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The Latest Technical Trend of Dry Film Photo Resist

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Abstract
This paper describes the performance of several types of the most advanced Dry Film photo Resist (DFR), for producing high-density package substrates and chip on films (COF).

1) High resolution type DFR, which achieves very fine conductive patterns less than L/S=15/15um by semi-additive plating process, is discussed.

2) High photosensitive type DFR is presented, which is used for Direct Imaging (DI) exposure systems expected to be applied to MPU package substrates. In the DI exposure systems, the irradiance of exposure lights affects the DFR resolution. Selecting a new initiation agents, which has high absorbance at h-line (405nm) for higher photo reaction efficiency, accomplishes the resolution of L/S=15/15um with 25um DFR thickness. This type of DFR also has high resistance for plating by using such monomers that increase of photo-reactive groups inside. The current target is L/S=10/10um resolution at quite low exposure energy, 10mJ/cm^2.

3) Ultra thin DFR below 5um for high density COF and TAB by subtractive method gives higher performance than conventional liquid photo resists. The DFR, which has demonstrated excellent 2um resolution and adhesion with 2um thickness on the experimental basis, extends the application field to near one micron scale, from the previous ten micron scale.

4) Other grades, thick layer DFR (120um thickness) for electroplating wafer bump formation and DFR for sandblasting which achieves dry etching of wafers, ceramics and glasses, are also introduced in the paper.

Introduction
Recent electronic products have created the need for high density interconnects, high frequency circuits, and low transmission loss, with renewed requirements for smaller shapes and lighter weights. The printed circuit boards, with mounted electronic devices and packages, have been used for all kinds of electronic equipment and apparatus. This demand for packaging substrates is documented in the International Technology Roadmap for Semiconductors[1].

Figure 1 shows trend of scaling of Flip Chip Substrates and of MPU Gate Length. They both continue to minimize from year to year, but a technology gap between them clearly exists. The importance of new technology systems, which enables the harmonization of semiconductor technology and interconnecting technology, has been pointed out, and a new technology of producing finer wiring has been expected.

Figure 2 shows the technical trend of high-density packaging, which supports the recent improvement of electronic products. The semiconductor devices have been compatible with low cost and small sizing, by cutting into small pieces based on scaling rule and using larger size wafers. But that will need to be looked over again in the future because of the increase of investment and process steps. Under these backgrounds, shift to SOC (System On Chip) has been looked at again, and SIP (System In Package) has been found preferable.

The packaging substrates have been changed from conventional rigid type to flexible tape type such as TAB or COF, and have been produced by a Reel-to-Reel method. The interconnecting technology on the packaging substrates has been shifted to semi-additive methods from conventional subtractive methods, to produce fine patterns and controlling impedance[2].

On the other hand, the interconnecting technology on the semiconductors has introduced “Damascene” method, which produces the conductive patterns by CMP (Chemical Mechanical Polishing) after filling the groove on the insulator with copper. The technology gap between semiconductor and packaging substrates has not tended to become narrower. The development of the fine interconnecting producing technology by lower cost and the improvement of the materials has been expected to fill the gap. Also it is very important to apply the technology used in the packaging substrates to the semiconductor process to accomplish lower cost.

Dry Film photo Resist (DFR) is one of the most important materials to support the progress of the high-density packaging technology. This paper mainly introduces the performance of several types of the most advanced DFR, for producing high-density package substrates and chip on films (COF).

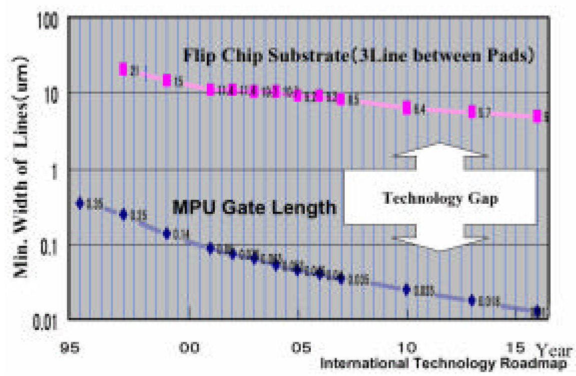

Figure 1 - Trend of Scaling

1. SOC → SIP
2. High Density Packaging
   - BGA/CSP、MCP(Multi Chip Package)、3dimension MCP、COC(Chip-On-Chip)、Embedded Substrate (R and C)
   - Rigid Substrate → Tape Substrate(COF/TAB)
3. Interconnection
   - Subtractive → Semi-Additive
   - Semi-Additive: Cu Seed → Ni Seed(Selective Etching)
   - Subtractive: Thinner Cu layer
   - New Technology(Direct Drawing): Ink-Jet Printing

Figure 2 - Trend of Packaging Technologies

Dry Film Photo Resist (DFR)

Figure 3 shows the structure of DFR, which consists of three layers, career film, photosensitive resist, and cover film. The photosensitive layer includes binder polymers, (meth) acrylated monomers, and photo initiators. Two types of processes are available for producing conductive patterns, subtractive method and semi-additive method (Figure 4).

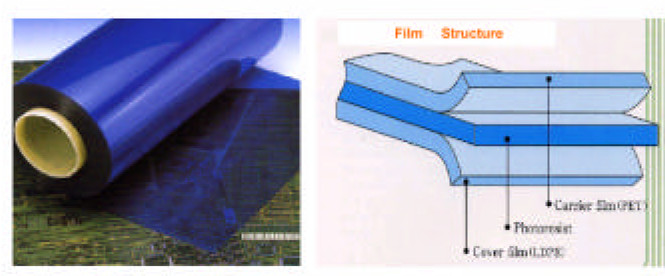

Figure 3 - DFR structure

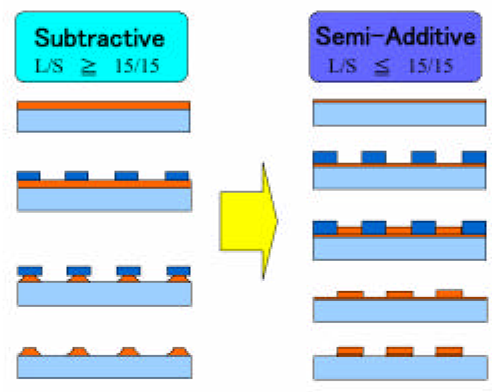

Figure 4 - Interconnection Technology

Super High resolution type DFR for Semi-Additive Process
Application
Semi-additive methods have often been used for producing very fine conductive patterns less than L/S=30/30um, because fine patterns require a uniformity of line widths and shapes to control special impedance. MPU package substrates, which need the design of less than L/S=15/15um resolution with 20um Copper thickness, will introduce semi-additive process with exposure by collimated or projection light.

Evaluation Conditions
Substrates: Electro less Plating (Copper 2um thickness)
Laminate: Hot-Roll Lamination(AL-70 Asahi):Lamination Temp 105°C: Speed 1.5m/min.: Lamination Pressure 0.35MPa
Exposure: Collimated Light(HMW801 Orc):Photo Mask : Glass Chromium
Development: 1% Na_2CO_3 solution. 30°C: Spray Pressure 0.22MPa
Plating :Copper Sulfate :Thickness 15, 20, 23um
Stripping: 3% NaOH solution. 50°C: Spray Pressure 0.2MPa

Resolution and Stripping Property
Figure 5 and 6 show the design of the high-resolution type DFR for semi-additive process. A high gamma value is needed to avoid the influence of light scattering or diffraction in photosensitive layer, and lower swelling for developing solution is also required. However, the stripping property of DFR generally decreases under lower swelling design, especially when the thickness of pattern plating is very close to the thickness of photosensitive layer.

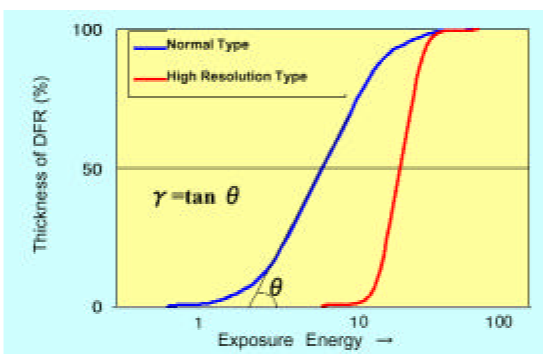

Figure 5 - Gamma value

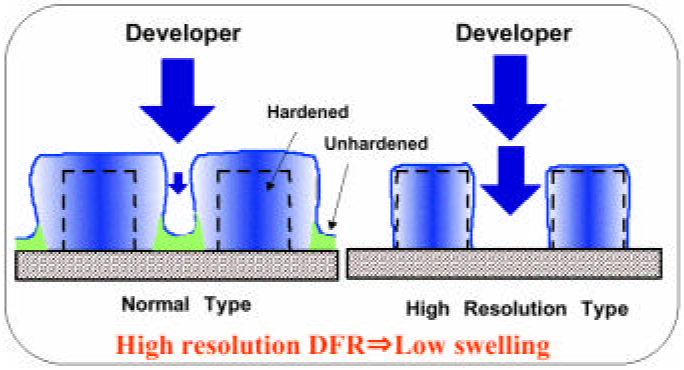

Figure 6 - Swelling in Development

Some amine solutions are used to strip DFR in above cases, which can dissolve DFR residue or cause small particles.

The shapes of the resist such as pleats of the sidewall or resist feet can seriously influence the stripping property (Figure 7). Pleats are caused by shading particles in the PET films or by defects of the photo masks. Including hydrophobic components in the photosensitive layer has been found to be effective in reducing such defects. Figure 8 shows the examples that have excellent L/S=8/8um resolution and good stripping property with fewer resist feet and a smooth surface sidewall. In the case of finer conductive patterns, selective etching or a full-additive process is required to prevent side etch and undercutting of patterns during the flash etching process[3].

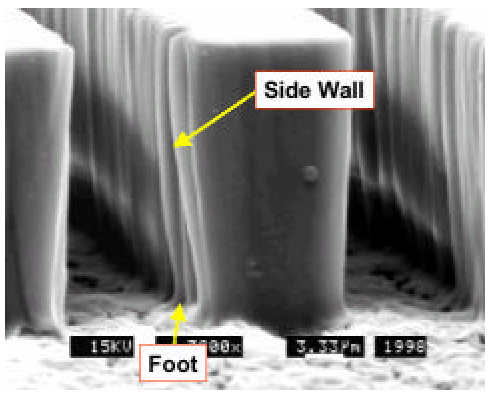

Figure 7 - Side wall and Resist Foot

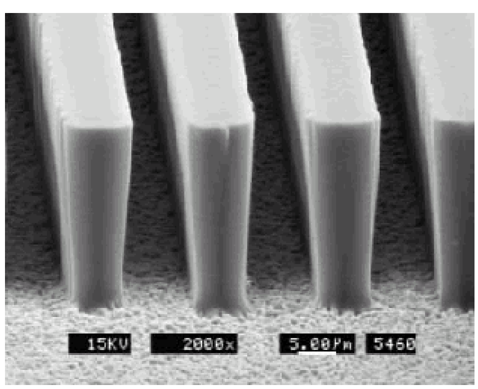

Figure 8 - Resolution and Stripping Property

High Photosensitive Type DFR for Direct-Imaging Process

Direct-Imaging Process

Direct-Imaging Process has also been applied to the MPU package substrates, because of the reasons indicated below.

(1) Accurate dynamic scaling and alignment
(2) Lower cost and lower defects by not using photo masks
(3) Labor-saving by automated exposure

The merits of this technology will be expected to extend the range of application from the traditional printed wiring boards, to technologies such as flat panel displays and so on.

Two types of exposure wavelength have been generally selected for DI process. One is i-line (365nm) using Polygon Scan method, and the other is the h-line (405nm) using a Digital mirror device. The H-line has generally been the most popular for process[4].

Evaluation Conditions

Exposure: DI-2080 (PIIC)
Other conditions are similar to the above section 2.

High Photosensitivity

For h-line exposure, conventional photo initiators for the i-line are not enough. Initiators having high absorbance at h-line (type A and B) are needed to achieve higher sensitivity (Figure 9). Although some photo initiators (type C etc.) having high sensitivity spectrum among visual light wavelength (especially more than 450nm) certainly had good sensitivity at h-line exposure, the sensitivity gradually decreased during holding DFR under yellow light (Figure 10). The new type of the photosensitive reagent 'B' was found to hold high sensitivity under yellow light conditions for a rather long time.

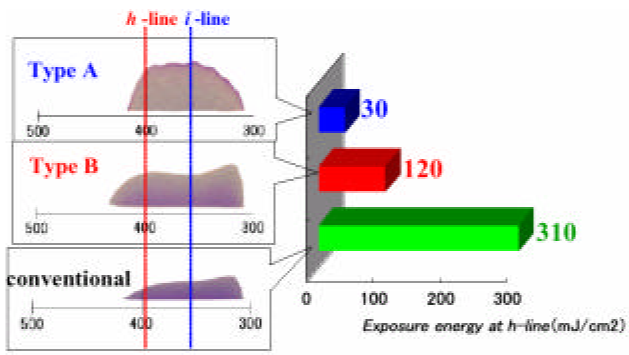

Figure 9 - Spectral Sensitivity

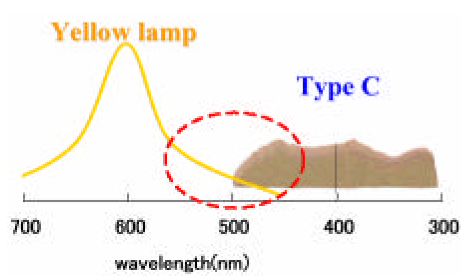

Figure 10 - Spectral Sensitivity

Resolution and Resist Shape

Under higher irradiance with shorter period of DI-exposure, the resolution and adhesion property tend to decrease so that the photosensitive layer cannot harden very well but swells during developing process. Increasing the double bond density involving photosensitive layer was found to be effective to achieve higher resolution and adhesion by reducing swelling of the hardened parts (Figure 11). Also to take advantage of the effect of refracting light from the Copper surface, photosensitive reagents, having a large absorbance at h-line, were introduced leading to excellent resist patterns with very high resolution and sharpened shapes (Figure 12).

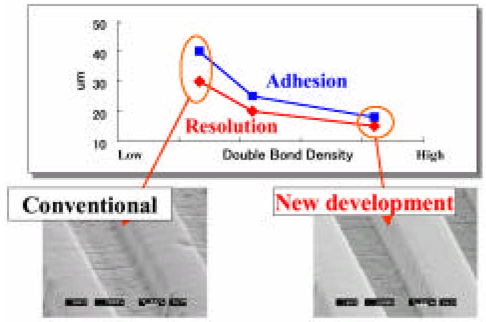

Figure 11 - Resolution and Adhesion Property

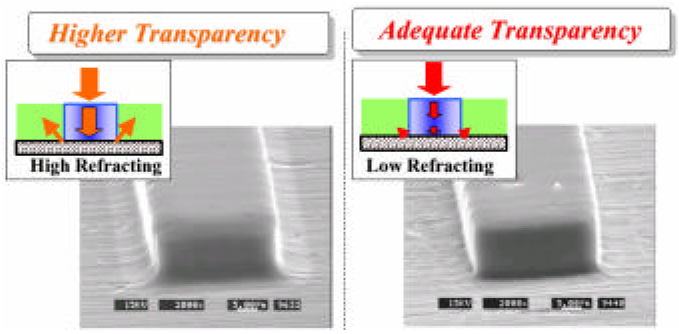

Figure 12 - The effect of Transparency at H-line

The Latest Accomplishment

Total performance of latest grade for DI-process is shown in Table 1. This DI-process has already demonstrated a resolution of L/S=12/12um with 25um DFR thickness at quite low exposure energy, 30mJ/cm2. This type of DFR also has high resistance for plating and good tenting strength and allowing it to be used for both the plating and tenting/etching processes. This DI grade can also be applied using i-line exposure.

Table 1 - Total Performance

	Grade A for DI	Grade B for Contact exposure
exposure	DI at h-line	Contact at i-line
thickness	25um	25um
sensitivity	30 mJ/cm^2	120 mJ/cm^2
resolution	12um	8um
adhesion	10um	8um
Shape of pattern	Good	Good
stripping	Good	Good

Ultra Thin DFR for COF&TAB Production

Applications

Ultra thin DFR (less than 5um thickness) for subtracting process has been used to produce conductive patterns of tape typed substrates such as COF or TAB. Mass production of these substrates has started and continues to expand from year to year replacing conventional liquid photo resists, which had been widely used in these processes.

To support this change projection exposure machines have been adopted to produce fine resolution under L/S=5/5um. In the near future, the semi-additive process will be introduced to produce even finer conductive patterns.

Evaluation Conditions

Substrates: 8umthickness of Copper with Polyimide basis

Laminate: Hot-Roll Lamination (AL-700 Asahi):Lamination Temp 105~120°C: Speed 1.0m/min.:Lamination Pressure 0.35 ~0.50MPa

Exposure: Projection (Ushio):Photo Mask : Glass Chromium

Development: 0.4% Na_2CO_3 solution. 30°C: Spray Pressure 0.15MPa

Etching :Copper Sulfate (Reel to Reel etching):Temp 50°C:Spray Pressure 0.35MPa

Stripping: 3% NaOH solution. 50°C: Spray Pressure 0.2MPa

Resolution Property

To achieve higher level of resolution and adhesion, thinner thicknesses of photosensitive layer are required. 5um thickness of photosensitive layer have been produced on a large scale in manufacturing. In addition, only one-micron thicknesses have been produced continuously with excellent control of the thickness in the laboratory. Figure 13 shows L/S=10/10um resist patterns after developing, and cross section of 20um pitch conductive patterns by a semi-additive process.

