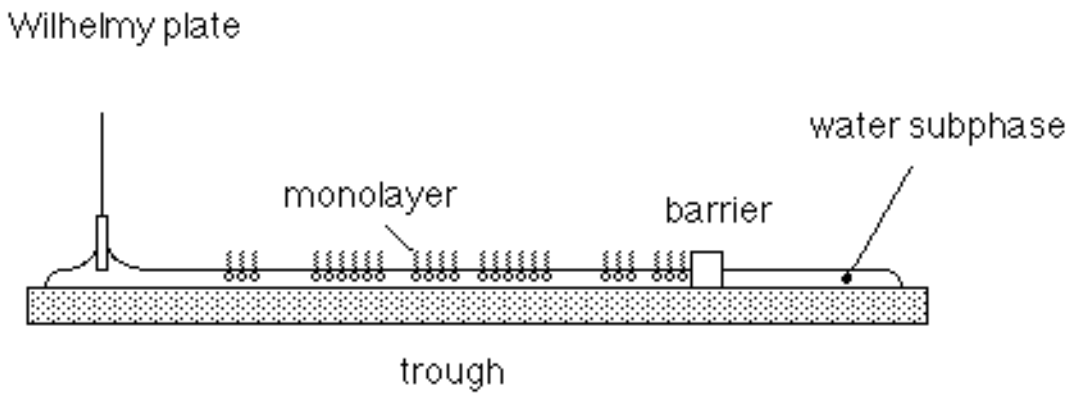

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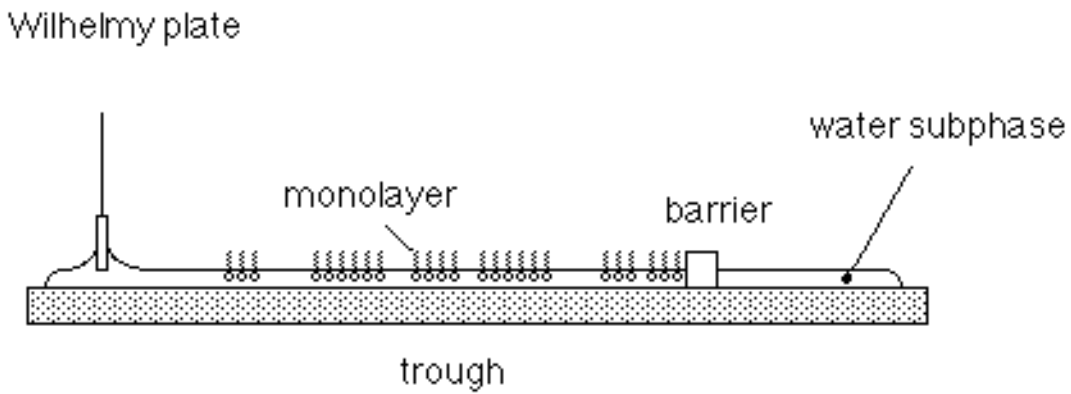

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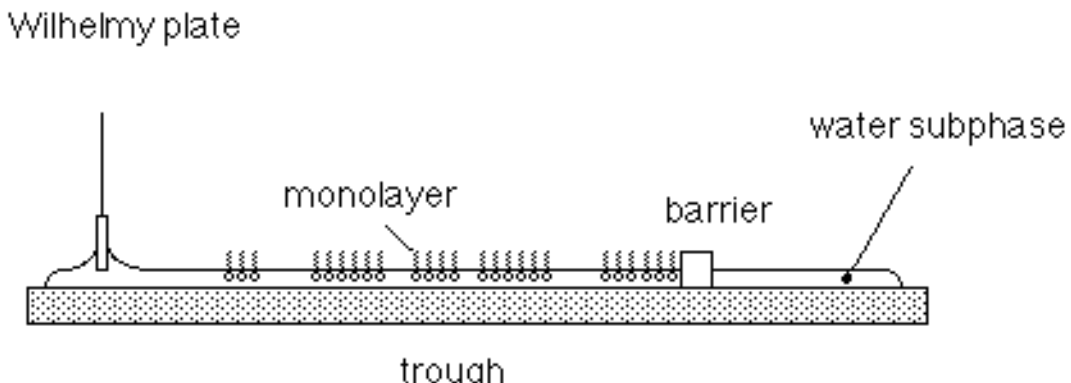

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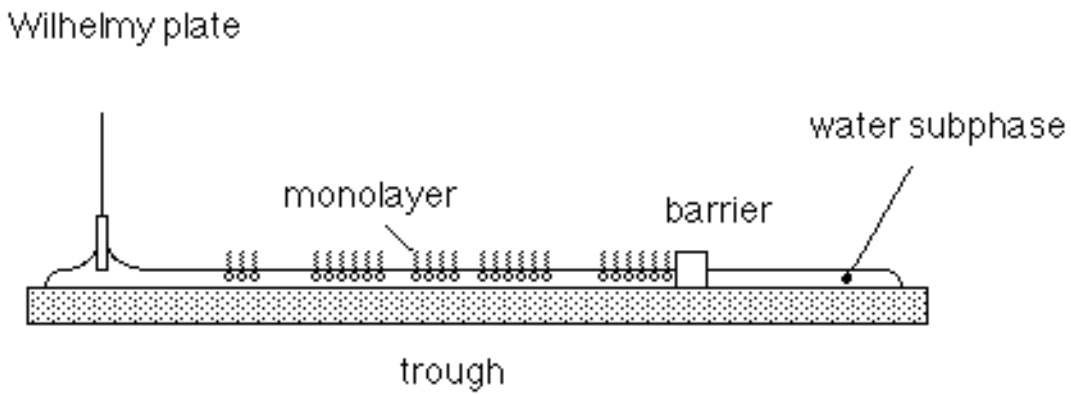

