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Improvement of Aspect Ratio with Long Arc Lamp on the Exposure System

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Abstract

In semiconductor, display, and PCB(Printed Circuit Board) industries, parallel exposure are used for implementing micro-patterns, and the light source is Short Arc Lamp. Because lamps and equipment are so expensive, initial investment and operating costs are high. This paper is a study of optical system that implements fine circuit pattern using Long Arc Lamp with relatively low price, and makes exposure with that optical mirrors to implement and verify micro pattern. The resolution of the pattern is 50 ㎛ * 50 ㎛, which is the resolution of the parallel light exposure for PCB. The optical system of the exposure is designed using the Light Tool, an optical design program. Computer simulation is performed by designing the concept of the optical system to adapt the Long Arc Lamp. The effective survey area shall be 610 ㎜ x 50 ㎜, and the optical properties shall be designed with a target of 5.32˚, Uniformity of 90%, Intensity of 10 ㎽/㎝ 2. The type of photo resist used shall be in the Film and Liquid. The photo list used uses a film-type DFR. with a thickness of 10 ㎛ The resolution of the fine pattern shall be 50 ㎛ * 50 ㎛ by Line & Space. This resolution is the ability to implement micro-patterns of parallel light-emitting exposure using Short Arc Lamps. In addition, conduct a test of the Liquid Photoresist. Experiment with Line & Space 2 ㎛ * 2 ㎛ for resolution. Analyze experimental results to improve performance.

Keywords: *Exposure, Photolithography, micro patterning, Aspect ratio, Long Arc Lamp,*

1. Introduction

The most important issue in the semiconductor industry is to increase memory aggregation. The difference in aggregation between 10 ㎚ in width and 5 ㎚ in width is four times. A large difference in the storage of information in the same area means a difference in competitiveness. The implementation of micro-patterning is also the basis for difference in communication speed and processing capacity even in ICT(Information Communication Technology) technology, which is the foundation of fifth-Generation industries. It is a technology that is keys to ICT technology development of ICT technologies. The size of the Display product is 5G, 8G, 10G and 12G, and the Size Scale represents productivity. It is also a source of differentiation and competitiveness. Methods for implementing fine circuits have been studied and realized in various ways. Parallel light exposure machines with Short Arc Lamps cost more than four times the price of lamps compared to scattered light exposure machines, and equipment prices are tens and hundreds of times more expensive. The frequency of lamp replacement is twice as short. The problem with the Long Arc Lamp is its aspect ratio and collimation angles are low. Long arc Lamps can be up to 4,000 ㎜ long. In general, when Long Arc Lamps are used, the luminous intensity and uniformity of the lamp direction and the flow direction of the product are low. Therefore, the aspect ratio is high and cannot be used for micro patterns. If the light distribution is low, it is difficult to guess the process conditions in the micro-patterning process and cannot be used. Using the Long Arc Lamp, obtain Uniformity by improving aspect ratio, and control the collimation angle to conduct research that can be used as a parallel light exposure.

The importance of aspect ratio in Nano patterns is illustrated in Figure 1. When manufactured in patterns less than 10nm, the aspect ratio is very low and there is a limit to the application of a mask to form a pattern of a semiconductor Nano-pattern. [1]