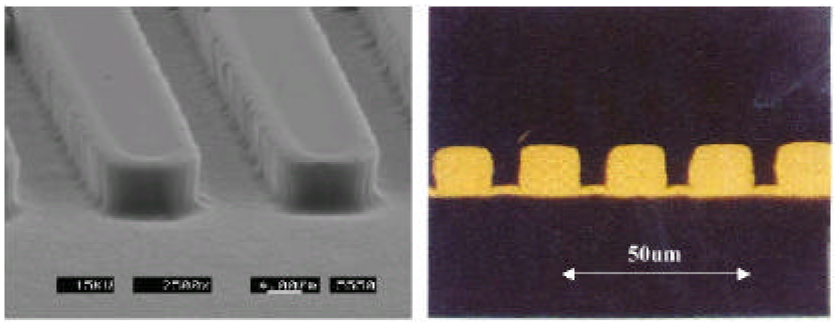

Figure 13 - COF 20um Pitch (L/S=10/10um)

Reducing Lamination Error

One of the most important problems in the DFR process is decreasing lamination errors[5]. The thinner thickness of DFR provides more opportunities for lamination errors.

The three methods listed below are found to be to the most effective in decreasing lamination errors to almost 'zero'.

1. Low viscosity design of photosensitive layer: Good conformation to the substrate surface reduce errors.
2. Copper surface treatment: Smoothing of the Copper surface by soft etching is effective. Especially using an etching solution that finely roughens gives good performance.
3. Lamination conditions: Some process conditions, e.g. low speed (1m/min.), high temp (110~120°C), high roller pressure (0.5Mpa), help to reduce errors. The quality of lamination rolls also has a very strong effect: metal on the substrates side and rubber on the DFR side is optimum.

Comparison with Liquid Photo Resists

Several merits of ultra thin DFR compared with liquid photo resists are shown below.

1. Laminating both sides of the surface at the same time is available.
2. Lower producing cost by decreasing the number of processes such as spreading photo resists, drying, controlling thickness, etc
3. Reducing investment cost
4. Tenting processes are available.
5. The semi-additive process is available (though not for ultra thin).
6. Very close resolution and adhesion
7. Lamination errors are 'almost ZERO' by selecting good methods and conditions.

The Latest Accomplishment

Ultra thin DFR, which has already accomplished excellent 2um resolution and 2um adhesion with 2um thickness on the experimental basis (Figure 14), extends the application field to near one micron scale, from the previous ten micron scale. The application of DFR will be expected to widely spread with the acceleration of dual surface conductive patterns or multi layers.

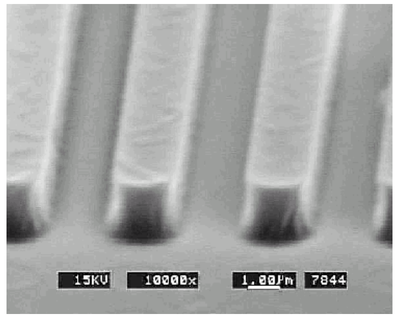

Figure14 - 2um Resolution and Adhesion

Other Dry Films
DFR has begun to be applied in several fields now using conventional liquid photo resist. Thick layer DFR (120um thickness) for electroplating wafer bump formation has already been used. This reduces lamination to a single step instead of several coatings of liquid photo resists. High resolution 60um (aspect ratio is 2) has been accomplished with good stripping properties (Figure15).

DFR for sandblasting has already been used for producing finer barrier ribs in Plasma Display Panels (Figure 16). In the large panels, the dissolving speed of DFR into alkaline solution is quite fast at the corner of the panel in comparison with the center. A wide process margin during development is needed to produce fine patterns correctly together with good resistance properties for sandblasting. This type of DFR can be applied to dry etching of wafers, ceramics and glasses, a property which has also enlarged the field of the DFR applications for Flat Panel Displays.

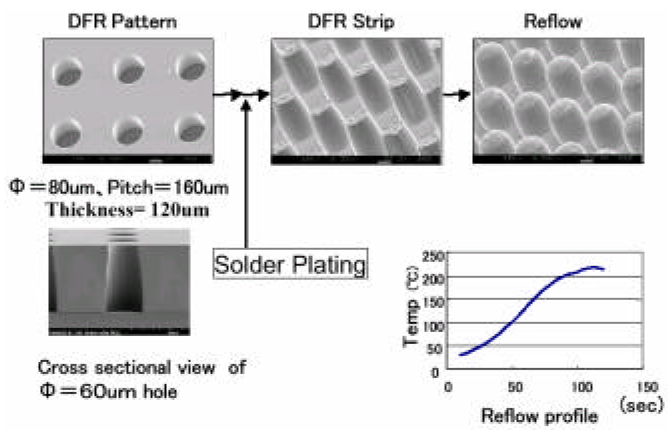

Figure 15 - Wafer Bump Formation

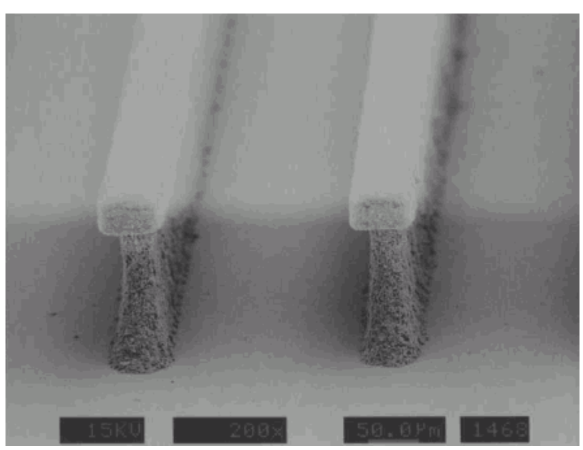

Figure 16-50um Width Barrier Ribs

Summary and Conclusions

The technology of producing films less than 10 um and designing photosensitive layers enables one-micron order resolution and adhesion. Reducing lamination errors, which is one of the most important problems of liquid photo resist, is nearly solved by selecting lower viscosity of photosensitive resin and proper lamination conditions. Introducing new initiators, having high absorbance at h-line frequencies, has expanded the range of application of the Direct Imaging process. Therefore, Dry Film photo Resist can be expected to make a great contribution to the trends of scaling as indicated in International Technology Roadmap for Semiconductors.

References

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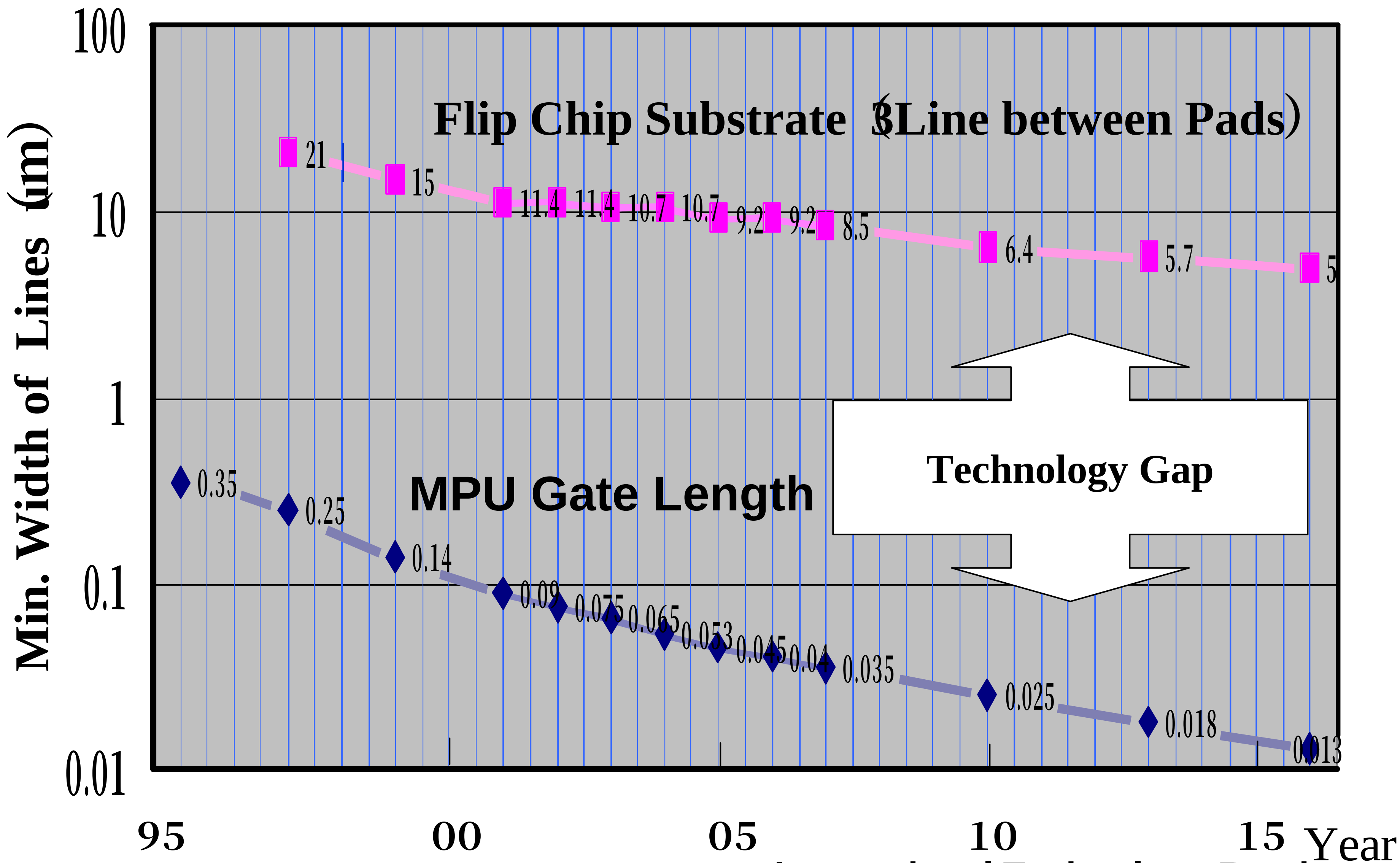
Trend of Scaling

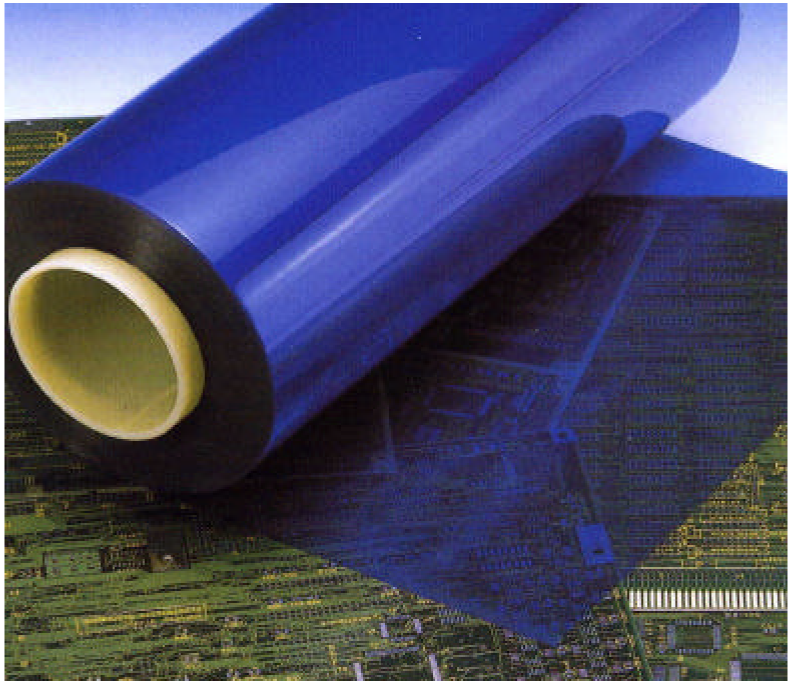


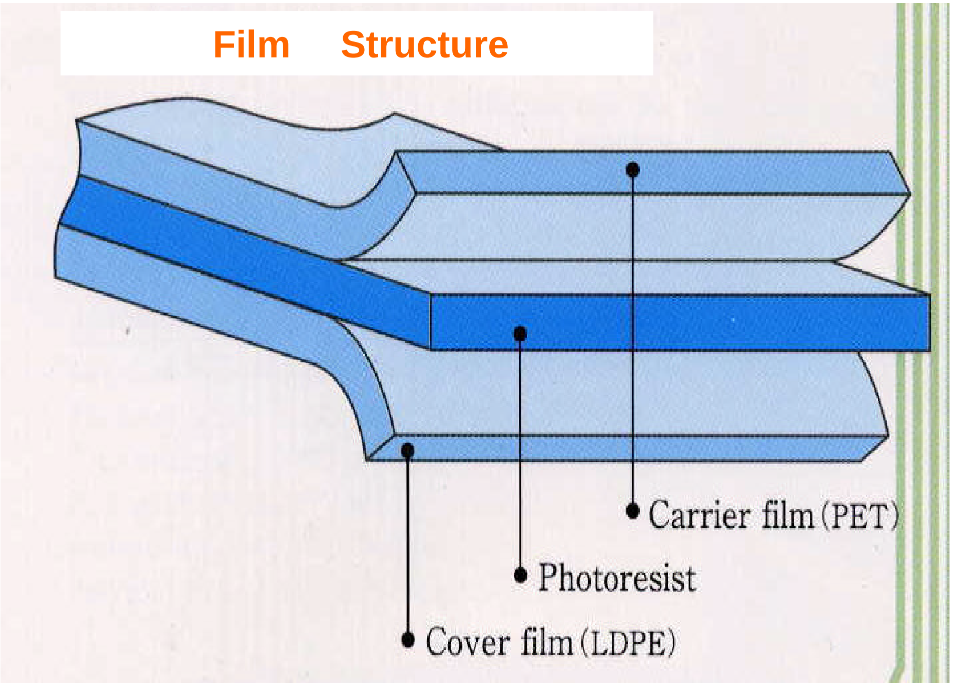
International Technology Roadmap

Trend of Packaging Technologies

1. **SOC → SIP**
2. **High Density Packaging**
   - **BGA/CSP、MCP（Multi Chip Package）、3dimension MCP、COC（Chip-On-Chip)、Embedded Substrate (R and C)**
   - **Rigid Substrate → Tape Substrate（COF／TAB）**
3. **Interconnection**
   - **Subtractive → Semi-Additive(including Direct Imaging)**
   - **Semi-Additive：Cu Seed → Ni Seed（Selective Etching）**
   - **Subtractive：Thinner Cu layer**
   - **New Technology（Direct Drawing）：Ink-Jet Printing**

DFR Structure





Photoresist includes **Binder polymers**
Acrylated monmers
Photo initiators

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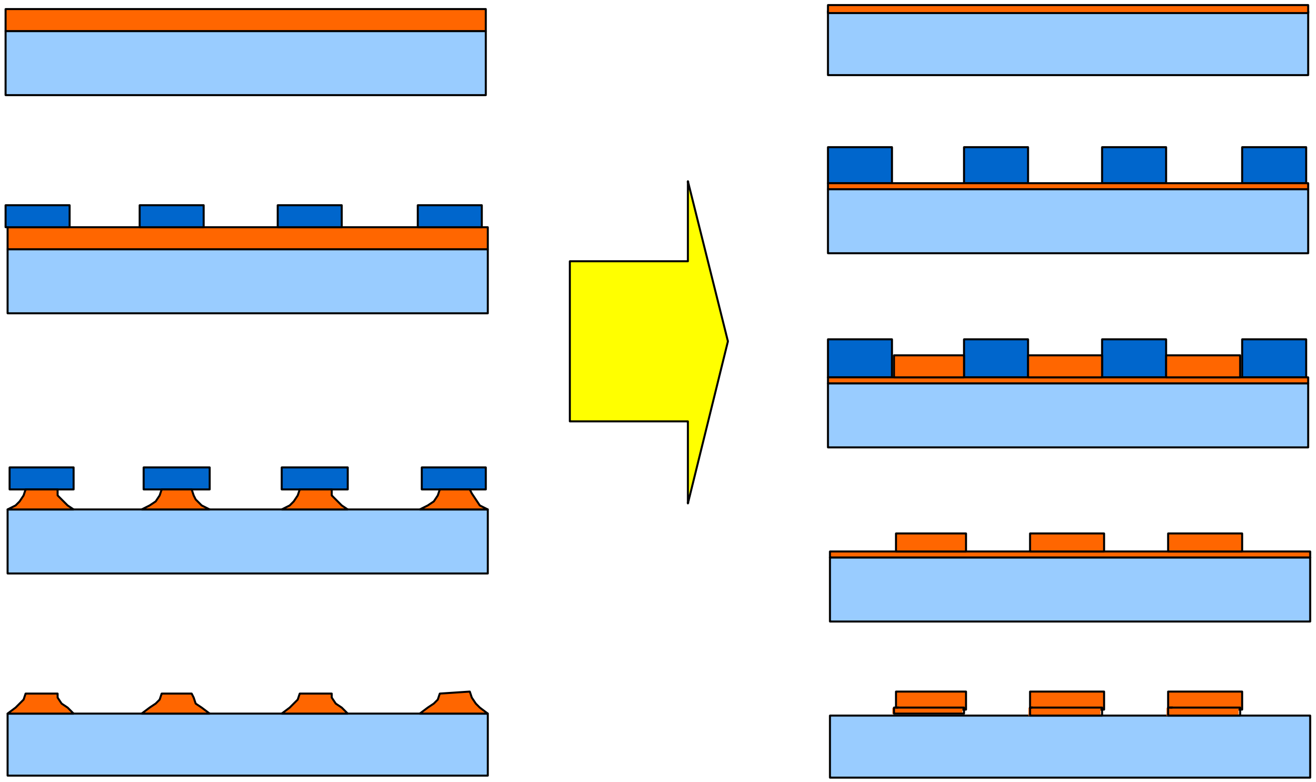
Interconnection Technology