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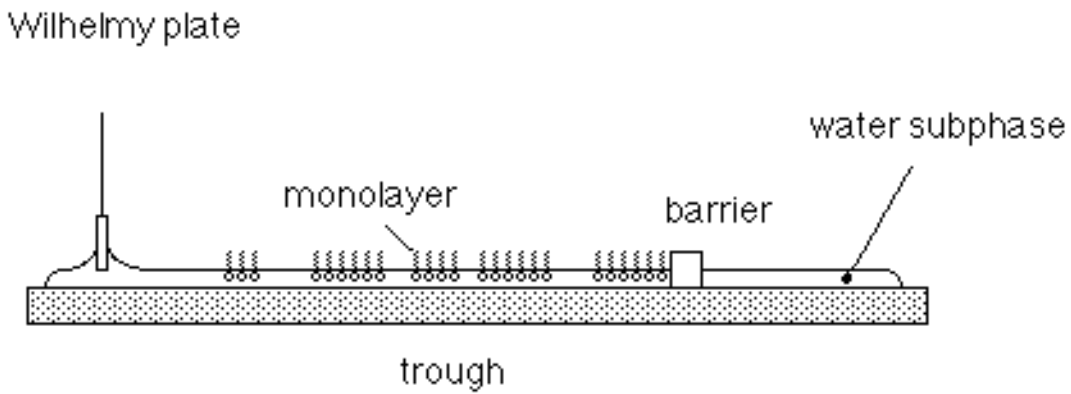
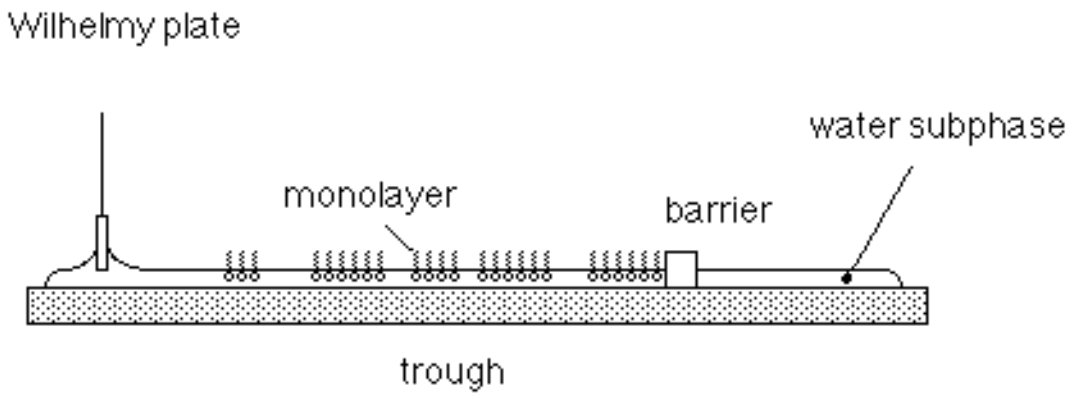
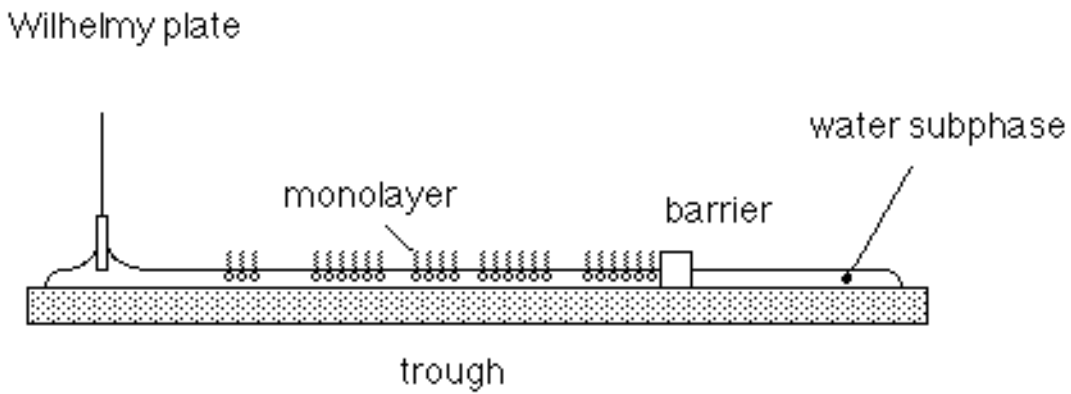


ラングミュア谷



ラングミュア谷



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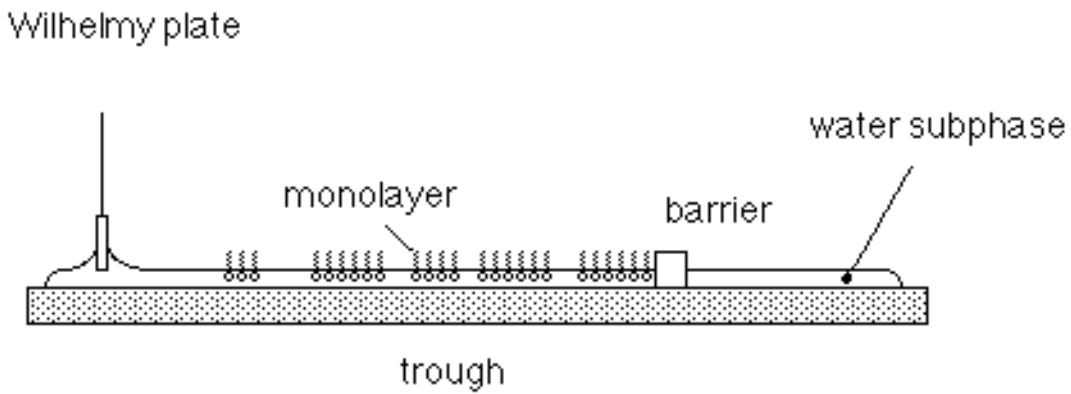

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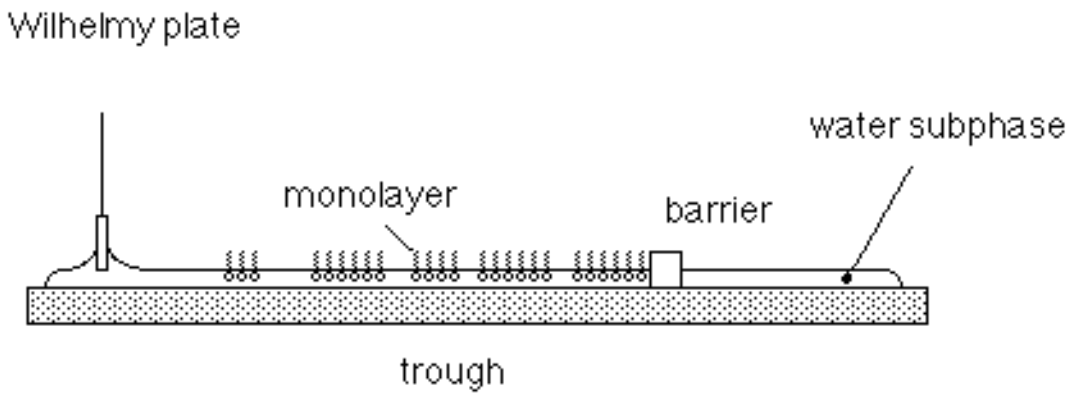

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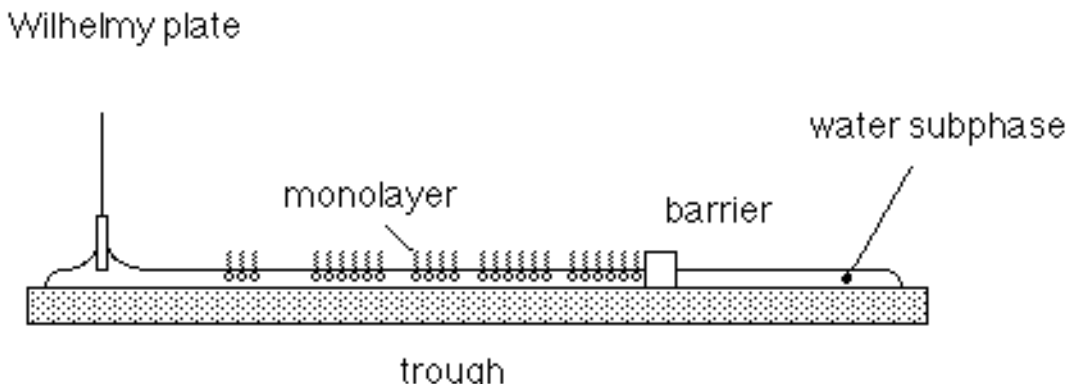