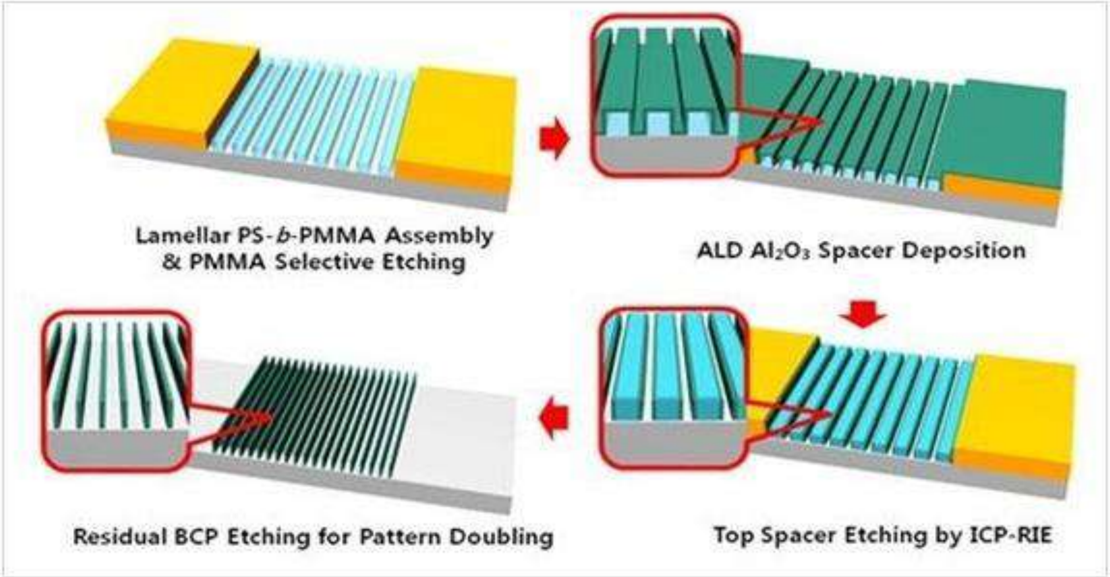


Figure 1. 5 ㎚ Super fine pattern schematic diagram; Original Link http://news1.kr/articles/?1655120

In this paper, through optical simulation, 1 million Ray traces are generated, and efficiency is analyzed by tracking the light rays. Mirror is designed and corrected according to the simulation analysis results. Select the best Condenser Projection Mirror method for computer simulation analysis and evaluation. Improving the aspect ratio of the Long Arc Lamp improves Uniformity to conduct exposure experiments on products with an area of 600 ㎜ (W) * 500 ㎜ (L). Design an optical with an effective area of 600 ㎜ (W) * 50 ㎜ (L). , We want to verify the performance by producing an exposure machine.

In the study of this paper, an exposure device that can be scoured with Long Arc Lamp would be produced, and, if a micro-pattern was implemented, could be used to improve the productivity, efficiency and economics of the light source using the Short Arc Lamp. Applicable industries will be large area exposure, high-speed exposure, OLED(Organic Light Emitting Diodes) Mask, TSP(Touch Screen Panel), PCB, FPR(Film type Patterned Retarder) Film, 5G(5th Generation) MIMO(Multi Input Multi Output) Antenna, Micro Lithography and MEMS(Micro Electro Mechanical System) process.