Subtractive
L/S ≧ 15/15

Semi-Additive
L/S ≦ 15/15



Concept of Formulation Design

for DFR for semi-additive process

(1)Super High Resolution

(2)Easy Stripping

(3)Good Conformation

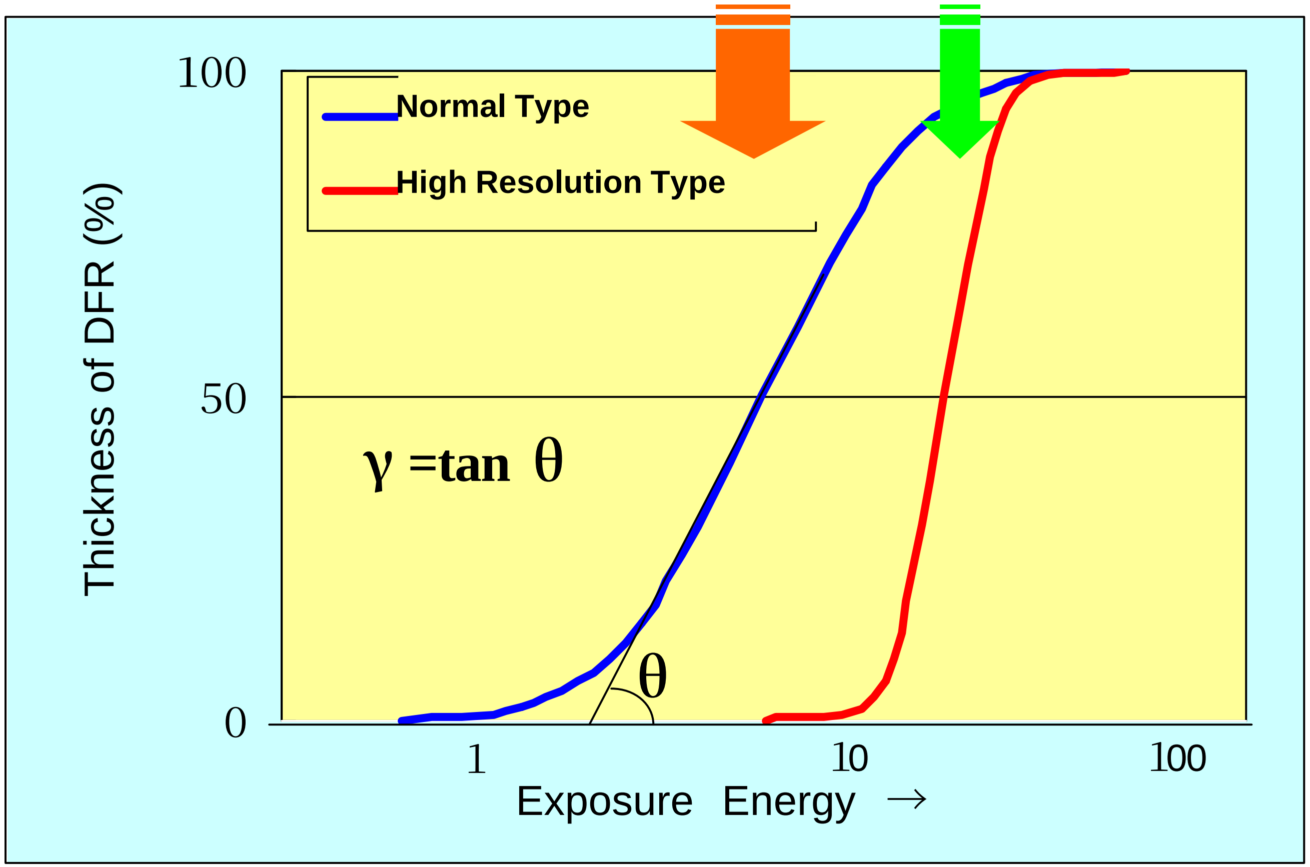
(4)High Resistance to Electroplating

(5)Wider Process Margin

Super High Resolution

Higher γ -Value

Gray Zone is not hardened enough.



The γ –value is higher ,

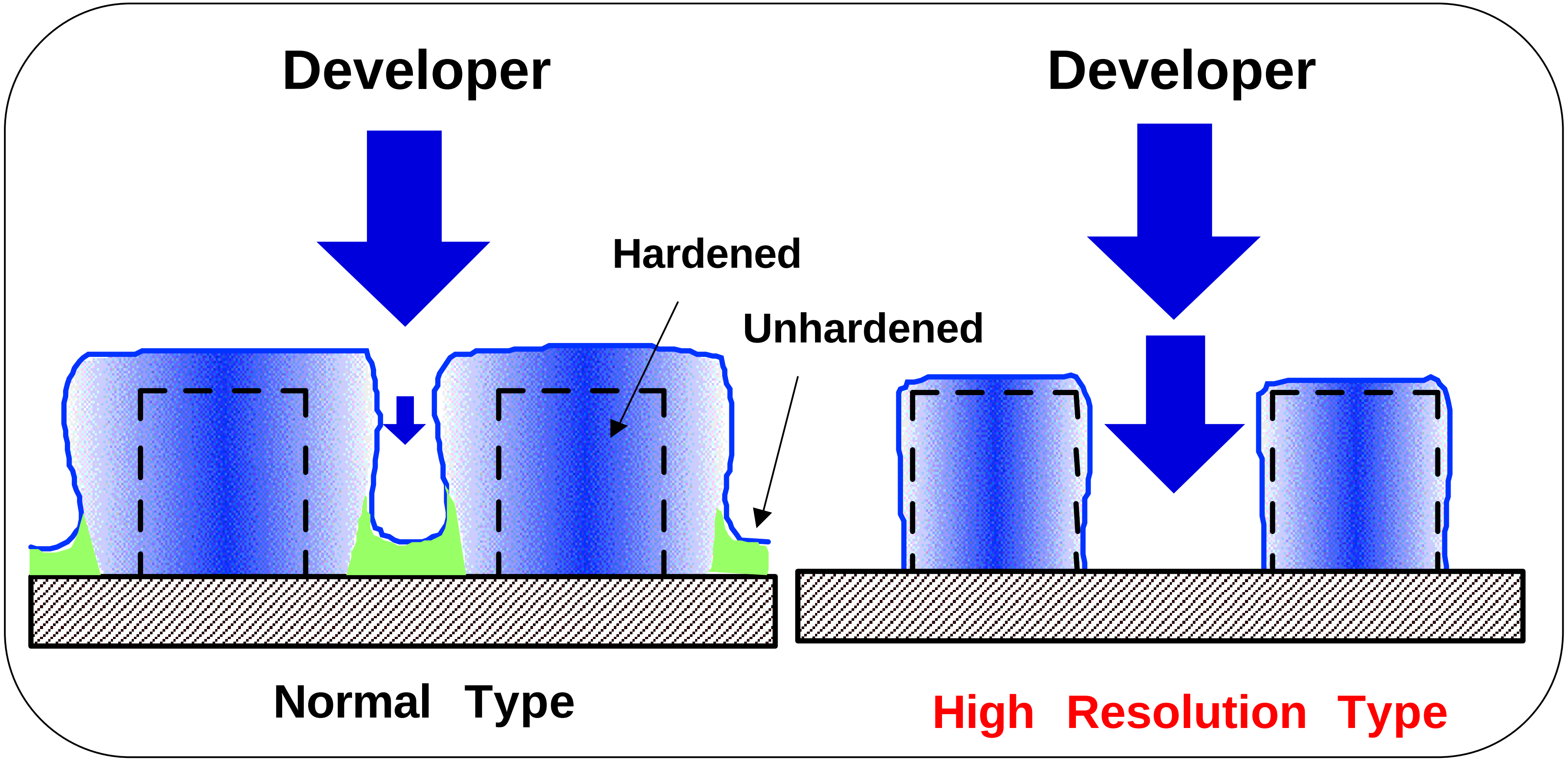
The gray zone of DFR is narrower.

⇒ Hardens enough

⇒ brings Increase of Resolution

Super High Resolution

Lower Swelling in Development



•The hardened part swells under alkaline solution

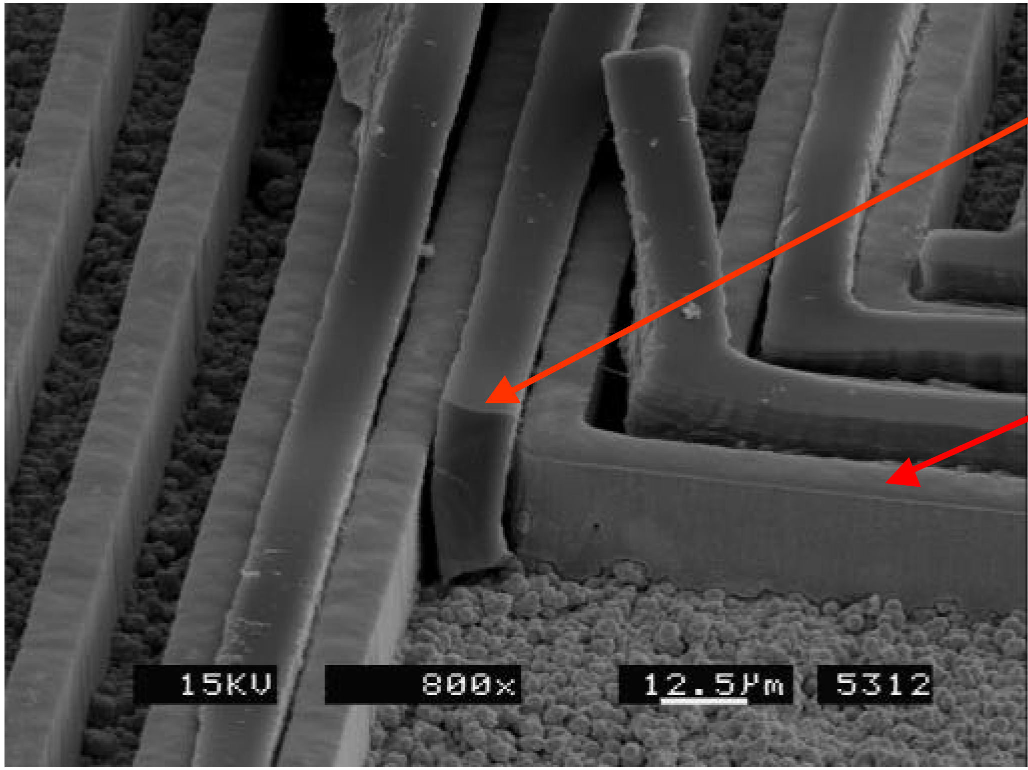
⇒ Difficult to develop narrow space

⇒ Decreasing resolution

High resolution DFR ⇒ Lower swelling

Residue of Resist after Stripping

Example of Defect



Residue of resist

Cu Pattern

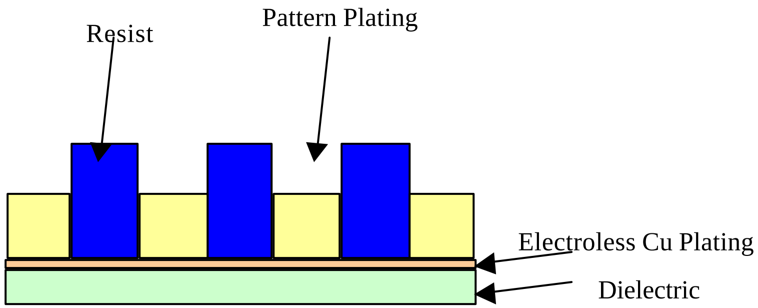
The finer resist patterns are more difficult to strip.

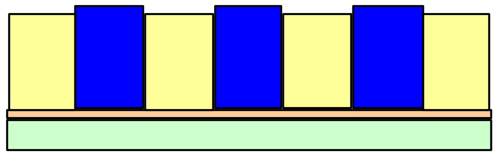
Easy Stripping

Mechanism of Resist Stripping

1. Thinner Pattern Plating

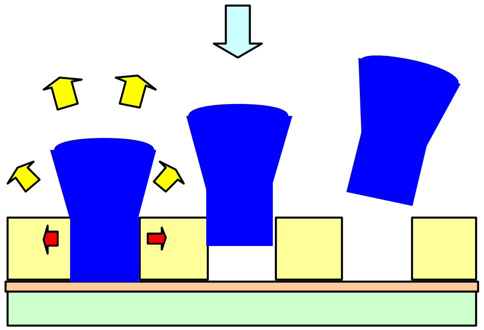
2. Thicker Pattern Plating

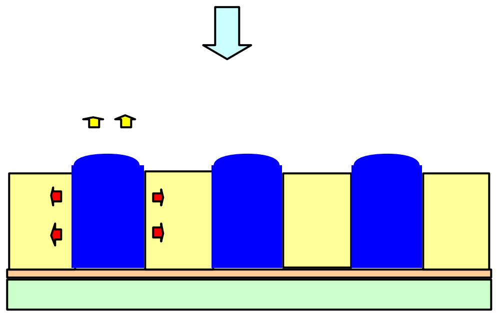




Stress from Swelling

Low stress from Swelling





No Resist residue

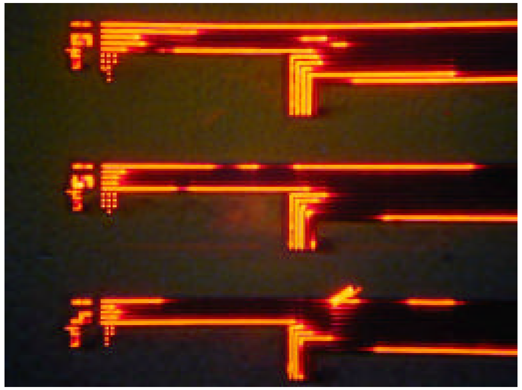
Resist residue

1. **Adequate thickness of electroplating.**
2. **Swelling adequate amount of resists**

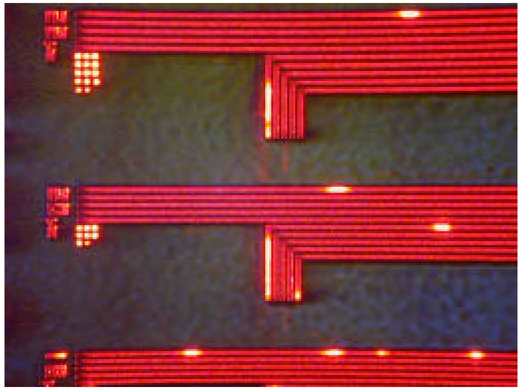
Easy Stripping

Improvements of Stripping Properties

Resist residue(shining red parts) after stripping

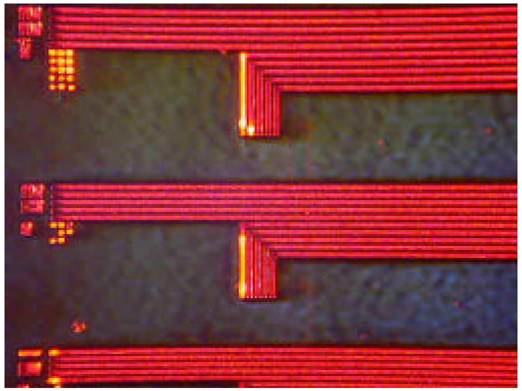


Conventional monomer



less

New monomer



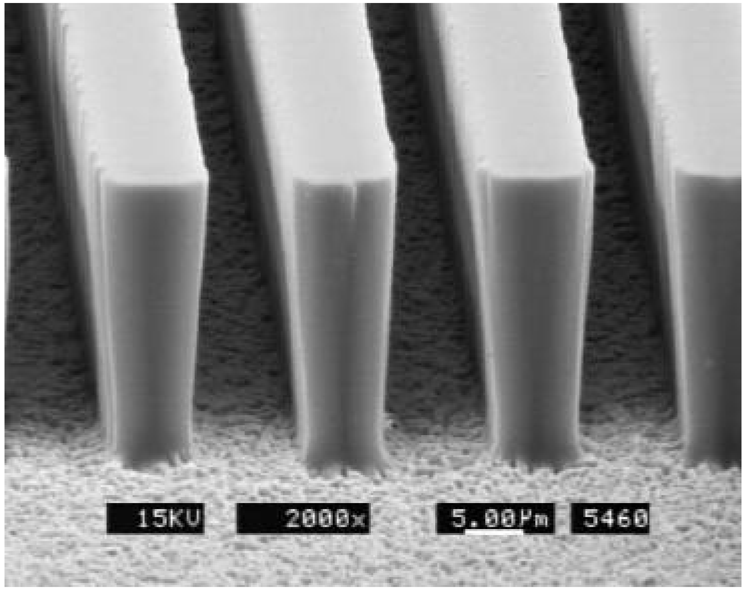
none

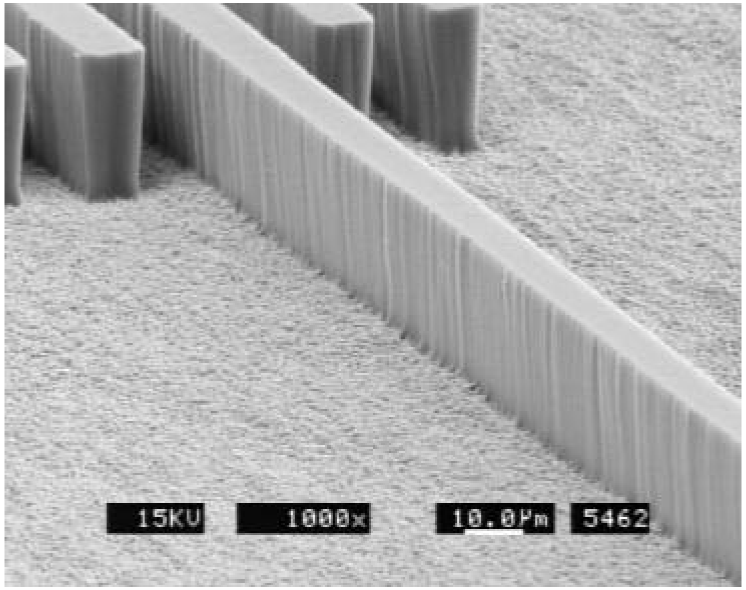
New monomer (changing Mw)