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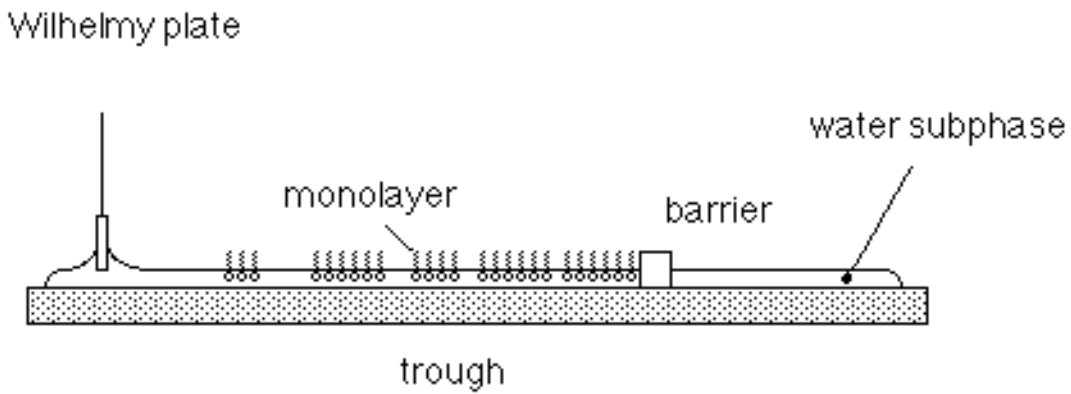

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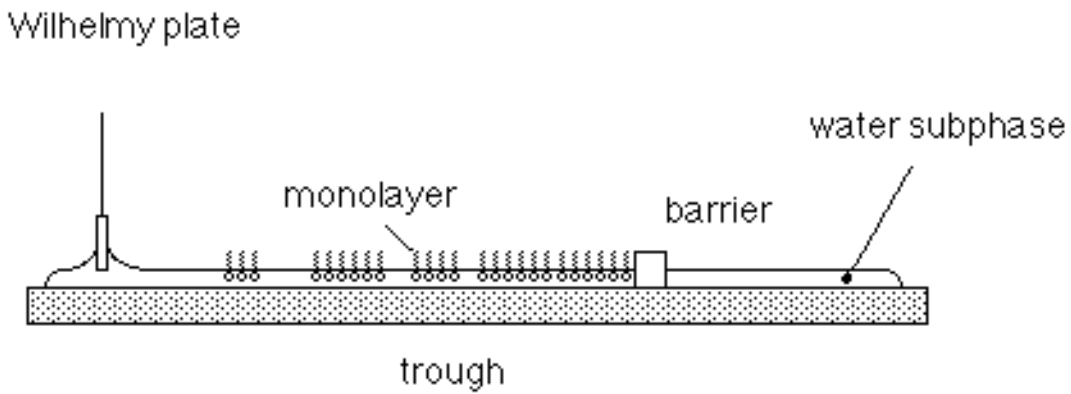

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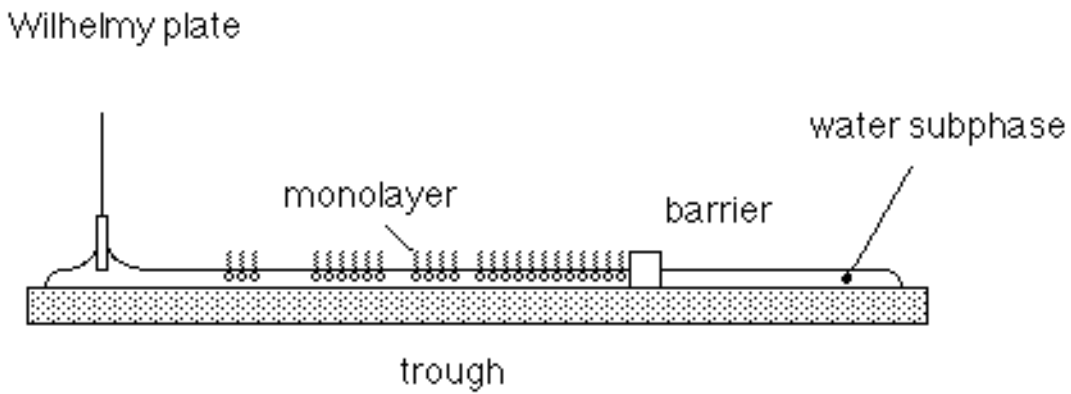

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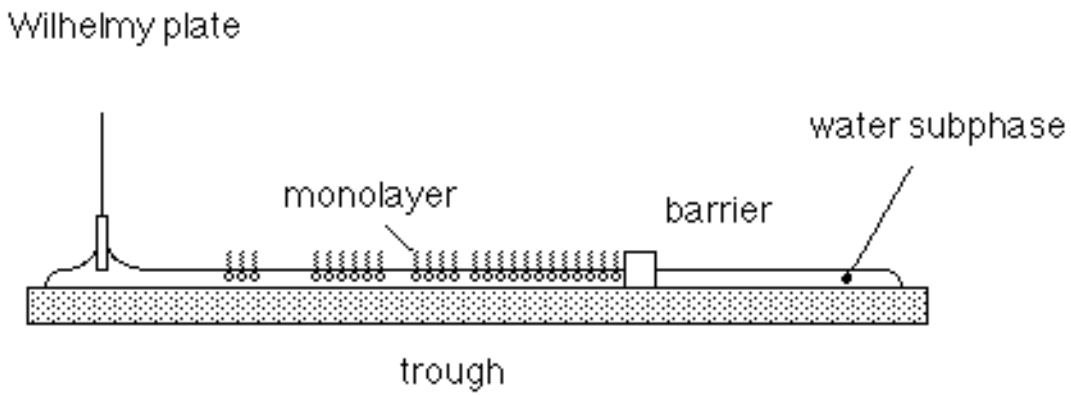

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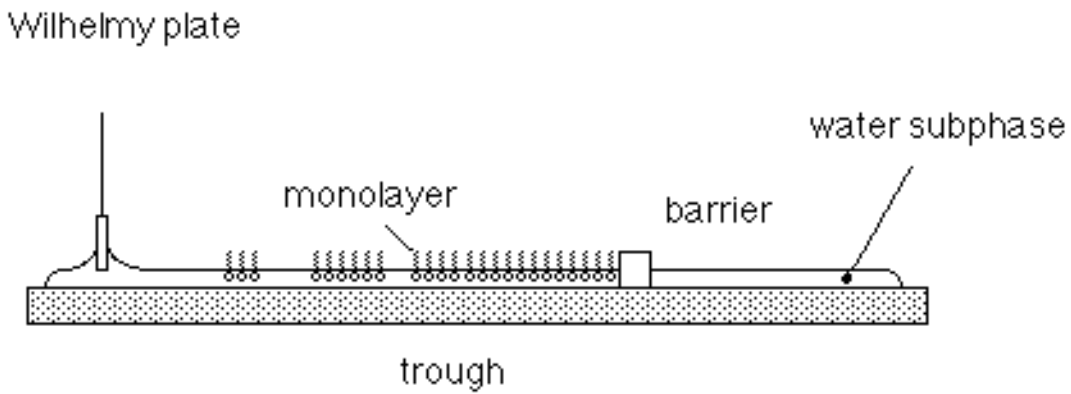