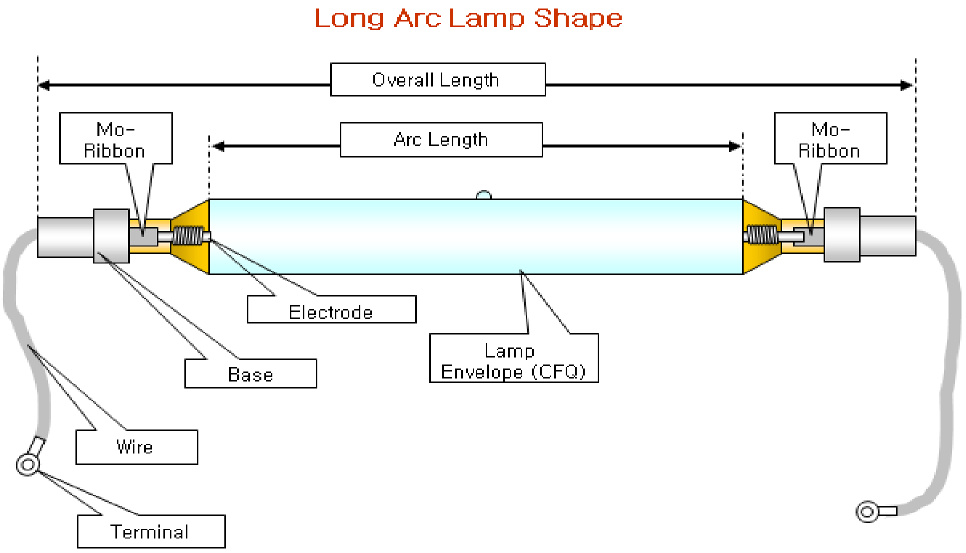


Figure 2. Long Arc Lamp Structur

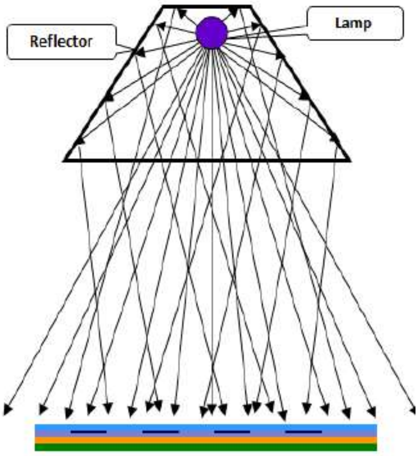


Figure 3. Long Arc Lamp Optical structure

2. Analysis of Lamps and Optical Systems in an exposure System

2.1. Structure of the exposure lamp and optical system using Long Arc Lamp applications.

Figure 2. is the shape of the Long Arc Lamp. The electrode length can be extended. It is highly utilized and relatively inexpensive for UV.(Ultraviolet) curing rather than pattern exposing. The attractive feature means that up to 3.0 meters of lamps are available, which can accommodate web widths. [2]

Figure 3. is a schematic diagram of the structure of a scattered light exposure device using Long Arc Lamp. The scattering of light is high and the angle of incidence of light varies. Due to the difference in illumination, the uniformity of the substrate face is low. The high aspect ratio limits the use of long lamps. In addition, the UV light conversion rate of the lamp is approximately 20% and the remainder is converted to visible light and heat. The intensity of light is constant only when the wind wall temperature of the lamp remains constant. Cooling shall also be done for the irradiation apparatus and cooling of the photoreaction material. Depending on the photoreaction material, the heat caused by the optical reaction must be controlled to produce an

efficient response. The cooling of the cooling lamp requires a temperature of up to 800℃ to be lowered to 250℃ to maintain the lamp's life for a long time. [3]

For use, use for exposure 70 ㎛ or more. It is used in UV Cure, PCB Patterning Process, Shadow Mask, etc.

2.2. Short Arc Lamps and Optical System Structure

The most targets of the work are displayed below:

Figure 4. is the shape of the Short Arc Lamp. The electrode is 5-10 ㎜ in length, which is characterized by short electrode. Electrons flow in one direction using direct current. Arcing occurs in the center of the electrodes and electrodes and is called the spot light source. Light produced by a point has an advantage in controlling light. Most commonly used in exposure equipment for micro-patterns.