The Latest Accomplishment of

Super High Resolution Type DFR for Semi-additive process

L/S=8/8um resolution and adhesion





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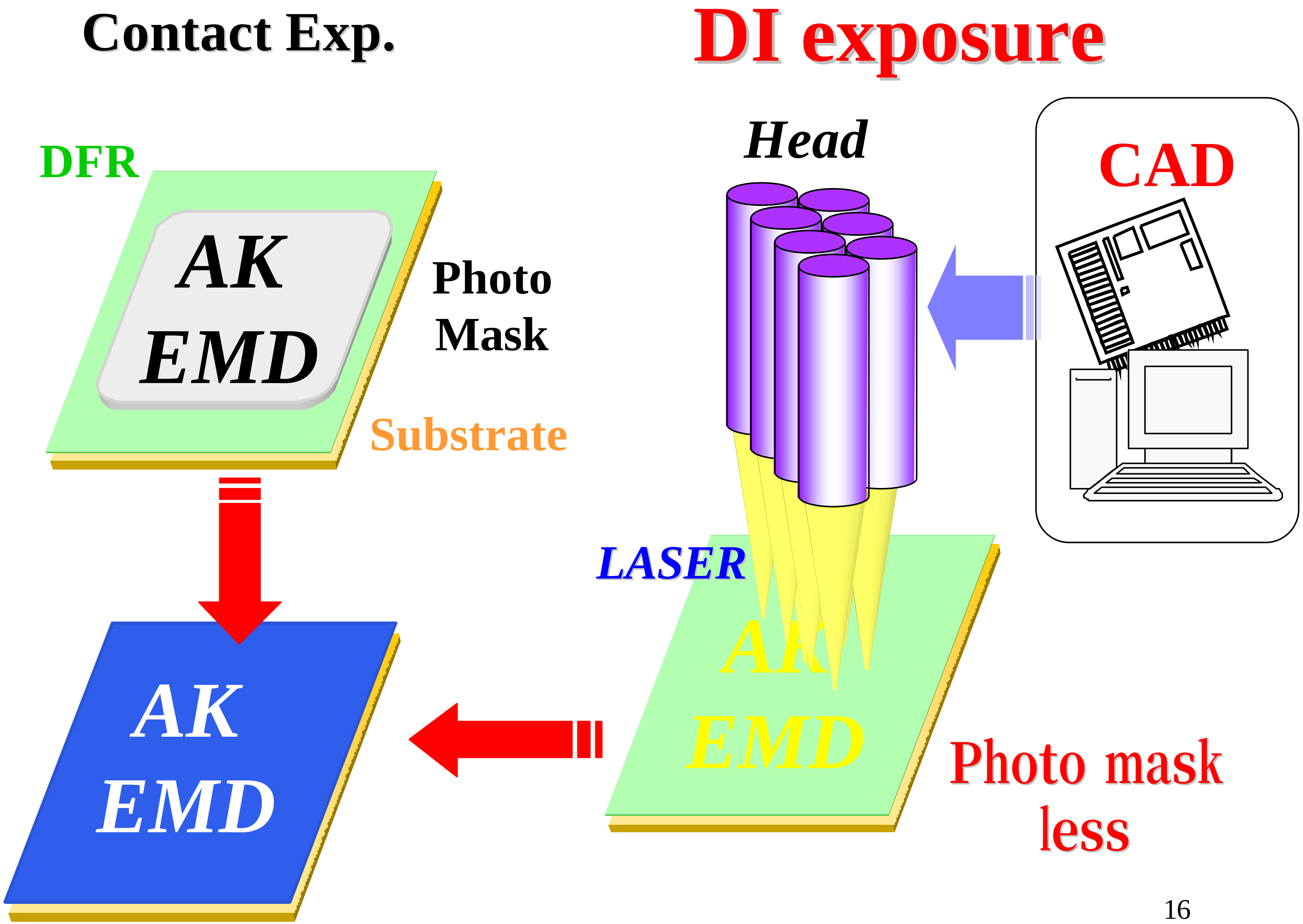
New Exposure Method



Several merits of introducing DI

(1) Accurate dynamic scaling and alignment

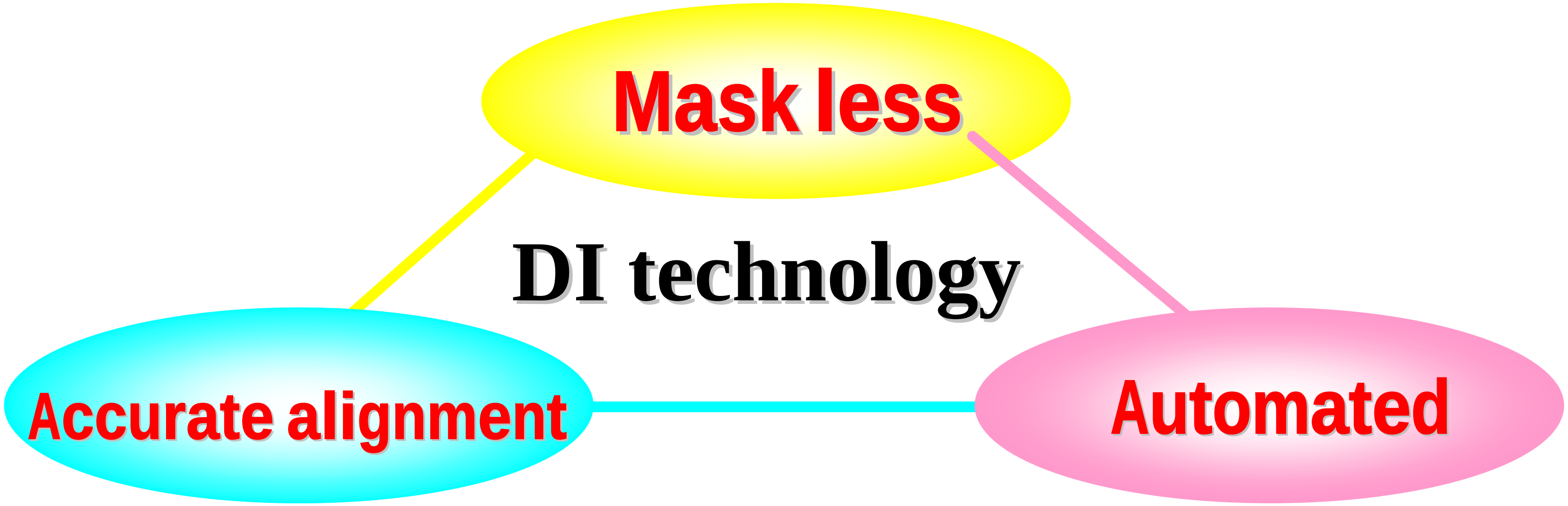
(2) Lower cost and lower defects by not using photo masks

(3) Labor-saving by automated exposure

Extent of DI technology

Large Size Substrate

- **FPD**

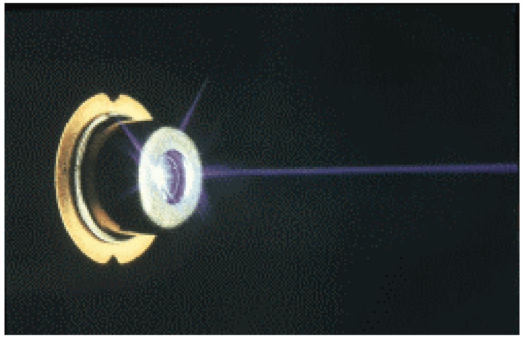
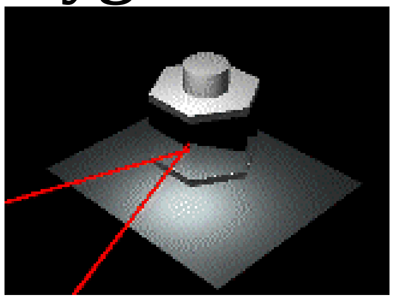
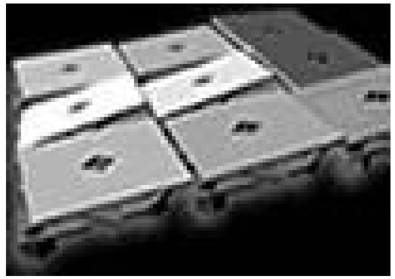


Ultra Fine

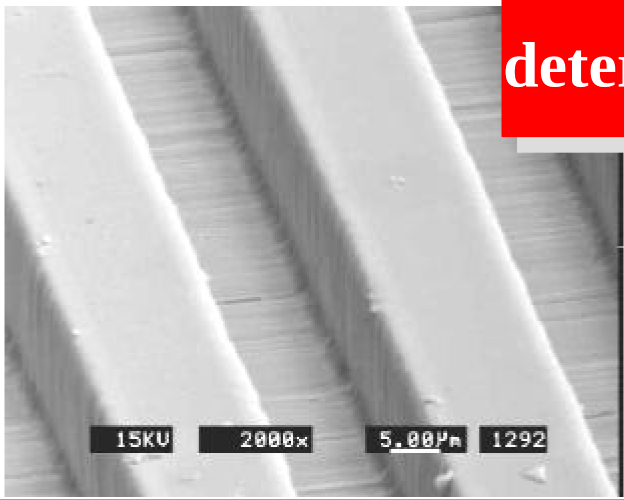
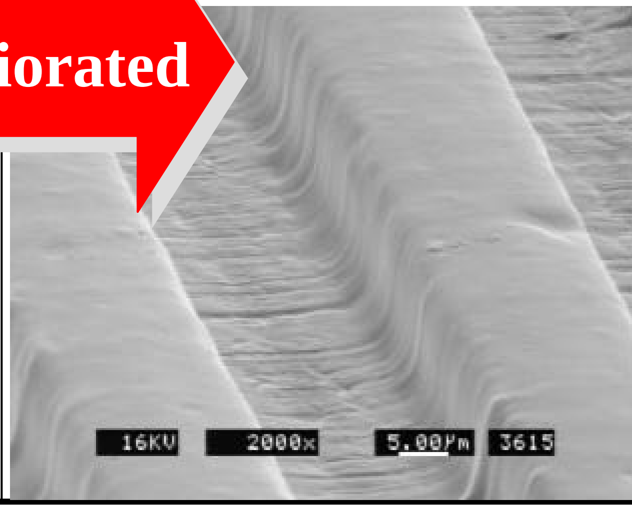
- **MPU Package**
- **Flip Chip Package**

Less amount but
A lot of varieties
PWB

DI Exposure System

	i line (355*n*m)	*h line (405nm)*
Source of Laser light	 ＊COHERENT	 ＊NICHIA
Method of Exposure	Polygon Mirror  ＊IMAGICA	DMD  ＊TEXAS INSTRUMENTS
Manufacturer	Orbotech etc	Hitachi Via, *PIIC (PENTAX)*, Ball, Fuji Film etc

Imaging property of Conventional DFR

Method of Exposure (light source)	Contact (*g,h,i* line)	DI (*h* line)
Sensitivity	40 mJ/cm^2	100 mJ/cm^2
Resolution	20 mm	40 mm
Adhesion	25 mm	50 mm
Resist Shape		

lower

deteriorated

Exclusive DFR for DI is essential !

Two major problems for DI process

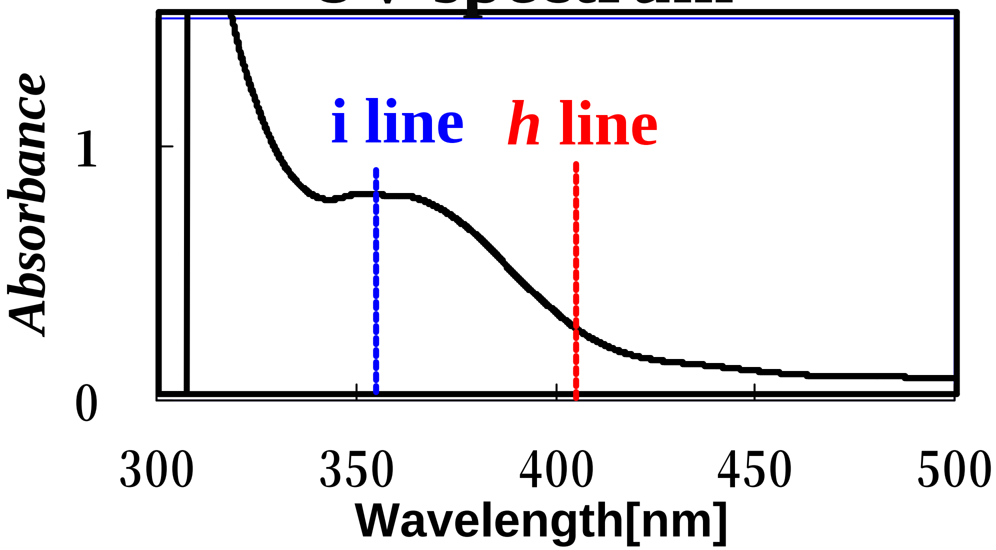
1st problem ： High Sensitivity at h-line

2nd problem ：Hardening resist enough under higher irradiance within a short period

1st problem ： High Sensitivity at h-line

Decreasing sensitivity at h-line

UV spectrum



Spectral sensitivity

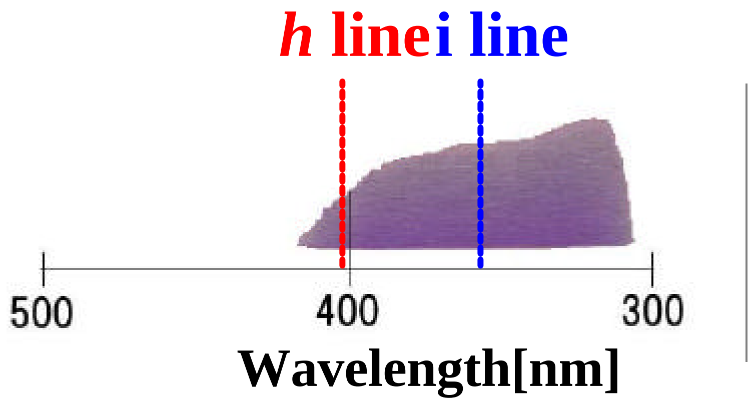


Photo sensitivity at h-line 1/2 ～1/5

at i-line 1

1st problem ： High Sensitivity at h-line

"Sensitivity" greatly contributes "Productivity"

High Sensitivity → Short exposure time → Highly productive

	DI exposure	Contact exposure
Exposure time	Short	Long
Required Sensitivity	10 ~ 50 mJ/cm^2	50 ~ 150 mJ/cm^2

Higher sensitivity at h-line than conventional sensitivity at i-line is required.

1st problem ： High Sensitivity at h-line

⇒ Selection of Initiator

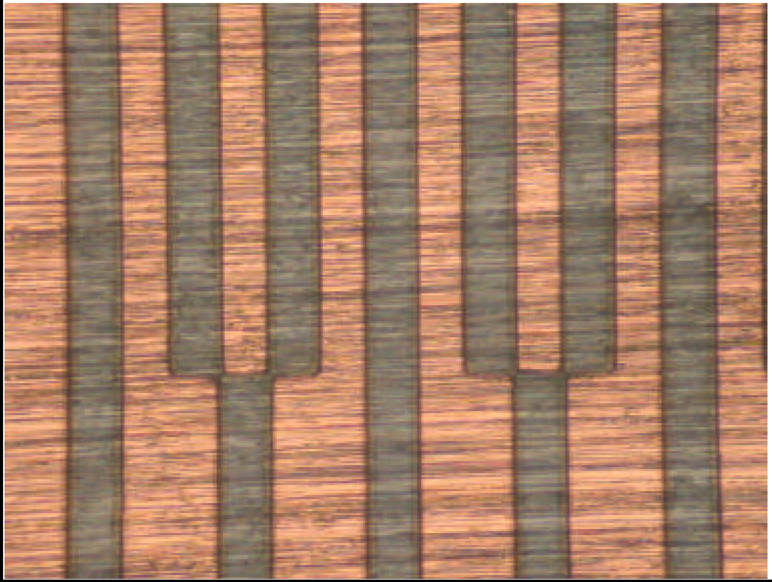
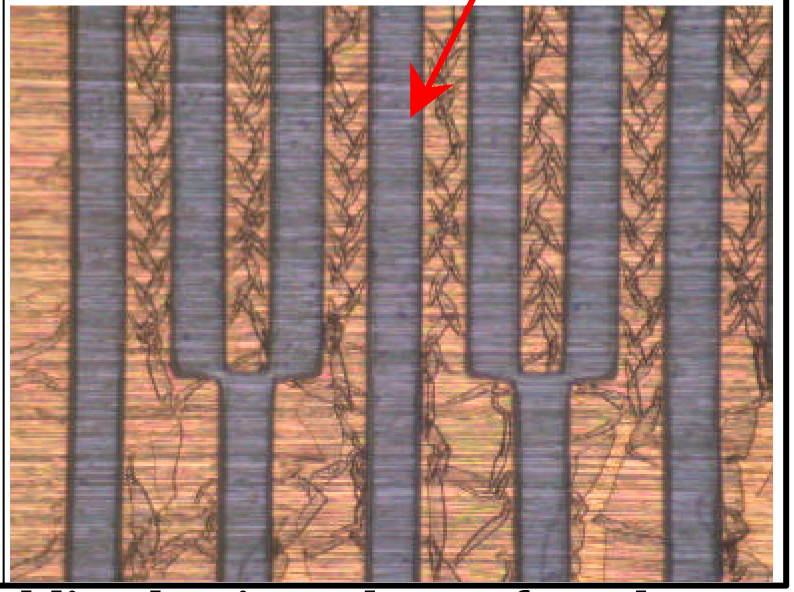
is important.

1st problem ： High Sensitivity at h-line

Selection of Initiator (1)

Increasing the amount of the "I-line" initiator

Residue after development

Good	Poor
	

Resist patterns developed after holding laminated state for 3days

Too much amount of initiator causes instability of DFR.

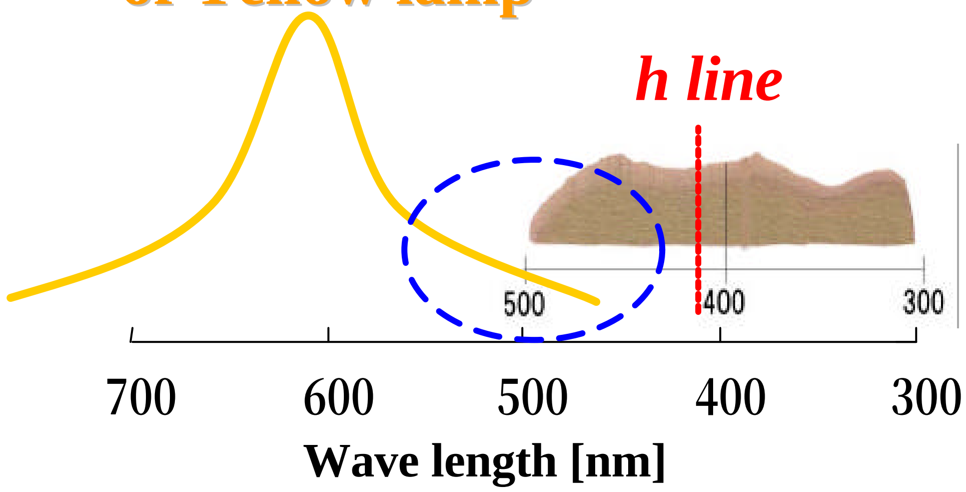
Changing other kind of initiators is necessary.