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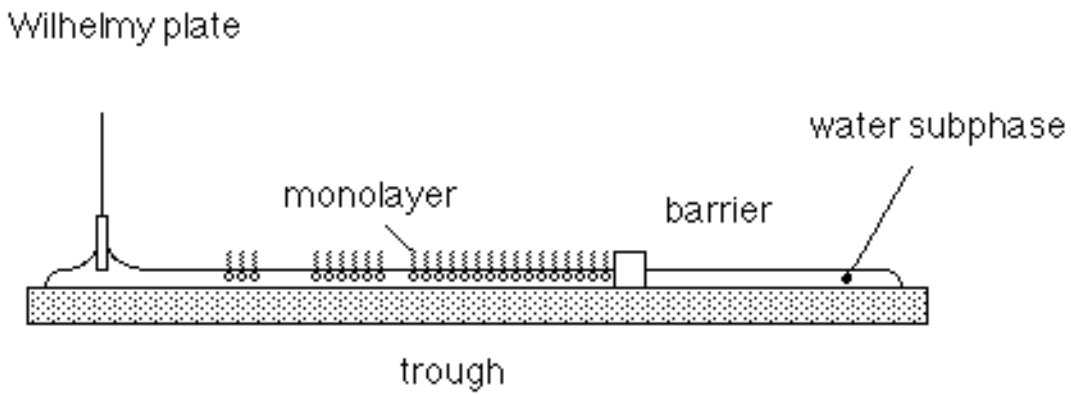

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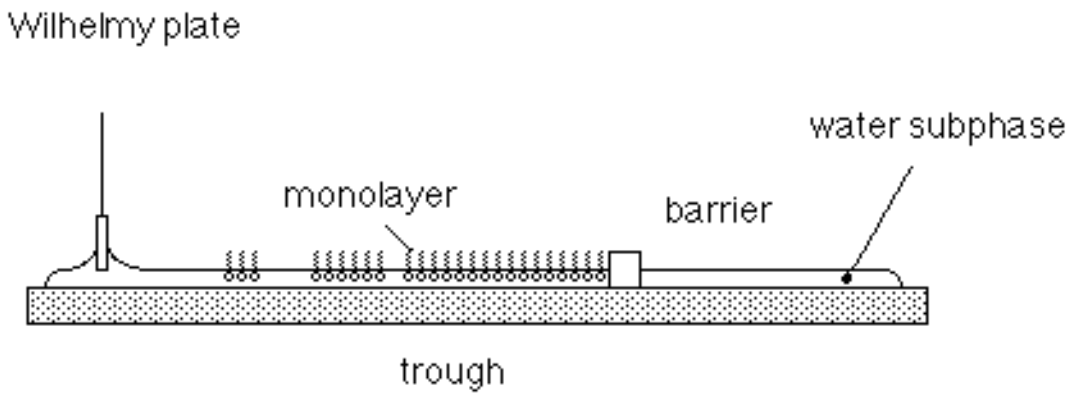

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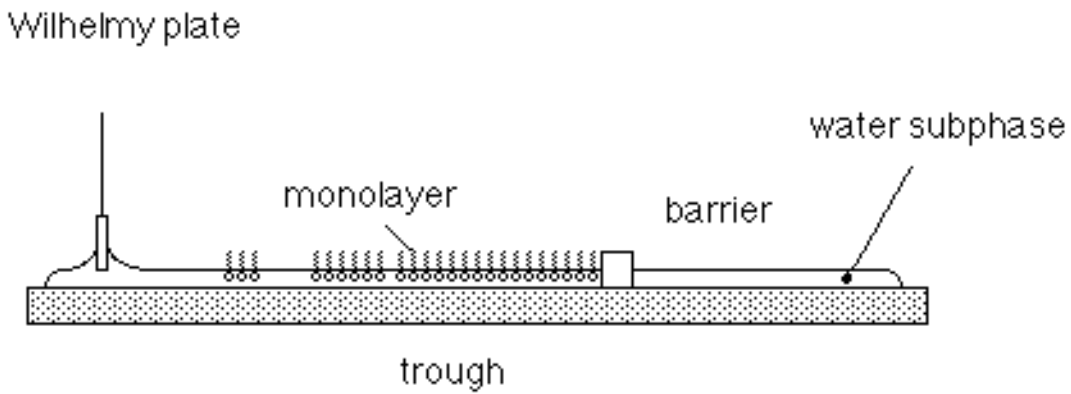

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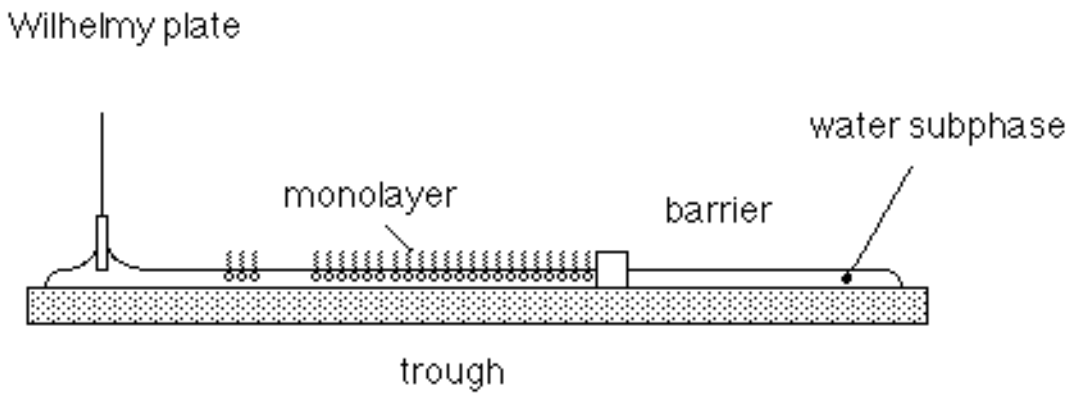
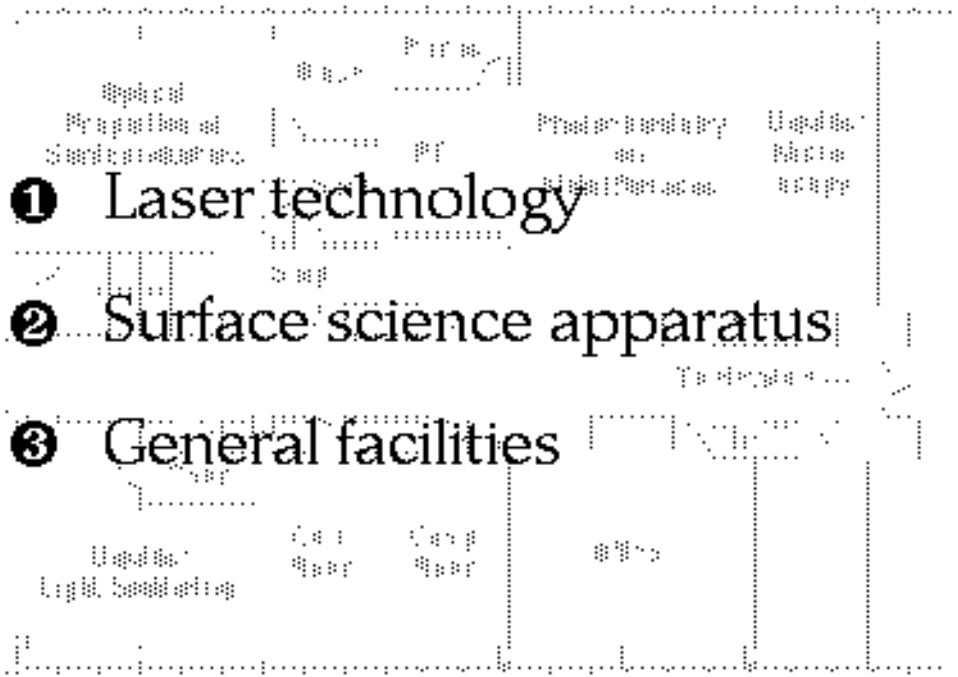