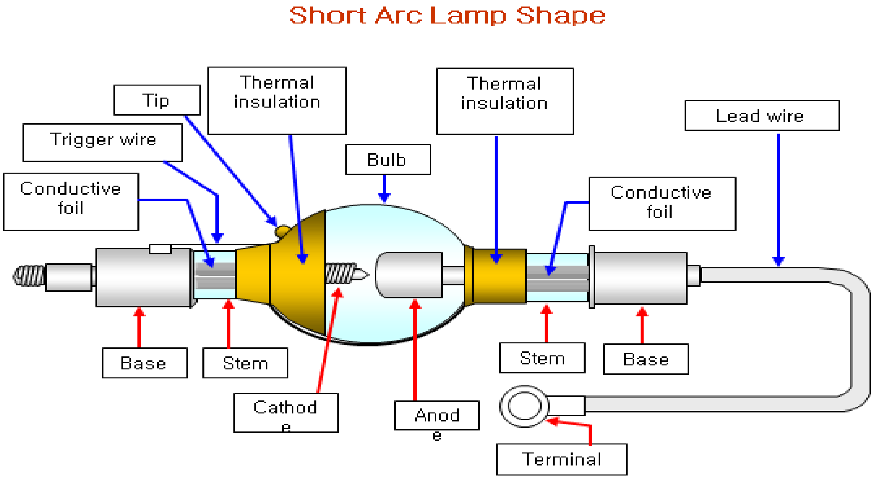


Figure 4. Short Arc Lamp Structue

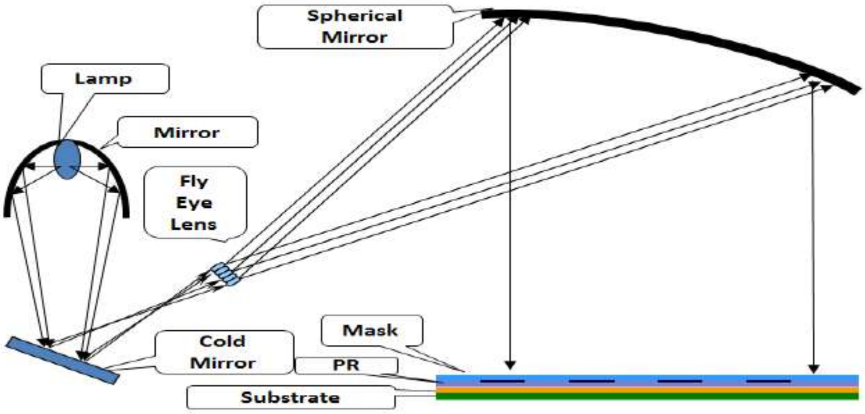


Figure 5. Short Arc Lamp Optical structure.

Figure 5 is a schematic diagram of the structure of an exposure that uses a Short Arc Lamp. High uniformity is achieved by less scattering of light and overlaying the light to the substrate through FEL. It is the most utilized structure. Use multiple levels of Lens and Mirror from the occurrence of light in point light sources to the substrate. This will increase the angle and uniformity of the light.

For fine patterns, procedures for the Lens and Mirror used should be managed. Tolerance and error for assembly shall be verified. Applications are used in semiconductor circuits with high Resolution, Wafer process, Membrane process, C/F(Color Filter) and T.F.T(Thin Film Transist) circuits of large LCD(Liquid Crystal Display), and OLED Mask process

2.3. Optical technology for fine patterning

The first of two important techniques for fine-patterning in this experimental study is wavelength. The shorter wavelength is better the fine-patterning. I-Line with a Wavelength of 365 nm, H-Line with a 405 nm and G-Line with a 435 nm are mainly wavelengths used for pattering. Typically, using only one wavelength using a band pass filter makes the wrench shape of the Resist clear. There are relatively few wavy patterns on the side wall. However, in this experiment, high-pressure water lamps produce mixed wavelengths. To achieve the micro-pattern, the field of light waves has gradually changed from the existing G-line (436 nm) to the I-line (365 nm) and KrF (248 nm) and now the AF (193 nm) is starting to be used. [4]

The second is the technique of light diffraction and interference associated with the mask. This was considered when making masks and slits. Light causes diffraction that is symmetrically routed when it passes through the boundary of an opaque object or niche. The longer the wavelength, the more it occurs, and the smaller the gap, the greater the amount of diffraction. In an exposure machine that uses Mask, diffraction occurs when UV light passes through the pattern of Mask. Good quality fine patterns can only be made when the technology that handles this diffraction is applied.

The diffraction effect by Slit is a formula

$$a * \sin\theta = m * \lambda \qquad (1)$$

ex) a : Slit interval (40μm : Pattern interval between the pattern), m: Bright spots with diffraction patterns, λ : wavelength (400nm), d : distance between mask and surface of exposure (500μm) angle of diffraction m=0 and inθ = mλ/a, θ= sin−1 (0λ/a) = 00 m=±1 = minθ/a = λ/a , θ1= sin−1(λ/a) = ± 0.5729 0 m=±2 is cin22= mλ/a = 2λ/a, θ2= sin−1(2λ/a) = ± 1.1459 0 m=±3 = minθ/a = 3λ/a , θ3= sinθ1 (3λ/a) = ± 1.71910 patterned distance tanθ = P/d, P = d•tanθ , d = 500μm, m=0 to m==1 Distance (P1) : P1= 500•tan (0.5729) = 4.99966m m=0 to m=±2 distance (P2) : P2= 500•tan (1.1459) = 10.001212m m=0 to m=±3 distance (P3) : P3= 500•tan (1.7191) = 15.0065μm