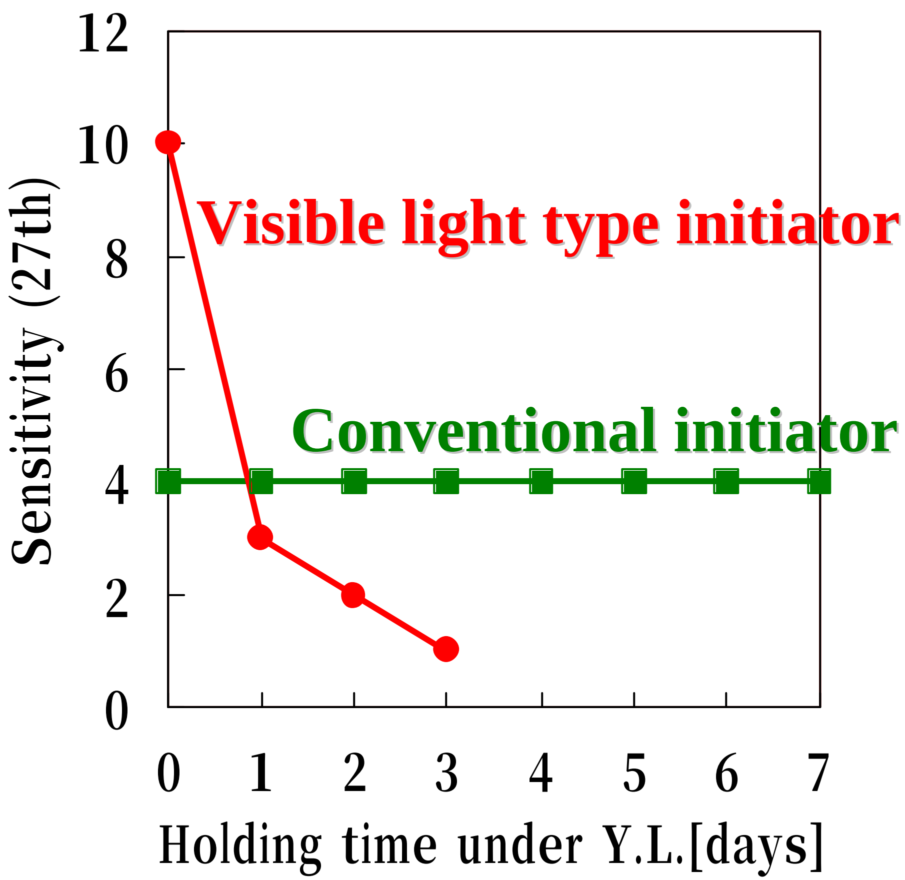
1st problem ： High Sensitivity at h-line

Selection of Initiator (2)

Introducing initiators having sensitivity at visible light

Luminous spectrum of Yellow lamp



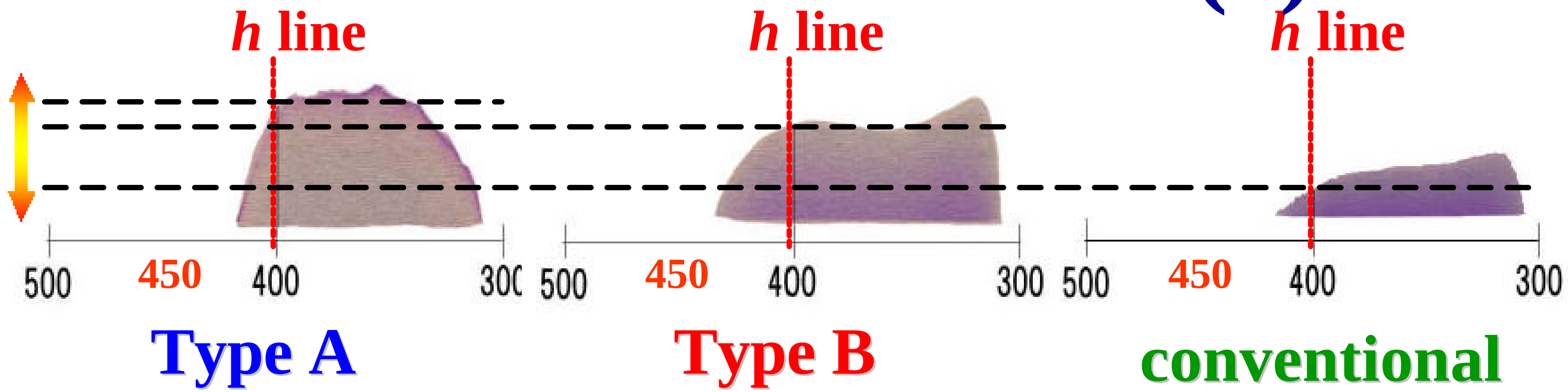


Sensitivity decreases after only one days' holding.

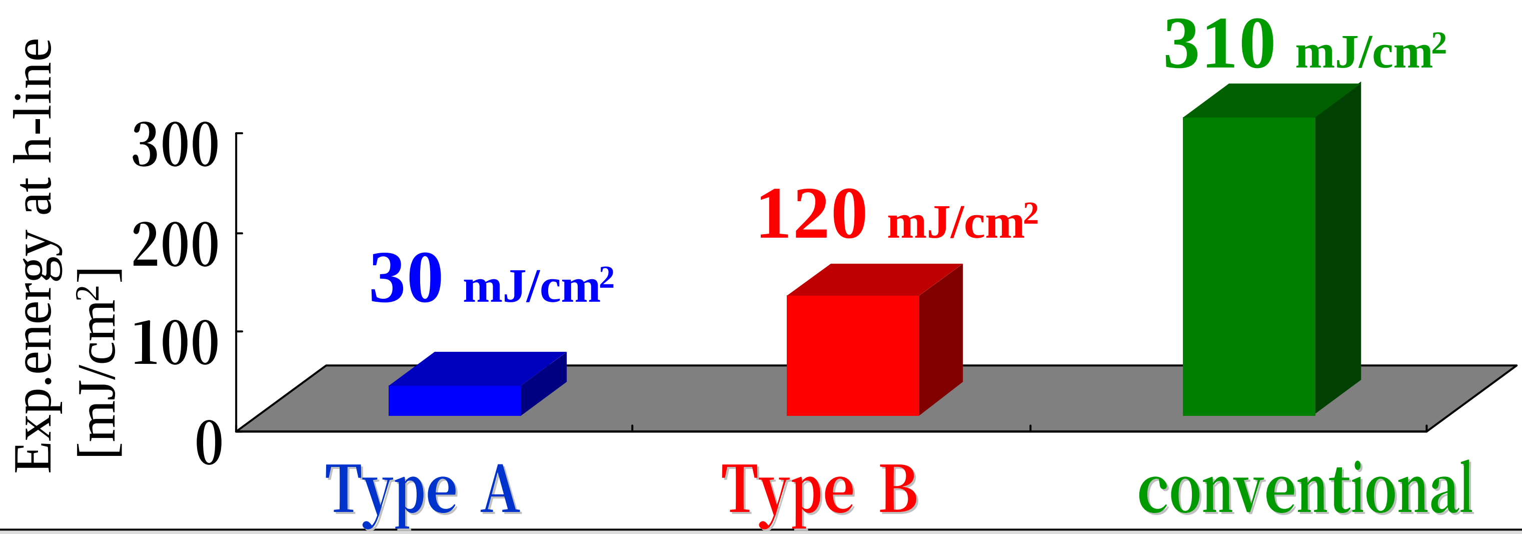
Initiator having high sensitivity at h-line but not reacting with light more than 450nm is necessary.

1st problem ： High Sensitivity at h-line

Selection of Initiator (3)



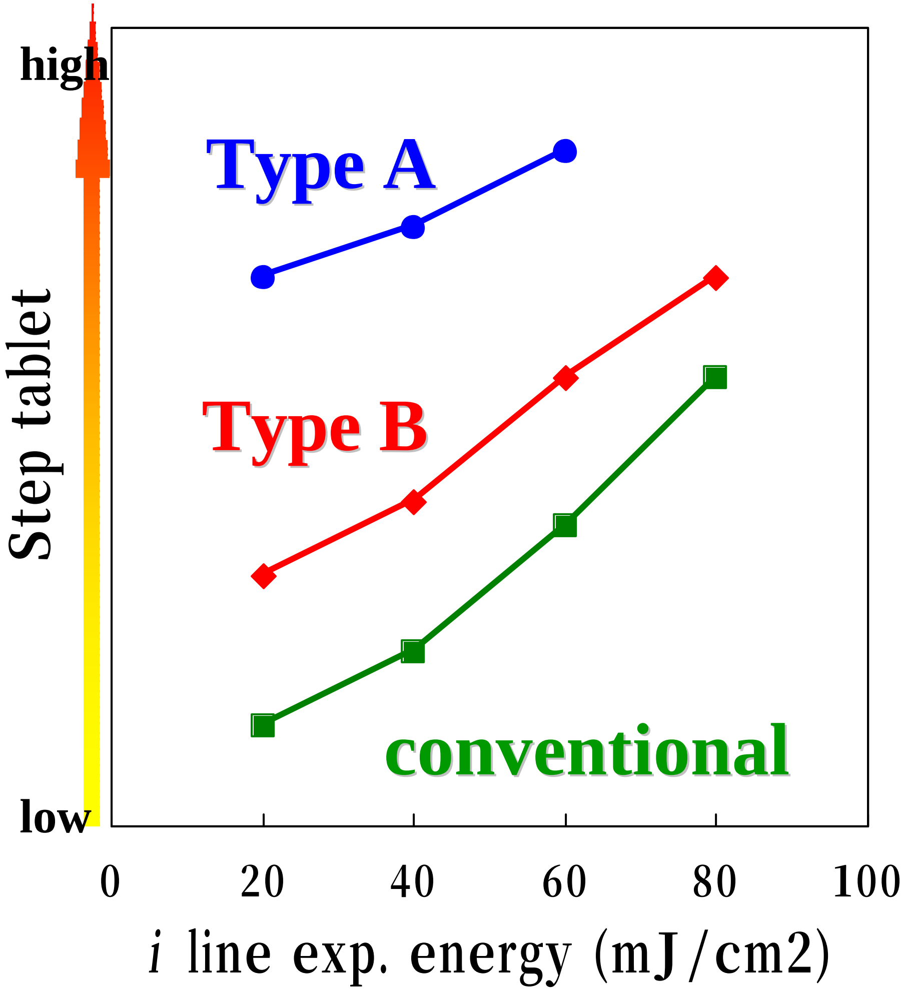
Exposure energy at h-line for hardening 10th step tablet

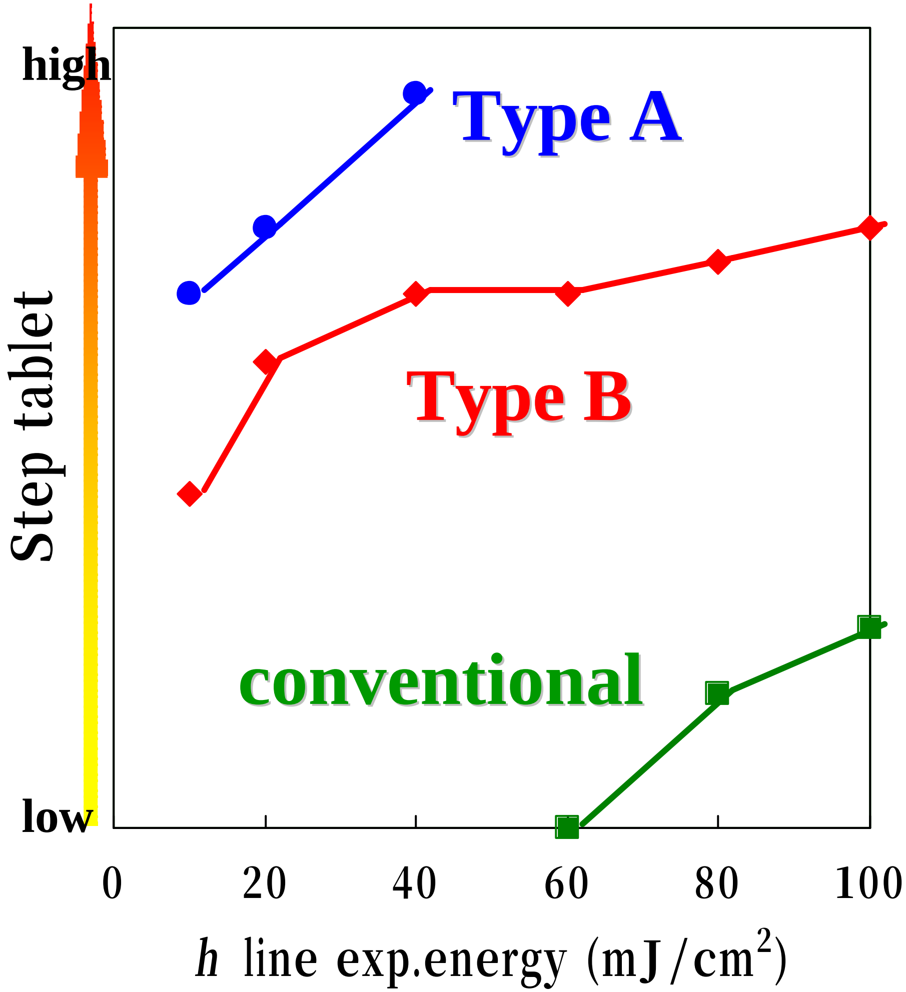


Sensitivity at h-line is greatly improved.

1st problem ： High Sensitivity at h-line

Sensitivity of Type A&B



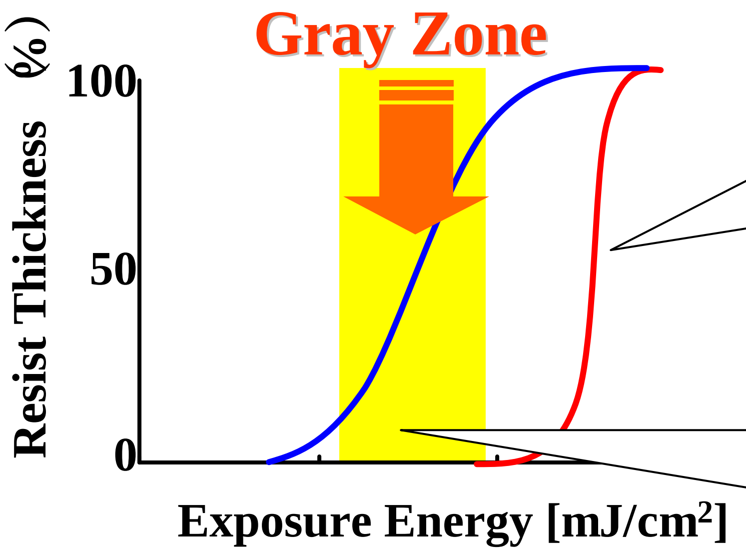


Type A&B have high sensitivity either at h-line or at i-line.

Gray zone tends to spread (1)

***Exposure time around one spot light is SEVERAL NANO SEC.**
(contact exp. → several sec.)

***Irradiance of DI is required 10～20 times as much as that of Contact.**



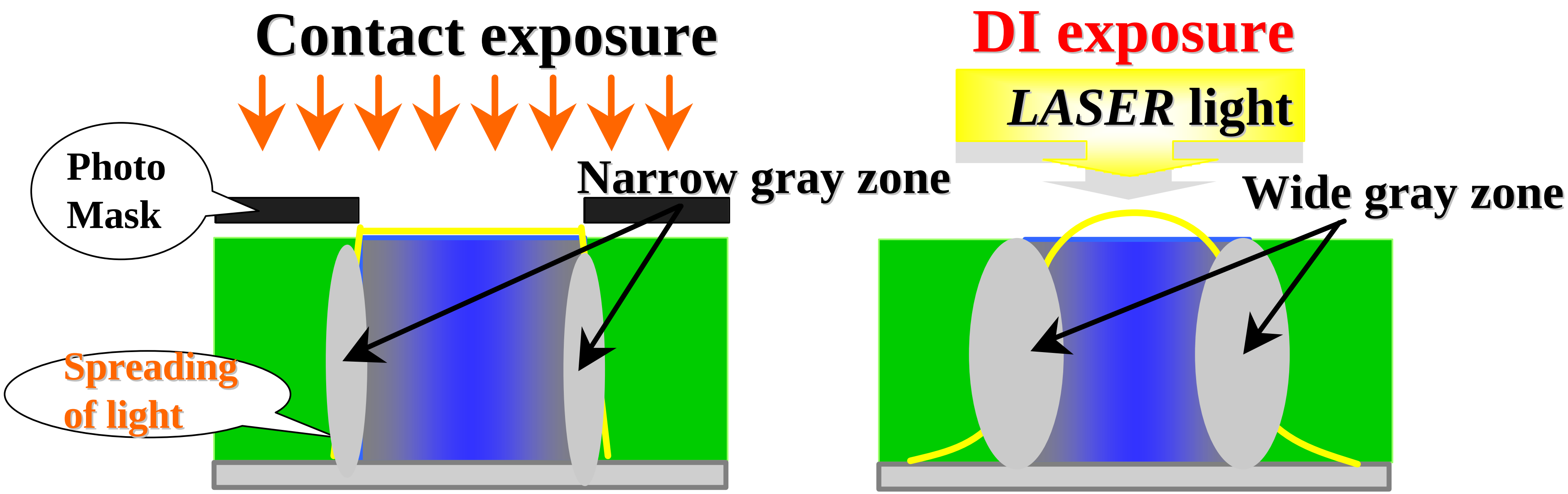
Contact Exp.
Low irradiance with a long period

DI Exp.
High irradiance within a Short period

Gray zone makes all of imaging properties like resolution and resist shape deteriorated.