設備



❶ Laser technology

❷ Surface science apparatus

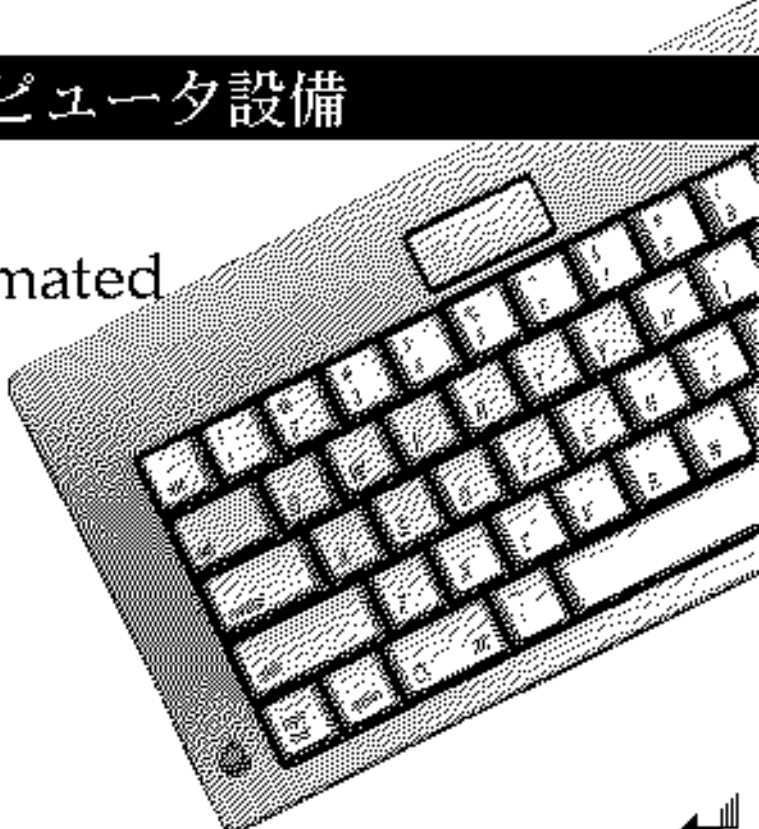
❸ General facilities

総合設備

- SEM, TEM & STM facilities
- Clean room microfabrication facility
- Accelerator facility (RBS, FRS, PIXE)
- Thin film deposition & lithography
- Molecular Beam Epitaxy