Thomas Young's single-slit, double-slit experiment illustrates diffraction and interference phenomena[5]. In the relatively short distance, the Fresnel diffraction is used to describe the diffraction, and in the case of the distance being relatively distant, the Fraunhofer diffraction is described as a diffraction. For fine patterns, the diffraction must be reduced or the diffused light collected again. Use lens to collect diffused light, and the numerical aperture of lens is called NA (Natural aperture).

$$NA = (n) * \sin\theta * m = \text{(radius of lens)}/\text{(focal length of lens)} \qquad (2)$$

n: Refraction rate of image medium (Air:1)

θ*m: The angle between the optical main axis and the ambient light at the edge of the lens.

Increasing NA allows the diffused light to be concentrated to make the maze clear. Optical systems become difficult and expensive. In addition, the light that enters the mask is impacted at an angle to align the fringes with the lens. This is called OAI(Off-Axis Illumination). These techniques reduce resolution limits and increase the focal depth of imaging. [6]

The shape of the Resist may vary due to the generation of static waves caused by standing waves, and it should be managed because it affects the pattern quality. The thickness uniformity of the Photoresist, the refraction characteristics of the top surface of the Photoresist, the reflective characteristics of the Stage Plane, and the interference of the incident waves and the reflected waves depending on the flatness. The shorter wavelength is the higher the reflectivity. Constructive interference occurs when the same wavelength and wave are met, and the wave is added. The two waves of frostbite add up to each other. "Destructive interference" means that the amplitude of a wave is zero when the best and lowest of the same wavelength are met. This occurs mainly when the incident wave is reflected on the stage and is caused by the reflected wave. The cause also occurs when the thickness of the photoresist is inconsistent. This phenomenon can be reduced if anti-reflective coating is also done on the top of the photo-resist. If the upper side wall of the registry trench is narrow and the lower side wall is wide, the static waves of the grape-legist can be seen as having an effect. The method for reducing static waves is to put a pigment in the Resist and make a PEB after exposure.

2.4 Process technology for fine pattern

The effects on the quality of the exposure process are wavelengths and diffraction, as well as the intensity of light and the amount of light. The quality of the pattern must be well matched between Photoresists and wavelength to create a good shape resist shape. The intensity of light is related to the sharpness of the line width. Appropriate strength determines the shape of the Resist. A weak intensity narrows the space. The higher the fine pattern, the more intense it produces a sharp-shaped resist. UV Meter shall be installed to precisely adjust the intensity of light in the composition of the exposure equipment. In addition, the illuminating intensity feedback system should be installed so that the same intensity of light is observed in the substrates in real time. The speed of exposure is also an important factor. The opening speed of the fast shutter, the light intensity at the line beam, shall be stabilized and the scan exposure shall be started. This is because the same amount of UV light should be examined in all areas with the same intensity. The exposure velocity (=stage speed) was found to be relatively faster, the narrower the width of the line[7].

2.5 Key Technologies for the Development of Exposure Equipment

There are five key technologies required to develop exposure equipment. The first is understood of optics. In detail, the ability to interpret and design ray trace and optical path is both. Also, do you know the characteristics, processing understanding, materials and handling of optical components? Understanding of UV lamps and wavelengths should proceed. Second is the ability to design machines. Is the substrate's characteristics understood and stored without damage and can be transferred? Do you understand the changes in the chemical process? Are control elements known and suitable instrument designs available for each process? Has the management criteria for environmental factors that can protect people, equipment and materials been applied? For example, safety, vibration, dust, temperature, humidity, and air should not react chemically electrically. The third is automatic alignment technology. To make products, the exposure process is repeated. To make display backplane boards, a four to seven Photolithography process is required for LCDs, and a five to 10 Photo Photolithography process is required for AM(Active Matrix) OLEDs.[8] Is the ability to construct the automatic alignment S/W(Software) with the design of the automatic alignment device? Analytical ability for align lighting technology and images is required. Fourth is automatic control technology. A technology to control equipment comprehensively is needed. There should also be power control technology for light sources. Fifth is exposure process technology. They should have experience and knowledge to track problems in case of poor exposure. Accurately understand the exposure process. In addition, environmental factors such as temperature, humidity, airflow and quality should be recognized.