2nd problem : Hardening resist enough

Gray zone tends to spread (2)



Laser beams have a wider distribution of irradiance.

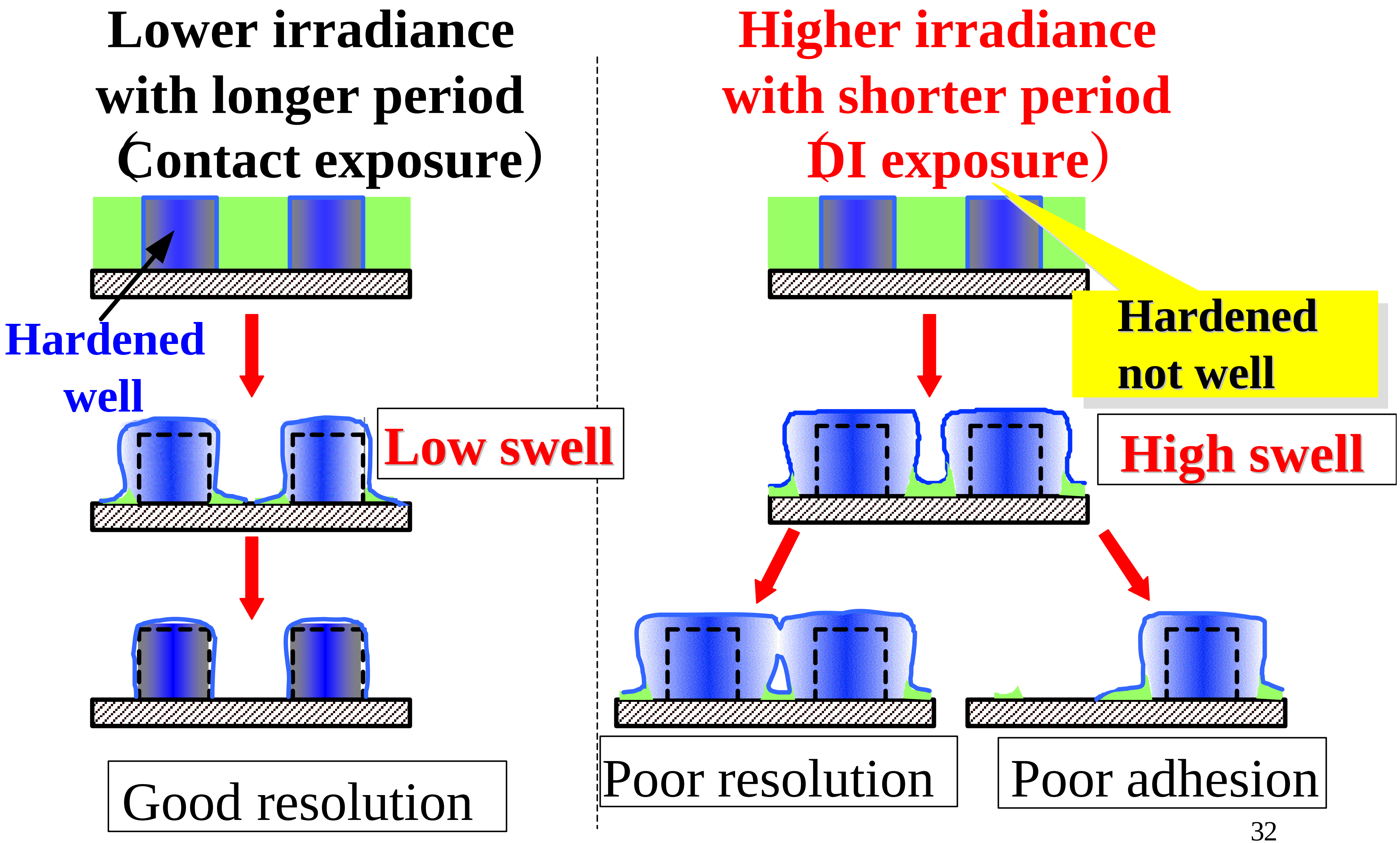
2nd problem：

Hardening resist enough
under higher irradiance within a short period

⟹ **Selection of monomers**
is important.

2nd problem : Hardening resist enough

Mechanism of decreasing imaging property



2nd problem : Hardening resist enough

Design for DI DFR

Improvement of imaging properties under high irradiance within a short period

↓

It is essential to reduce swelling.

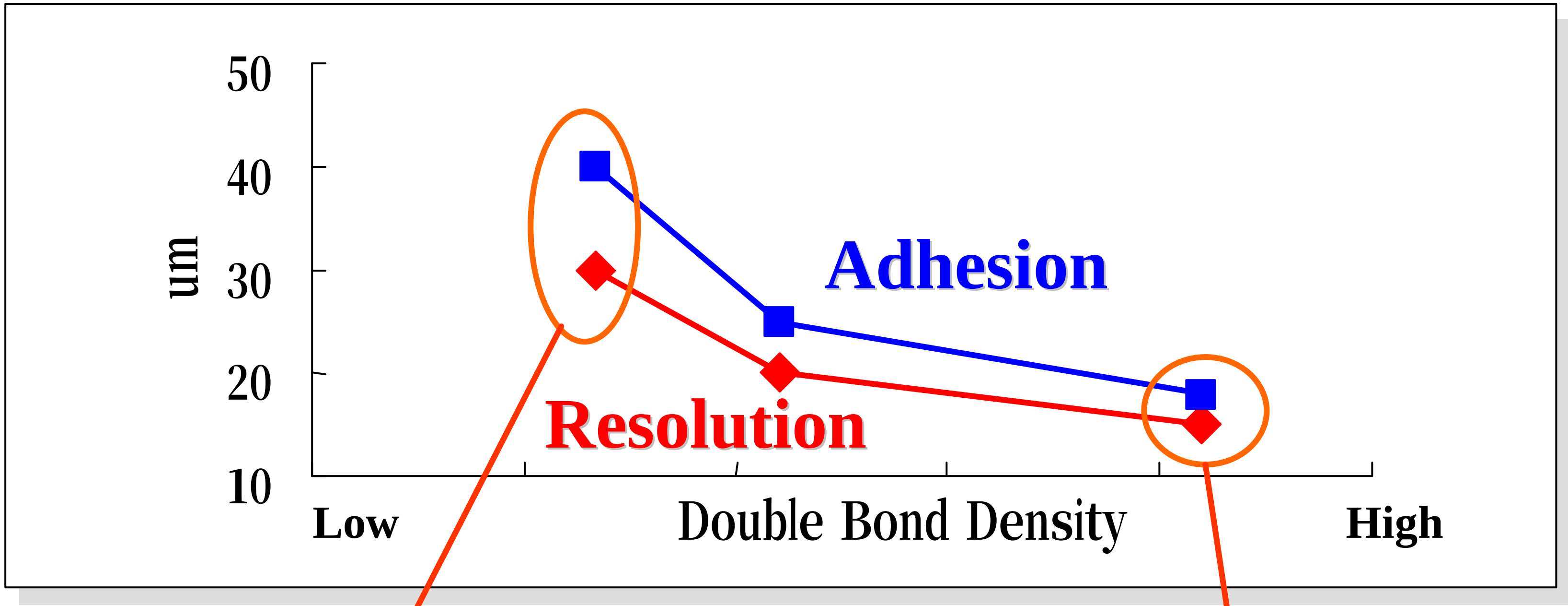
↓

Double bond density should be increased.

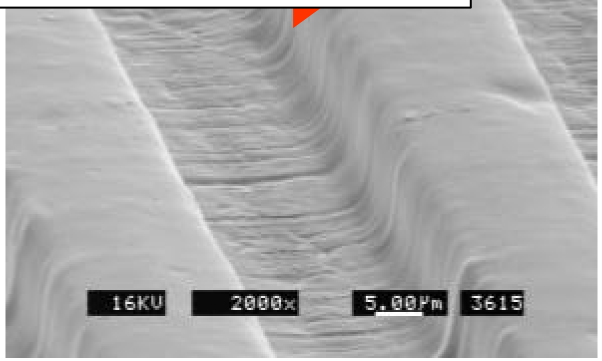
→ to escalate cross-linking density

2nd problem : Hardening resist enough

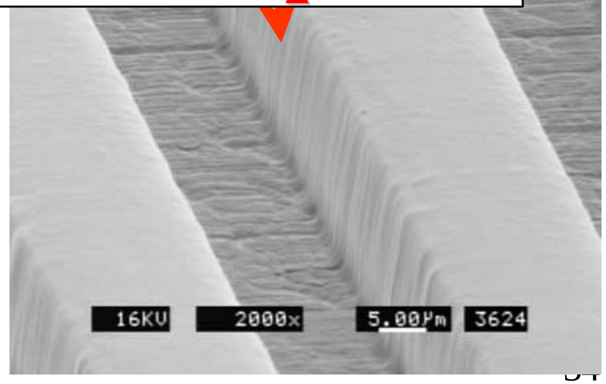
Effect of increasing double bond density



Conventional

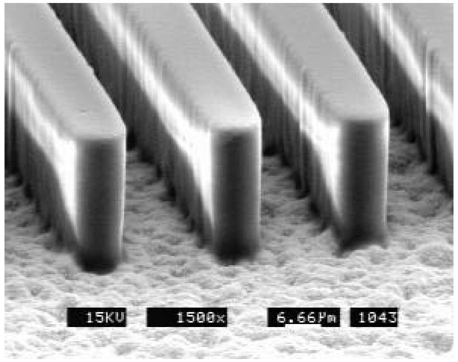


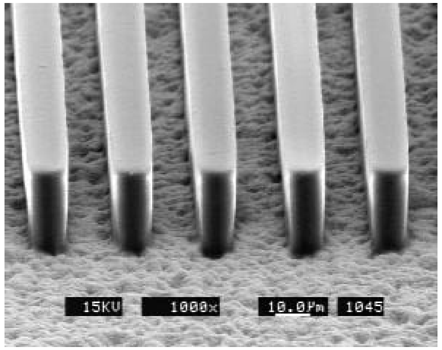
New development



Total properties of latest accomplishments

	Grade A for DI	Grade B for Contact exposure
exposure	**DI at h-line**	Contact at i-line
thickness	**25um**	25um
sensitivity	**30 mJ/cm²**	120 mJ/cm²
resolution	**12um**	8um
adhesion	**10um**	8um
Shape of pattern	**Good**	Good
stripping	**Good**	Good





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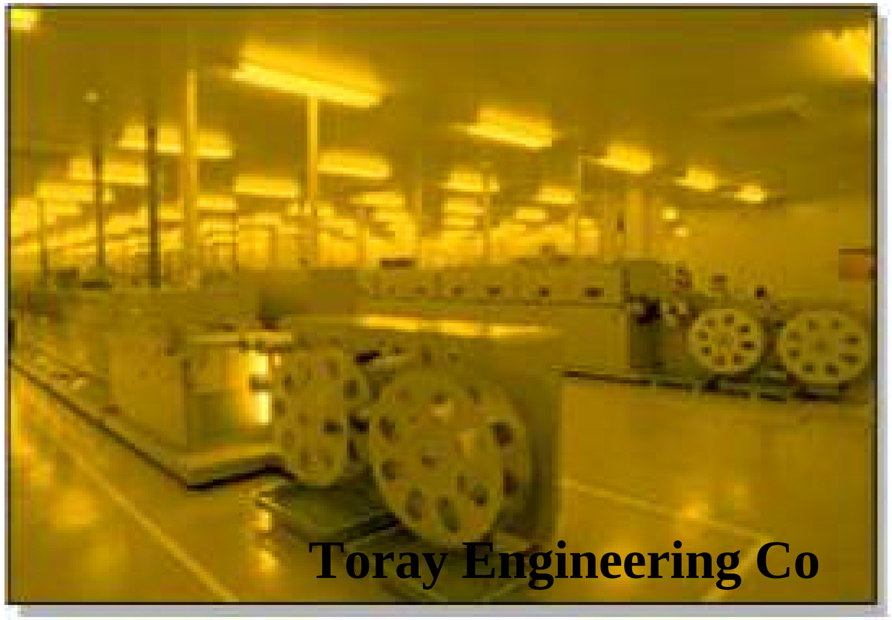
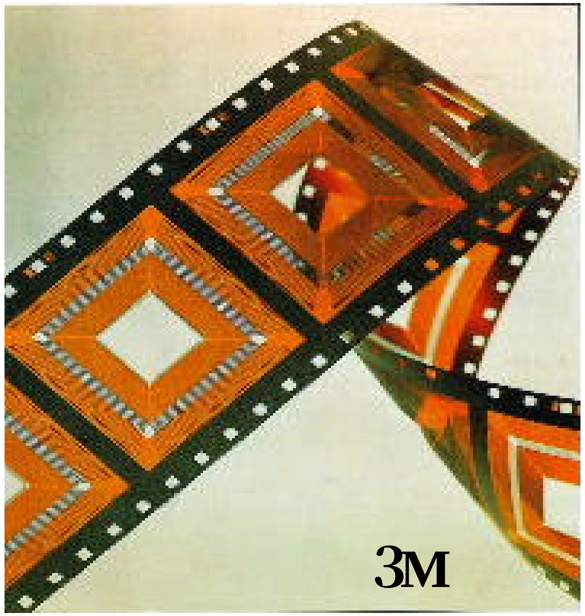
6)Summary & Conclusions

COF/TAB Substrate

High Density Patterning on the Polyimide film.
IC chip direct amounting on the film.

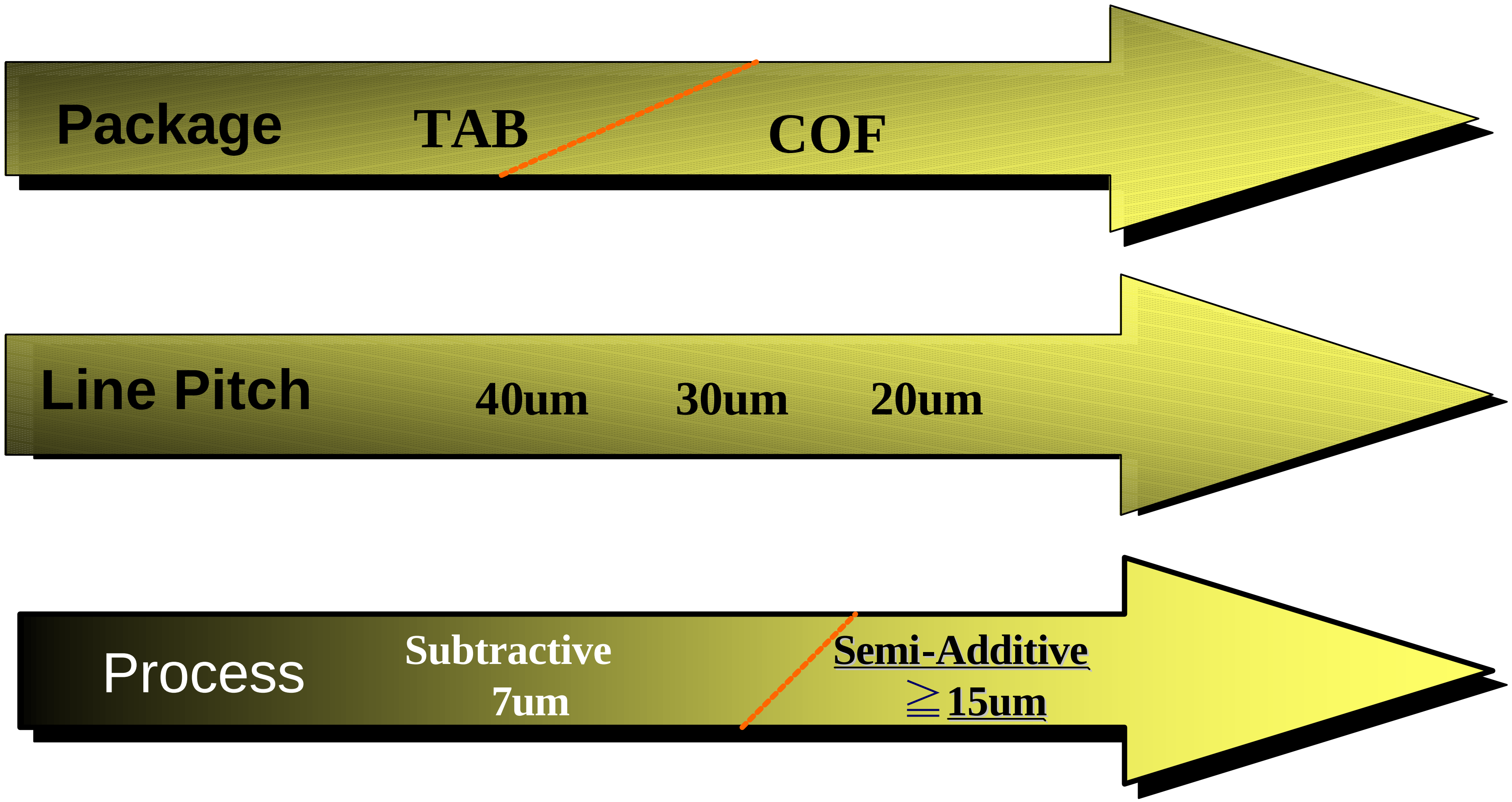




DFR is suited for roll to roll processes.

COF Technology Roadmap

2003 2004 2005 2006



Comparison with Liquid Photo Resists

<Merit>

(1) Laminating both sides of the surface at the same time is available.

(2) Lower producing cost by decreasing of the processes such as spreading photo resists, drying, controlling thickness

(3) Reducing investment cost

(4) Tenting process is available.

(5) Semi-additive process is available (not ultra thin).