コンピュータ設備

- All setups automated
- LabView
- Ethernet LAN



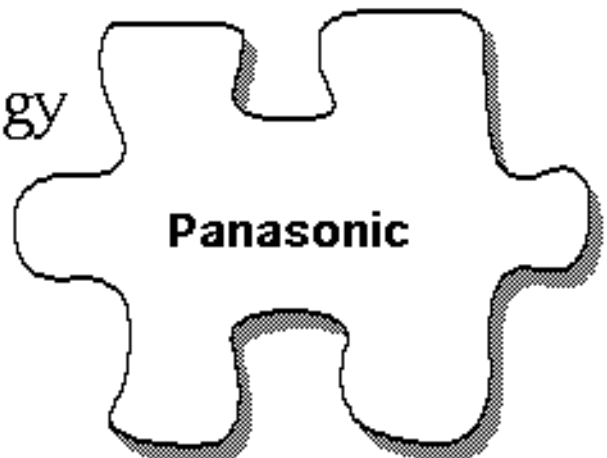
❶ Research

❷ Facilities

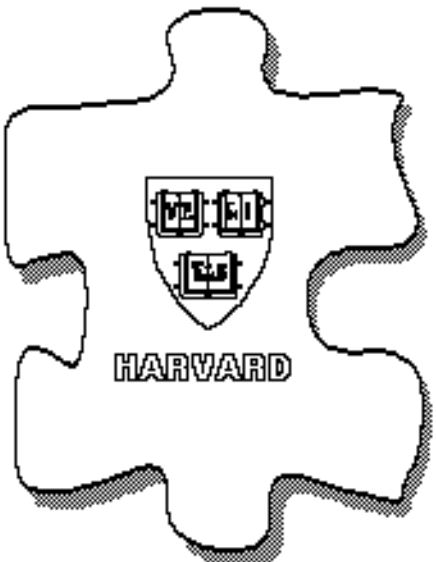
❸ Plans

最新技術

- device technology
- applications
- manufacturing

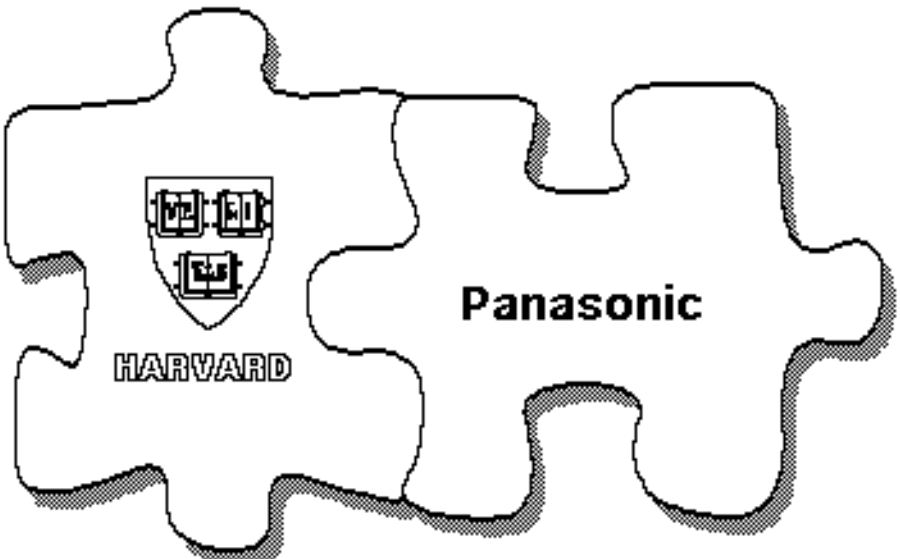


最新技術

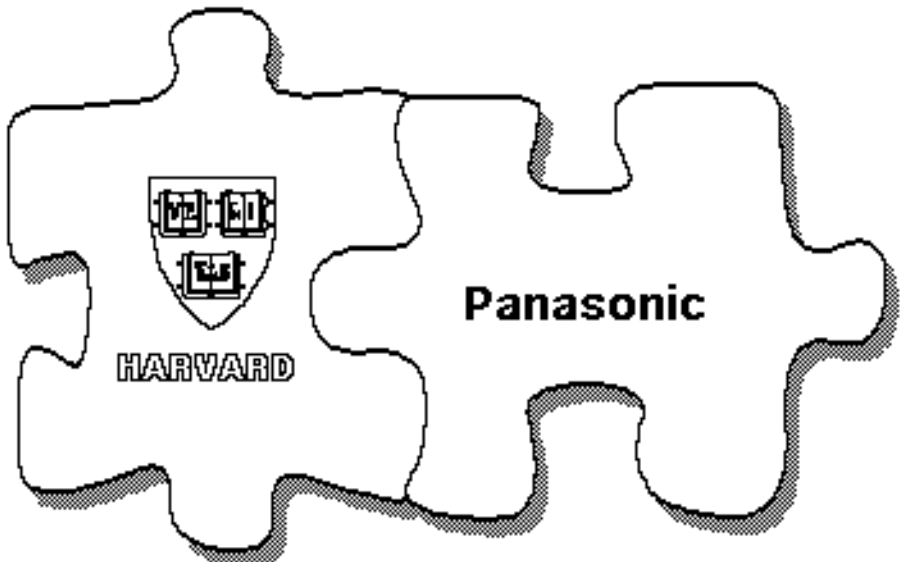


- laser technology
- surface facilities
- materials

最新技術



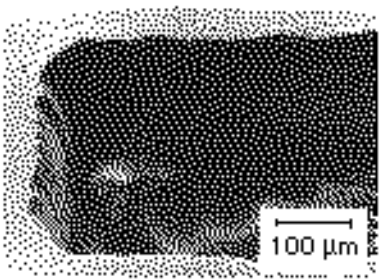
フェムト秒レーザー machining 化



フェムト秒レーザー machining 化

- ablation without heat transfer
- more precise cuts
- machining of transparent materials
- 3D machining

フェムト秒レーザー machining化研究

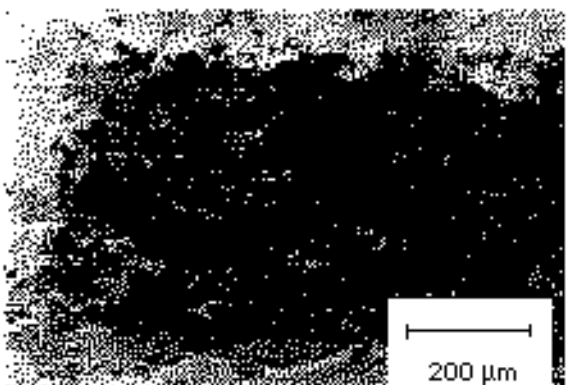


Teflon machined with
femtosecond pulses

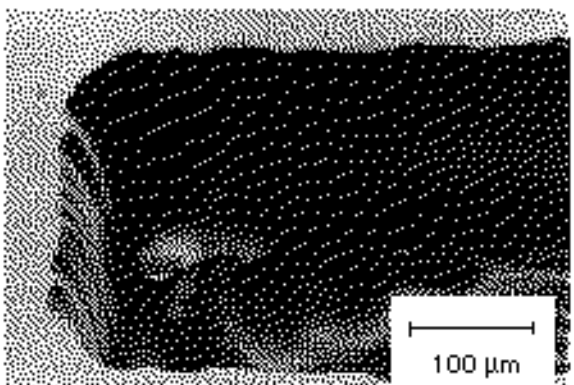
1. physical processes
2. materials
3. experimental probes
4. laser development

物理的過程

physics of ablation



nanosecond pulse ablation

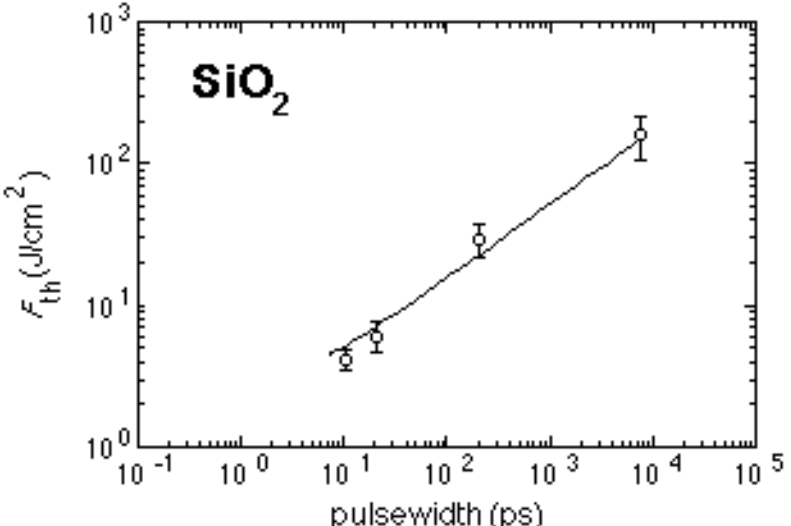


femtosecond pulse ablation

S. Küper and M. Stuke, Appl. Phys. Lett. **54**, 4 (1989)

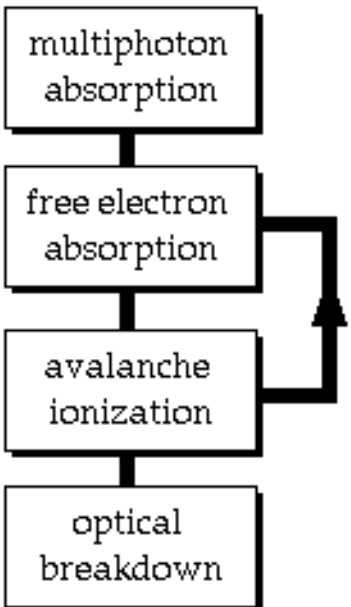
物理的過程

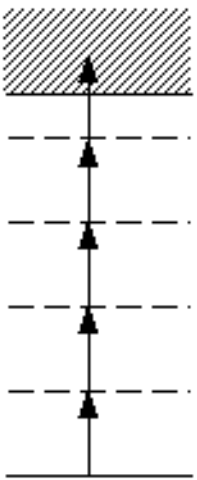
optical damage mechanisms



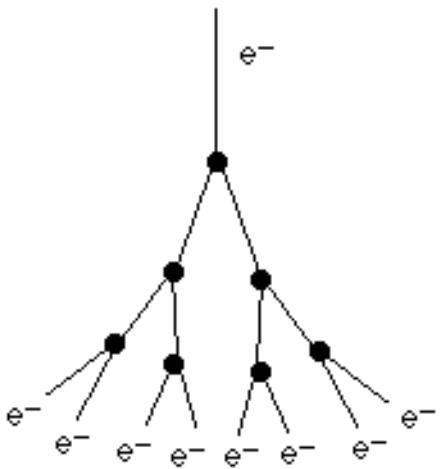
D. Du, et al., Ultrafast Phenomena IX (Springer Verlag, 1994)