2.6 A Study on the exposing Method and the Resolution

You can laminate the Dry Film (Film type photo list) on the board. You can also Coat a liquid form of Photo resist. There are four types of exposure. Soft contact printing method is applied to the surface of the photo mask, which is performed by the pattern, by vacuuming it. The pressure of pressing the mask and substrate is called the Hard contact method. If it is vacuumed, it is called vacuum hard contact method.

When a Gap is placed between the substrate and the Photo Mask, it is called a Proximity method. Also, if the Lens optical system is placed between the substrate and the Photo Mask, it is called projection. In this case, Photo Mask is called Reticle. If there are no particular problems, use a lot of vacuum hard contexts. Because the beam is examined with the substrate in direct contact with the mask, it can accurately convey the image it is trying to convey at a non-rate, resulting in a very precise fine pattern. In addition, a relatively large image is capable of single exposure [9].

Different industries require different micro-patterns. In this paper, the method of exposure is vacuum adsorption. The resolution and contact type in this case is determined by the magnitude and element of Fresnel diffraction by the Mask Pattern [10].

$$R = k * \sqrt{\lambda * g} \qquad (3)$$

R: resolution (5~10 μm)

K: constant 0.3 to 0.4 (R&D) 0.5 (volume)

λ: wave length

g: Gap between mask and judge

3. Improving aspect ratio and design of collimation angle

3.1. Design of Long Arc Lamp for Improving Long Arc Ratio

In this study, the length of the Long Arc Lamp is 200 ㎜. It is in the form of Slit with a block plate that can block off light, as in Figure 6. Block plate is Controls the longitudinal irradiation light. The size of the light barrier shall be 203 ㎜ * 100 ㎜ in size, and the installation position shall be placed between the 4th Parabola Mirror and the substrate. Cut off not less than 5.35° of the angle of light irradiated downward. Light loss occurs, but micro-patterns can be implemented by controlling the angle of incidence

3.2 Design of Long Arc Lamp for Improvement of Collimation Angle

3.2.1 Conceptual Analysis for Optical Simulation for Parabola Mirror Design

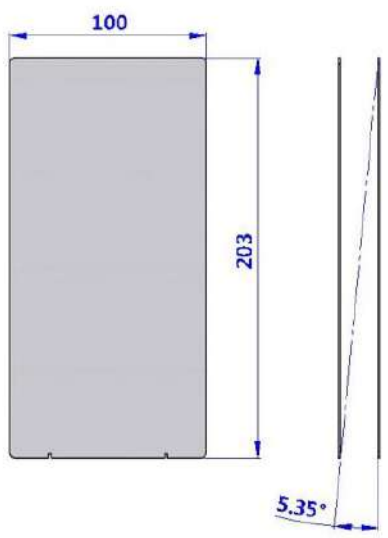


Figure 6. Block Plate.