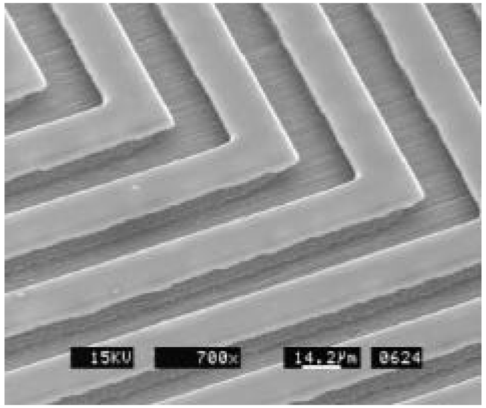
(6) **Very close resolution and adhesion**

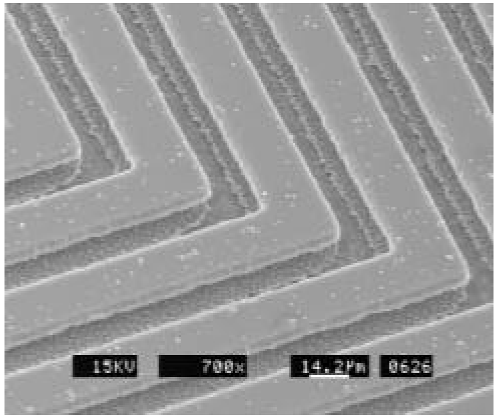
Resolution Property of Ultra Thin DFR

Subtractive method

After etching

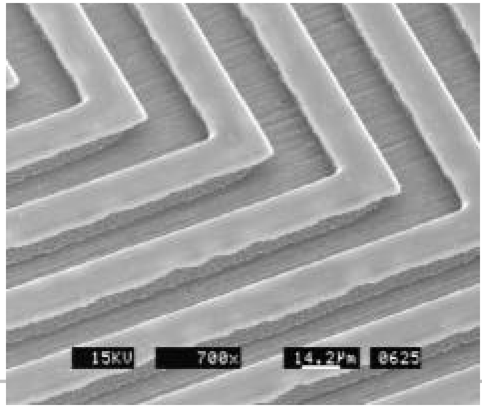
L/S=20/15

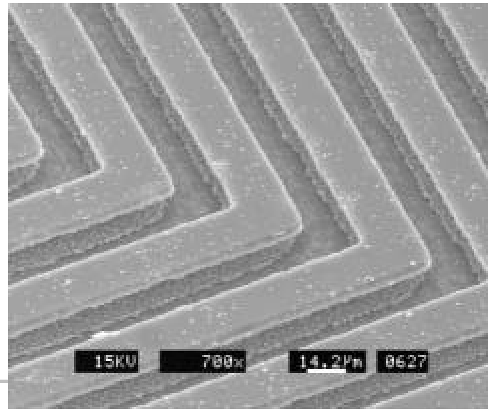




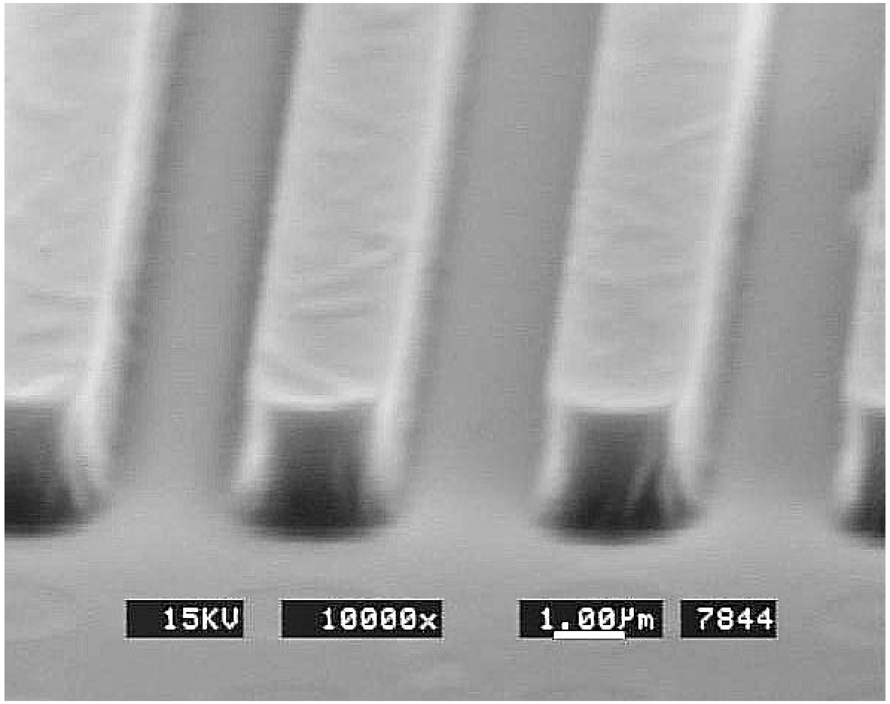
Liquid Resist **Ultra thin (4um) DFR**

L/S=18/17





The Latest Accomplishments



Excellent 2um resolution and 2um adhesion with 2um thickness on the experimental basis.

Comparison with Liquid Photo Resists

<Merit>

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(5) Semi-additive process is available (not ultra thin).

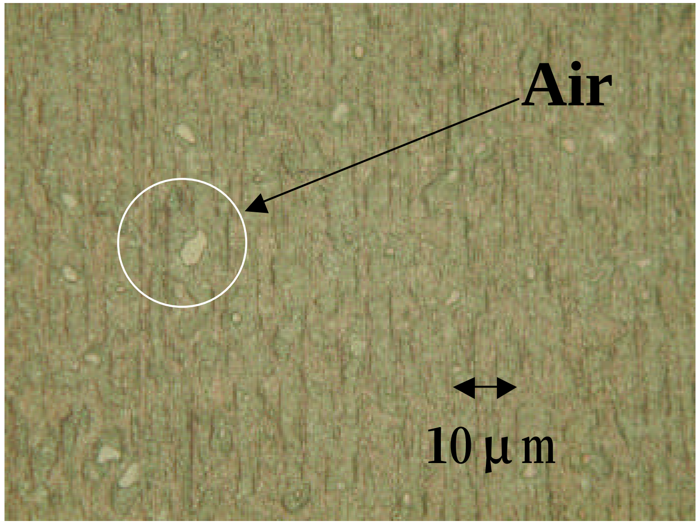
(6) **Very close resolution and adhesion**

<Demerit>

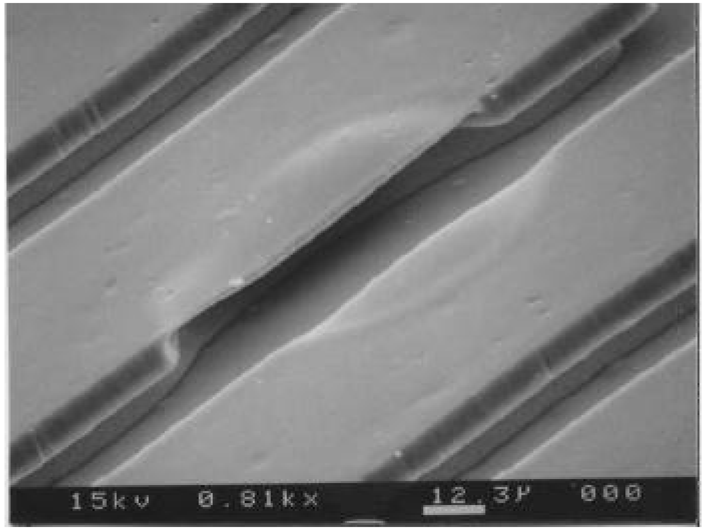
(7) **Lamination airs**

Lamination Airs

Micro Air (Lamination Air)



Open Failure



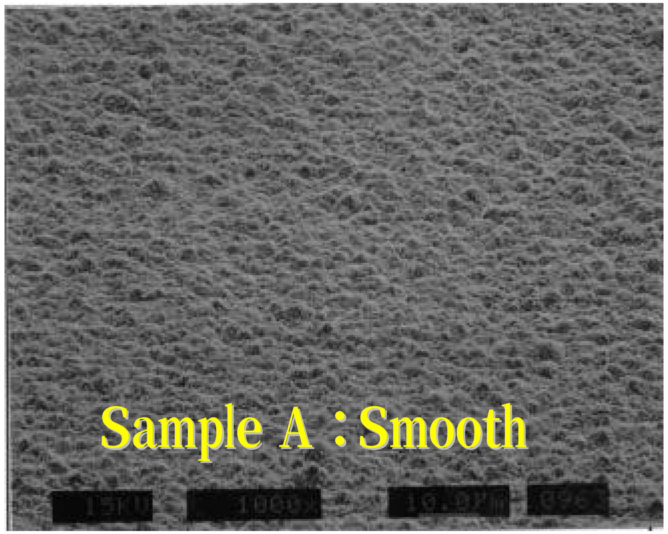
How to Decrease Micro Air

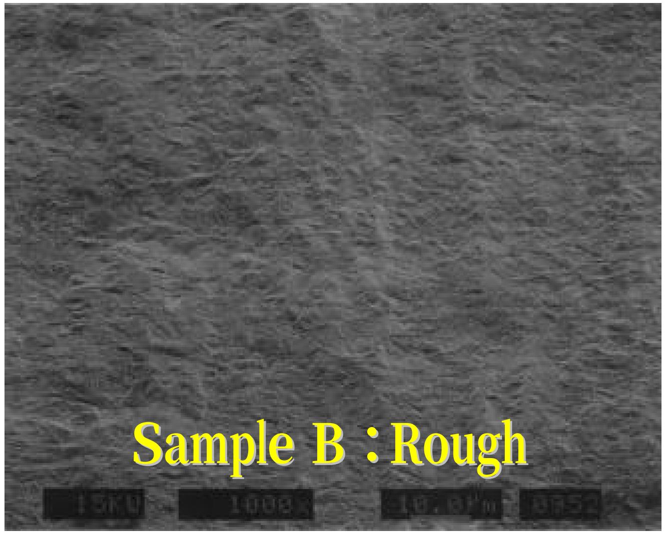
1) Cu Surface Treatment

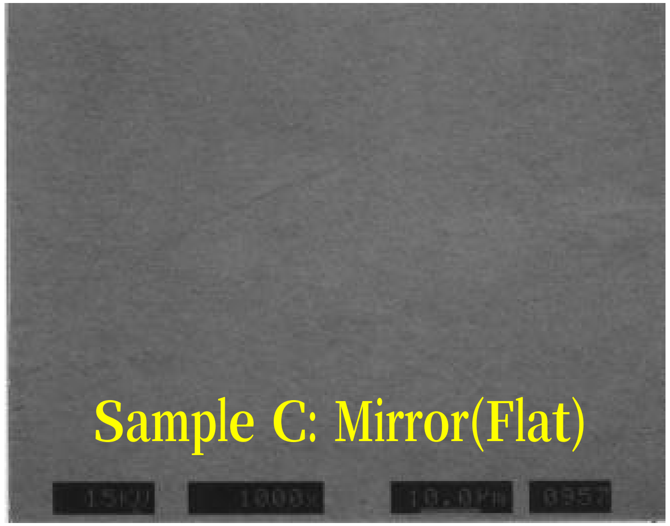
2) Lamination Condition

3) The quality of Lamination roll

SEM of Cu Surfaces

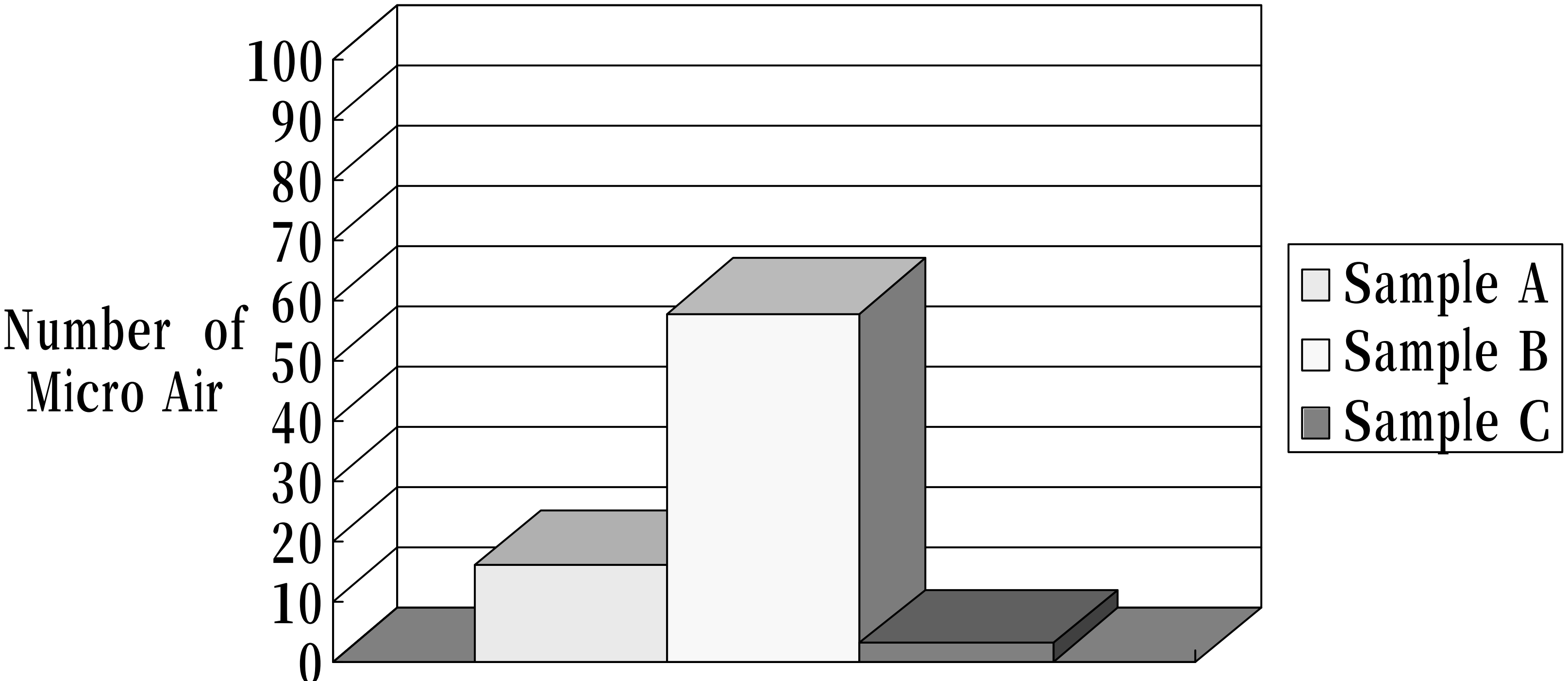






Cu Surface Treatment

Dependency of Cu Surface

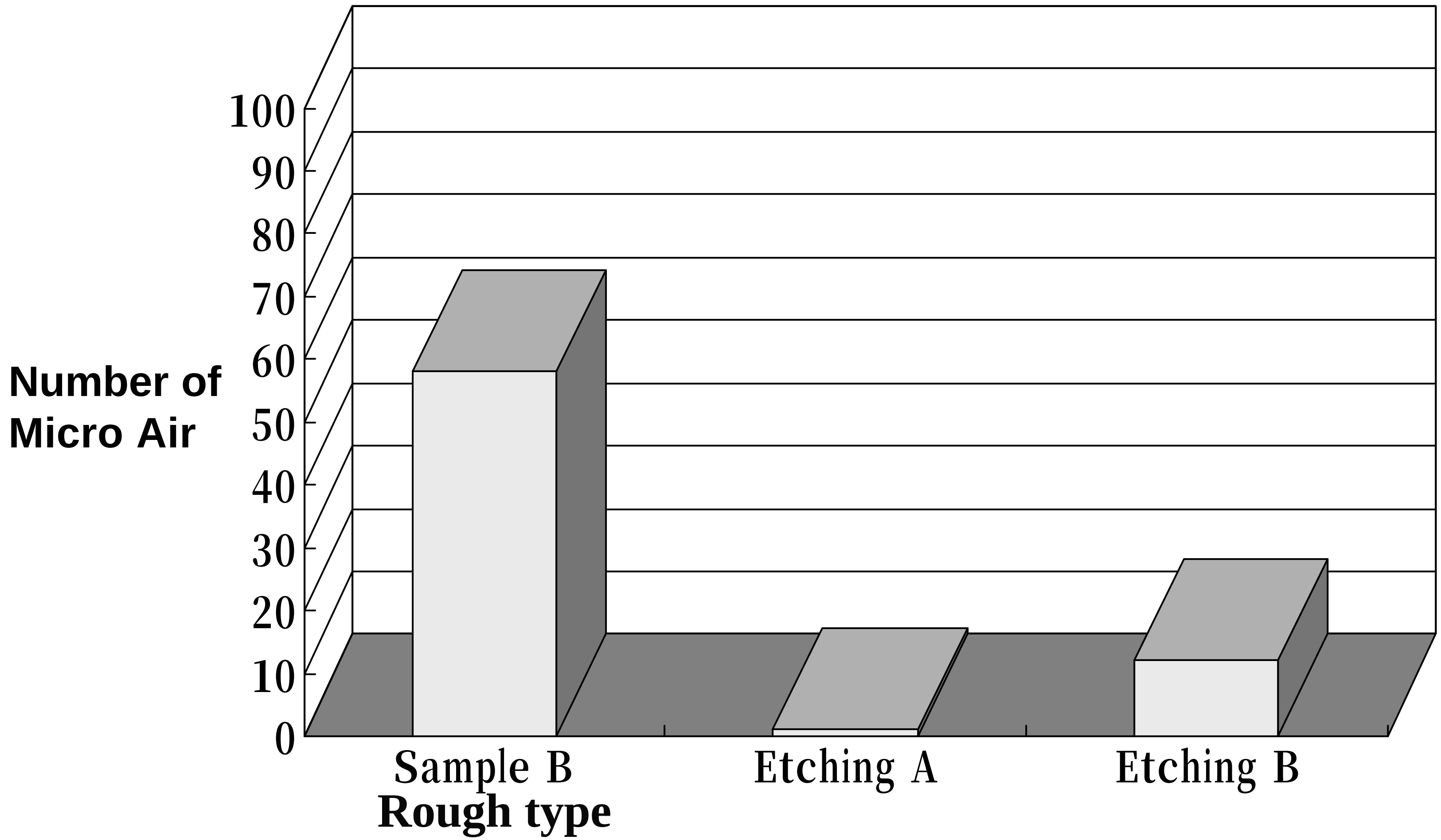


Lamination Speed 2.5m/min
Lamination Temp. 105°C
Lamination Press 0.35Mpa

Most rough type "B" has the highest amount of micro airs.