物理的過程

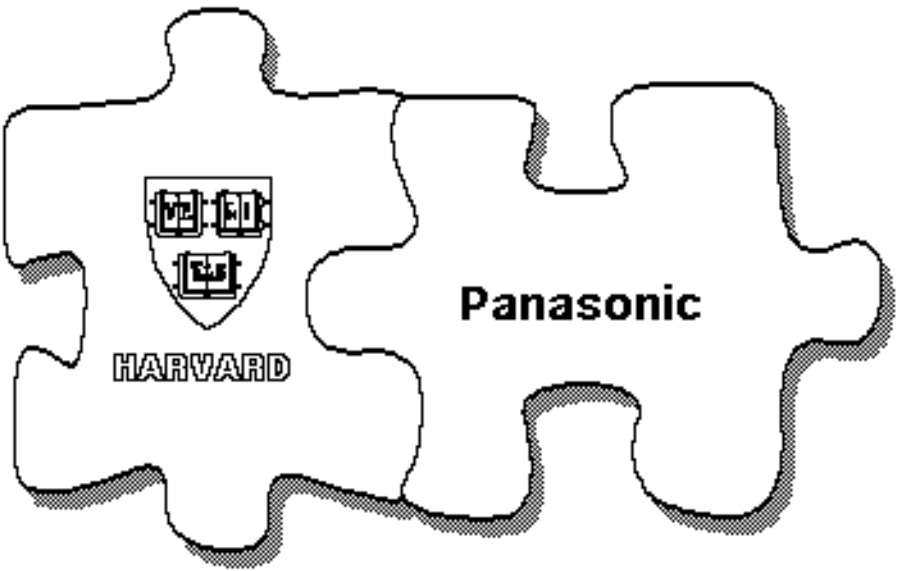




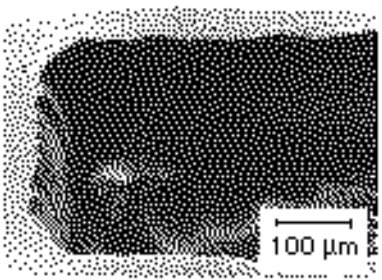
multiphoton absorption



avalanche ionization


HARVARD
Panasonic

フェムト秒レーザー machining化研究

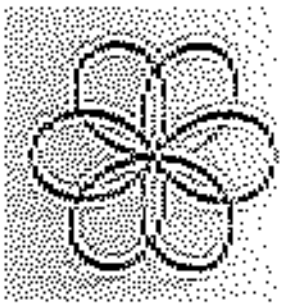


Teflon machined with
femtosecond pulses

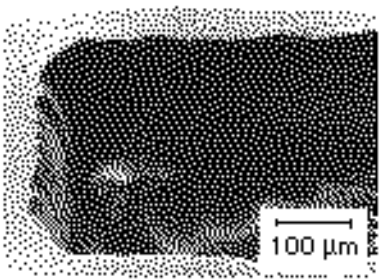
1. physical processes
2. materials
3. experimental probes
4. laser development

物質

- polymers
- silica
- semiconductors
- metals



フェムト秒レーザー machining化研究

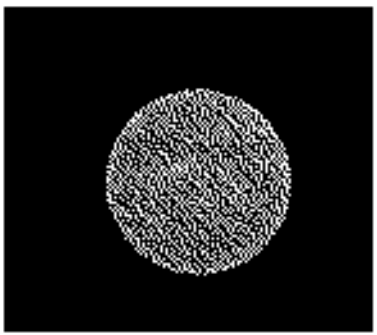


Teflon machined with
femtosecond pulses

1. physical processes
2. materials
3. experimental probes
4. laser development

実験用観測器具

–0.5 ps



M.C. Downer, et al.
JOSA B **2**, 595 (1985)

Ultrafast imaging

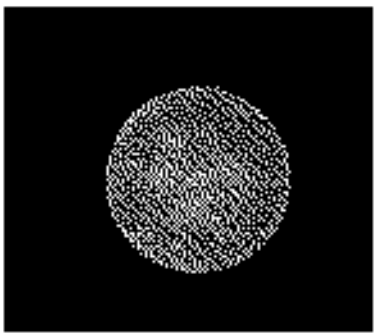
Time-resolved spectroscopy

Nonlinear optics

SEM, TEM

実験用観測器具

0.1 ps



M.C. Downer, et al.
JOSA B **2**, 595 (1985)

Ultrafast imaging

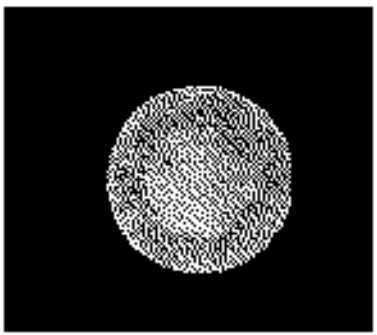
Time-resolved spectroscopy

Nonlinear optics

SEM, TEM

実験用観測器具

0.5 ps



M.C. Downer, et al.
JOSA B **2**, 595 (1985)

Ultrafast imaging

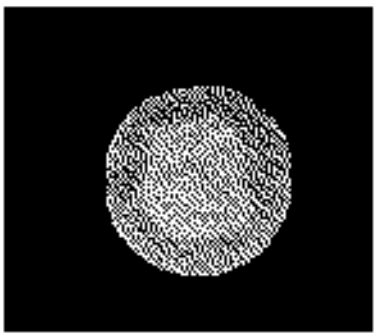
Time-resolved spectroscopy

Nonlinear optics

SEM, TEM

実験用観測器具

1 ps



M.C. Downer, et al.
JOSA B **2**, 595 (1985)

Ultrafast imaging

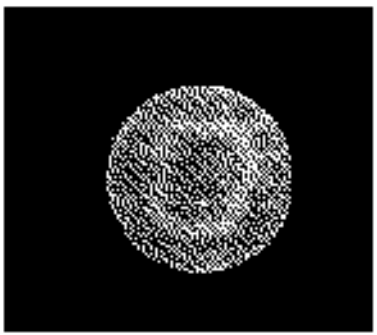
Time-resolved spectroscopy

Nonlinear optics

SEM, TEM

実験用観測器具

10 ps



M.C. Downer, et al.
JOSA B **2**, 595 (1985)