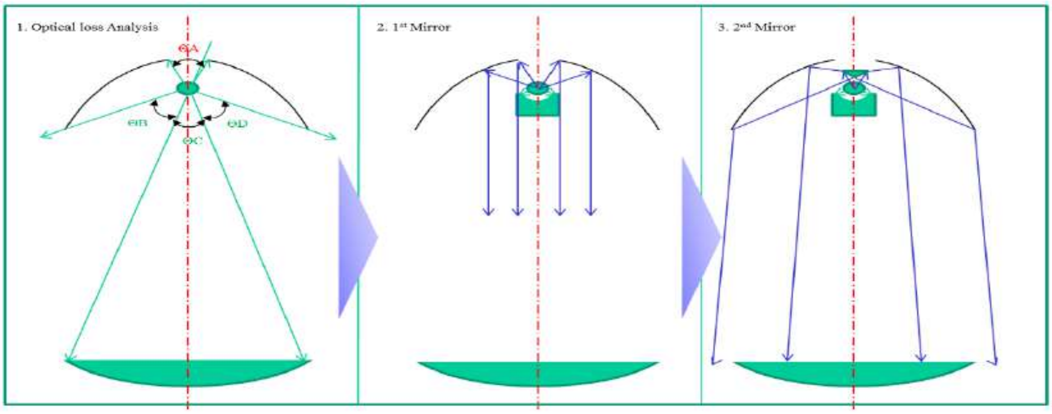


Figure 7. Parabola Reflector Concept Design to parallel the angle of investigation of the Long Arc Lamp.

Figure 7. Parabola Reflector Concept Design to parallel the angle of investigation of the Long Arc Lamp. The first concept divides the angle of light by A,B,C,D. Light is emmitted at A, B, C, and D angles. The second concept parallelizes light. Light at B, C, and D angles is Horizontically reflected by the condenser mirror. The third concept reuses the lost light. The Lost A-angle light is selected by the primary reflector and by the retrial reflector. 70 percent of the last angle of the A-angle can be used.

3.3 Optical Simulation Analysis for Efficiency Evaluation

Apply the concept in three stages, as Figure 8. Analyze the light efficiency with computer simulation so that the optical angle of the Long Arc Lamp can be parallel. Design the Reflectors and Mirrors for the light exposure and establish the optical path for placement. Concentration light + projection lens method. 1) Use the long axis wide angle correction lens of the lamp, 2) apply the long axis wide angle correction Reflector, 3) use the long axis wide angle correction mirror, and design using the collimation Reflector method, and perform the light efficiency simulation at each stage.

3.4 Simulation with Long Axis Optical Calibration Lens.

Separate the irradiance angles of light from the A, B, C, and D angles, position the Reflector by angle, design the Reflector to suit the angle of reflection, and design the layout.