Cu Surface Treatment

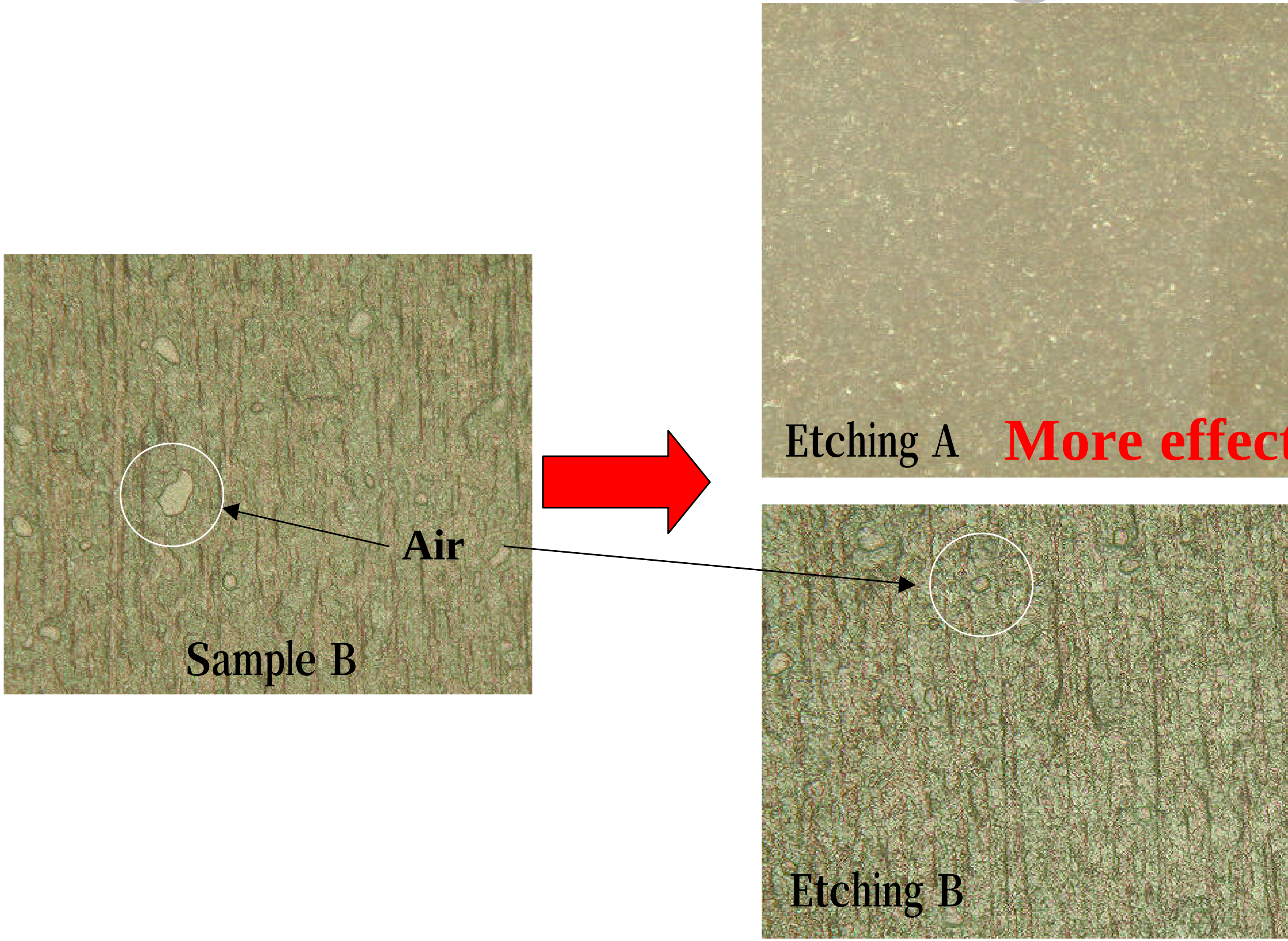
The Effect of Etching



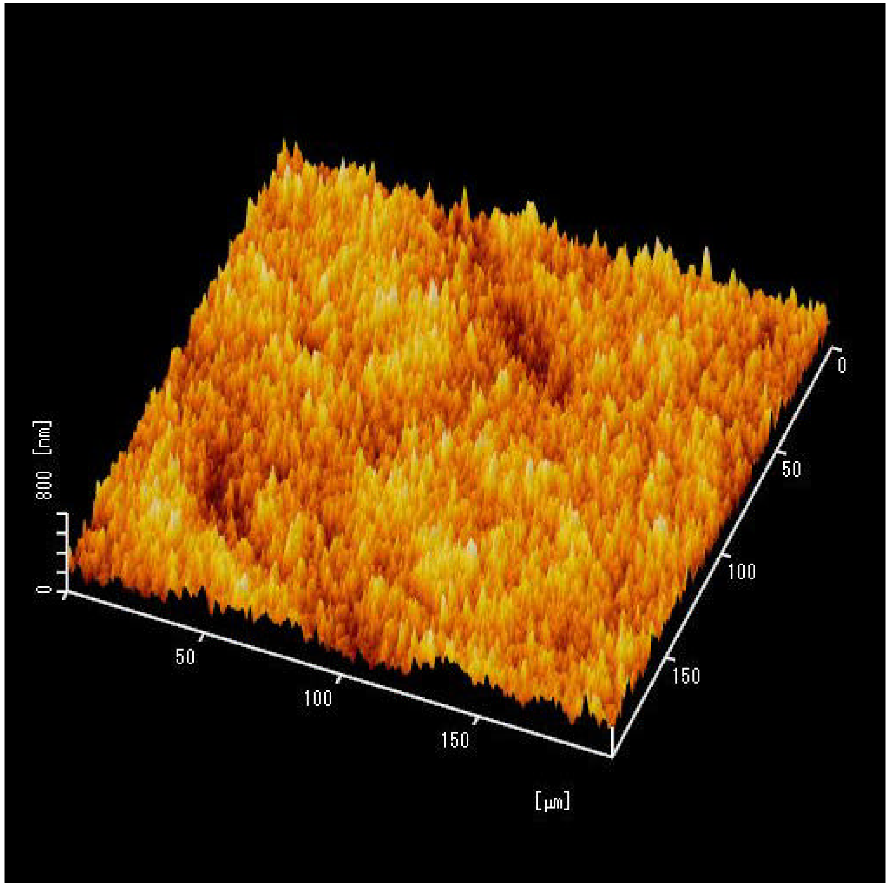
Etching “A” is more effective.

Cu Surface Treatment

The Effect of Etching

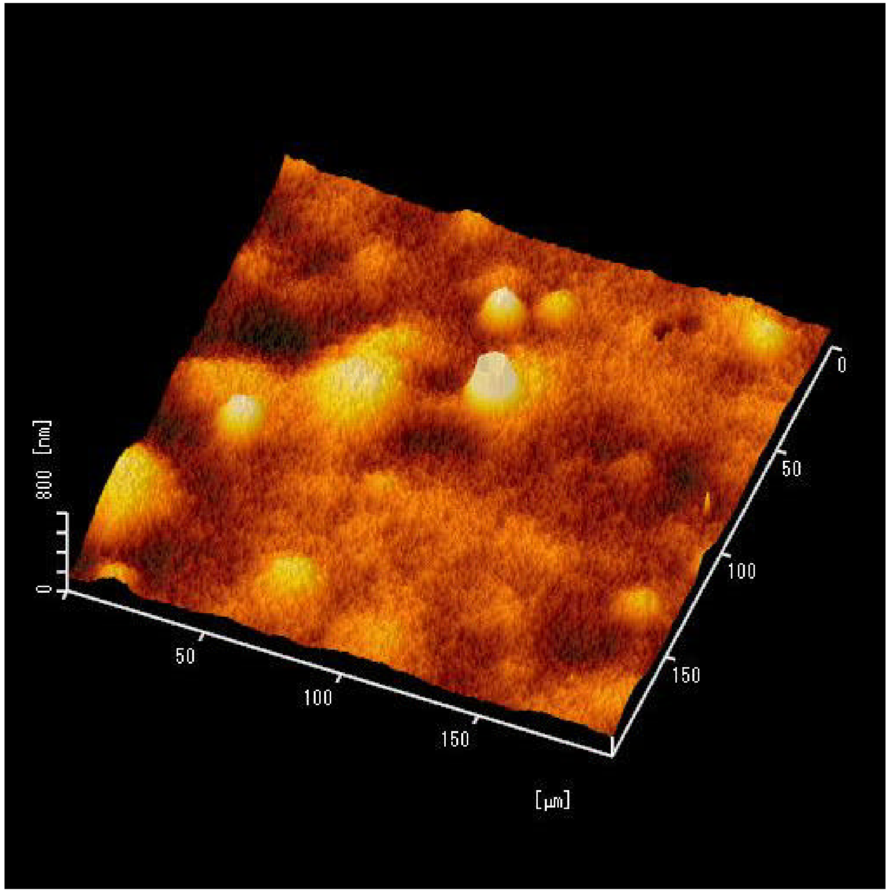


AFM Analysis after Etching



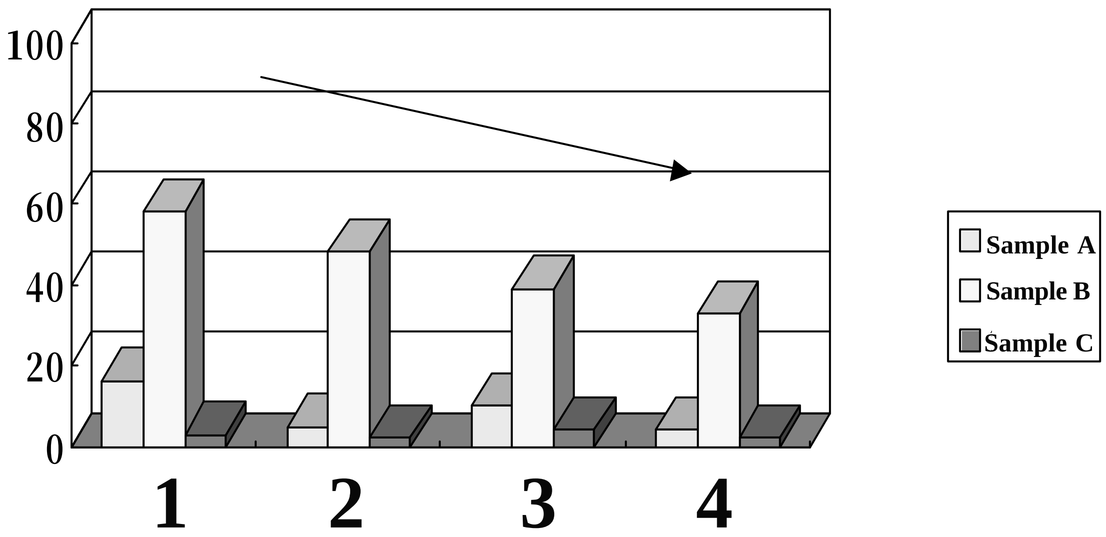
Etching A (etching finer)

More effective



Etching B

Lamination Condition



1 :2m/min
105°C
0.35Mpa

2 :1m/min
105°C
0.35Mpa

3 :2m/min
105°C
0.5Mpa

4 :1m/min
120°C
0.35Mpa

Low Speed, High Temp, High Press is good to decrease.

How to Decrease Micro Air

- **Surface Finer Soft Etching**

- **Lamination Condition**

  Low Speed, High Temp, High Press

- **Quality and Combination of Lamination Roll**

  rubber & metal

Comparison with Liquid Photo Resists

(1) Laminating both sides of the surface at the same time is available.

(2) Lower producing cost by decreasing of the processes such as spreading photo resists, drying, controlling thickness

(3) Reducing investment cost

(4) Tenting process is available.

(5) Semi-additive process is available (not ultra thin).

(6) Very close resolution and adhesio

(7)**Lamination airs** are **“ZERO”**by selecting good methods and conditions.

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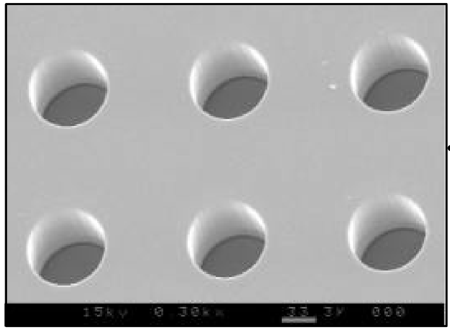
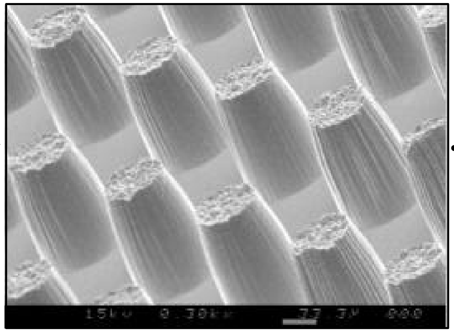
DFR for BUMP formation

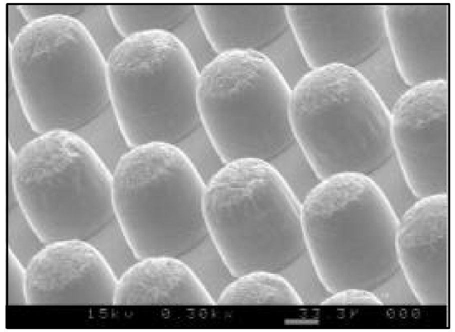
DFR Pattern



DFR Strip



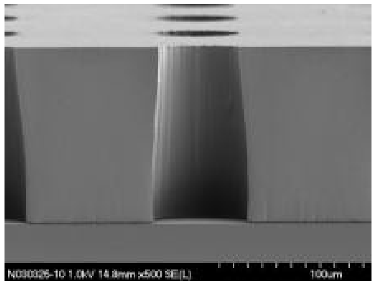
Reflow Reflow



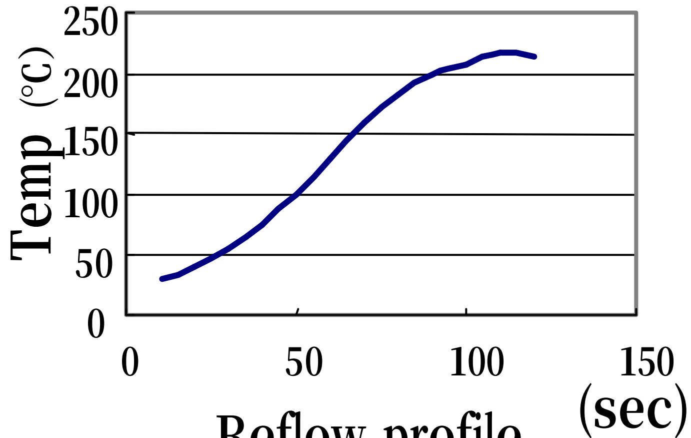
Solder Plating

Φ = 80μm、Pitch= 160um

Thickness= 120um



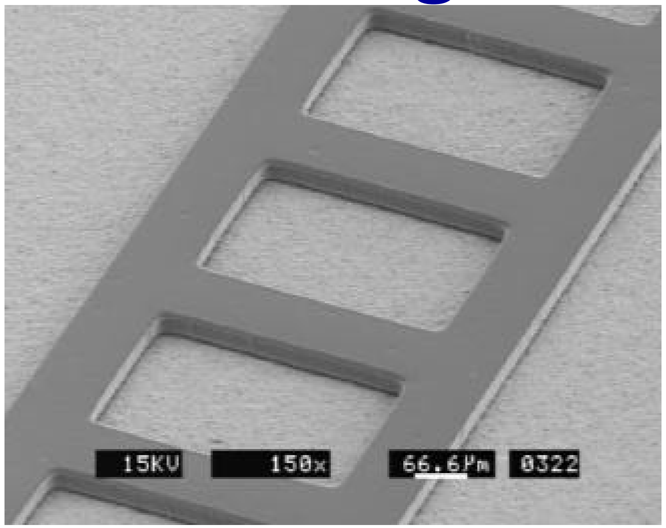
Cross sectional view of
Φ = 60um hole



Reflow profile

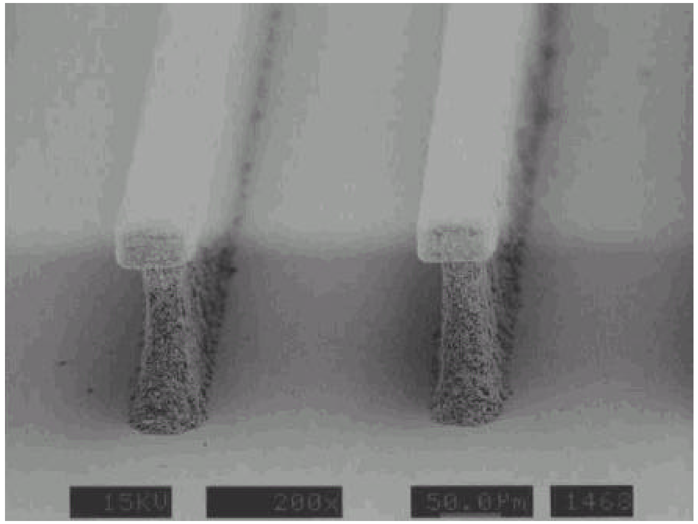
DFR for Sandblasting

Producing finer barrier ribs in PDP



After Development

Lattice pattern



After Sandblasting

Stripe pattern

Dry etching of wafers, ceramics and glasses is also available.

CONTENTS

Summary and Conclusions

- The design of higher gamma value and lower swelling reduces the gray zone, and brings L/S=8/8um resolution and good stripping property for semi-additive process.
- Introducing new initiators having high absorbance at h-line leads to spread the range of application on Direct Imaging process.
- The technology of producing thinner films less than 10um and designing photosensitive layers enables to accomplish one-micron order resolution and adhesion.
- Reducing lamination airs, which is one of the largest problems compared with liquid photo resist, is nearly solved by selecting lower viscosity of photosensitive resin and several lamination conditions.

Dry Film photo Resist will be expected to make a great contribution to the trend of scaling indicated in the International Technology Roadmap in the future.