Ultrafast imaging

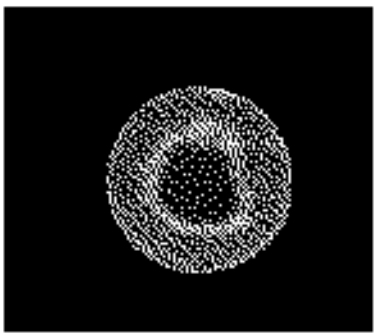
Time-resolved spectroscopy

Nonlinear optics

SEM, TEM

実験用観測器具

50 ps



M.C. Downer, et al.
JOSA B **2**, 595 (1985)

Ultrafast imaging

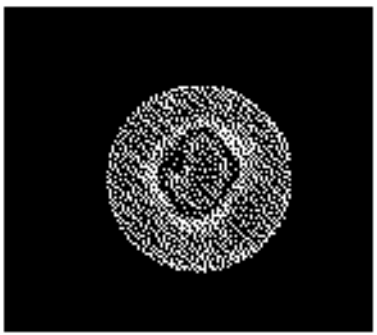
Time-resolved spectroscopy

Nonlinear optics

SEM, TEM

実験用観測器具

300 ps



M.C. Downer, et al.
JOSA B **2**, 595 (1985)

Ultrafast imaging

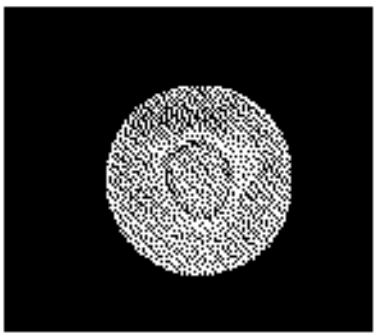
Time-resolved spectroscopy

Nonlinear optics

SEM, TEM

実験用観測器具

550 ps



M.C. Downer, et al.
JOSA B **2**, 595 (1985)

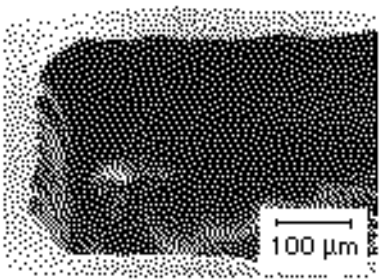
Ultrafast imaging

Time-resolved spectroscopy

Nonlinear optics

SEM, TEM

フェムト秒レーザー machining化研究



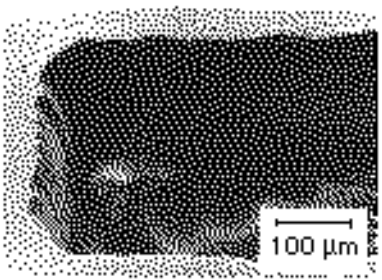
Teflon machined with
femtosecond pulses

1. physical processes
2. materials
3. experimental probes
4. laser development

レーザー開発

- high energy
- high beam quality
- high repetition rate
- variable pulse duration
- variable wavelength (visible, UV)
- delivery system

フェムト秒レーザー machining化研究



Teflon machined with
femtosecond pulses

1. physical processes
2. materials
3. experimental probes
4. laser development

共同研究目標

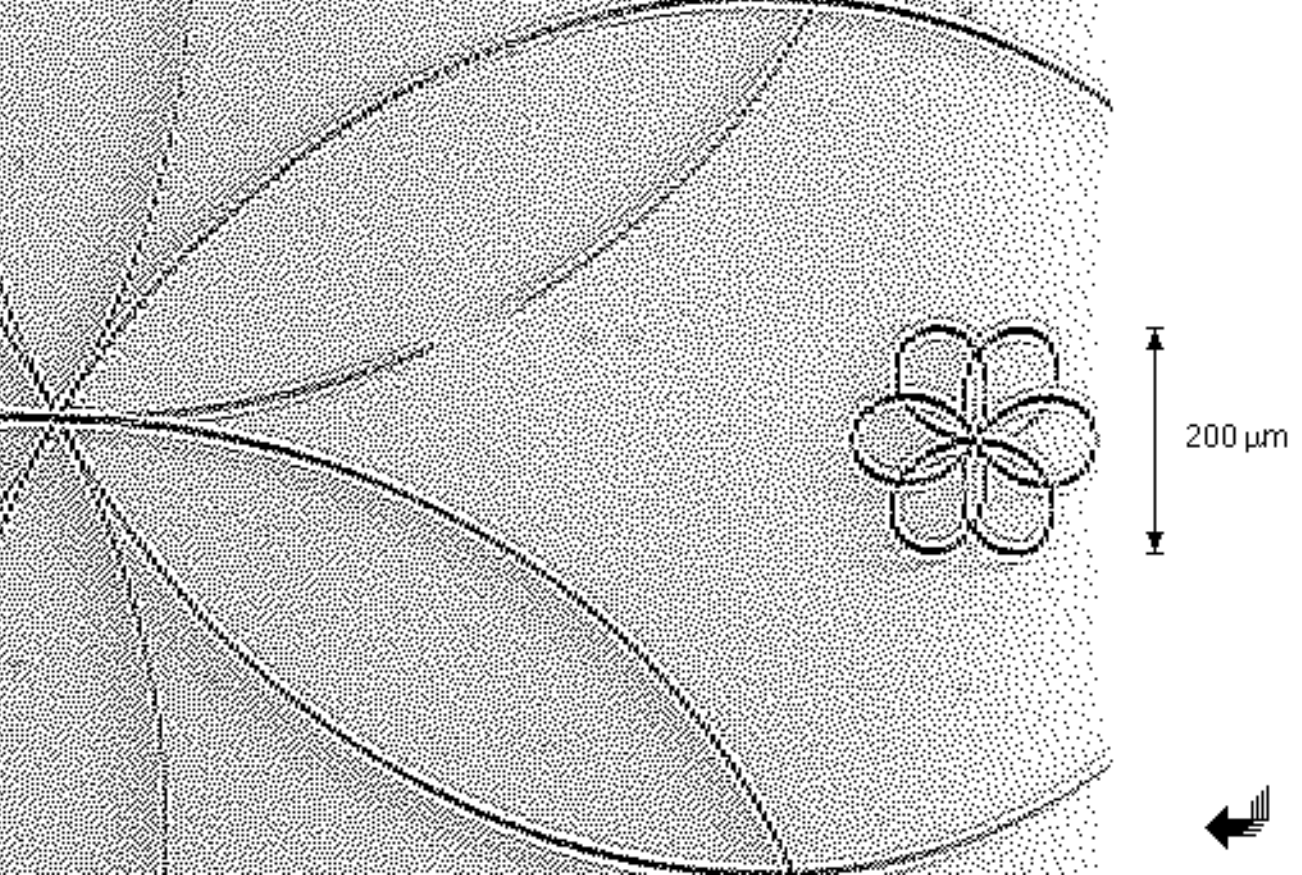
- technology transfer
- applications development
- creation of new materials / devices
- micromachining
- exchange with FST Project Center staff

Panasonic

今後の応用

- 3D memory
- devices for optical logic
- integrated optical devices
- industrial and medical applications

Panasonic


200 µm