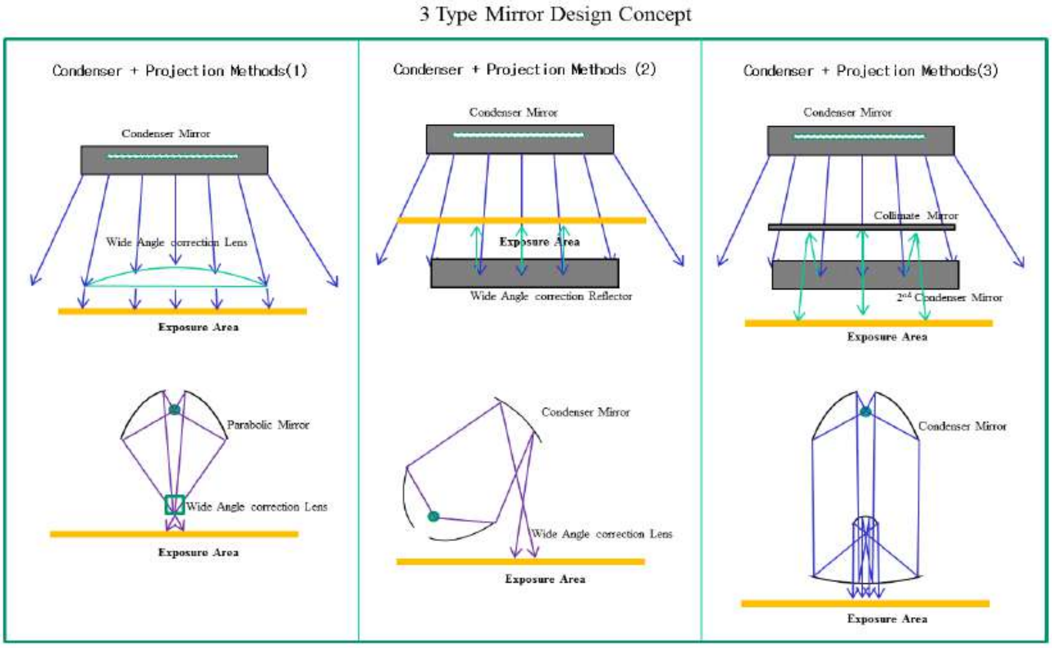
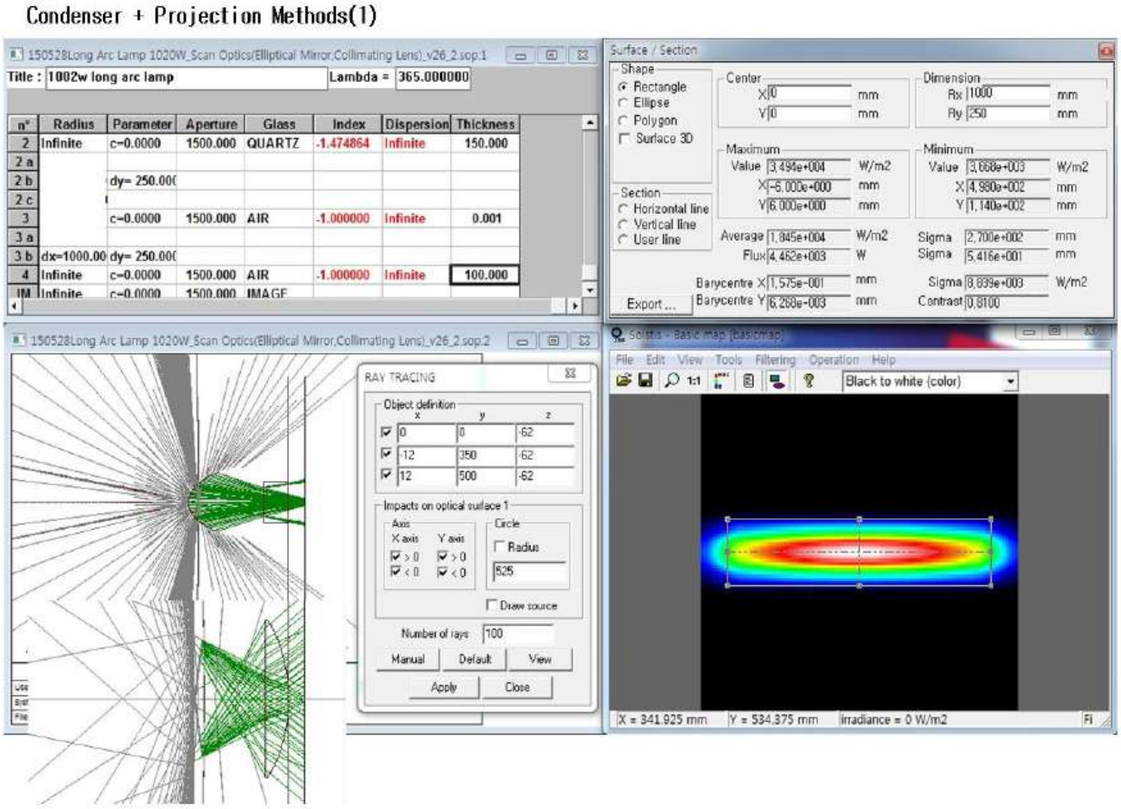


Figure 8. Mirror Design Concepts


Condenser + Projection Methods(1)

150528Long Arc Lamp 1020W_Scan Optics(Elliptical Mirror,Collimating Lens)_v26_2.sop:1

Title : 1002w long arc lamp
Lambda = 365.000000

n°	Radius	Parameter	Aperture	Glass	Index	Dispersion	Thickness
2	Infinite	c=0.0000	1500.000	QUARTZ	-1.474864	Infinite	150.000
2 a							
2 b		dy= 250.00(					
2 c							
3		c=0.0000	1500.000	AIR	-1.000000	Infinite	0.001
3 a							
3 b	dx=1000.00	dy= 250.00(					
4	Infinite	c=0.0000	1500.000	AIR	-1.000000	Infinite	100.000
IM	Infinite	c=0.0000	1500.000	IMAGE			

Surface / Section

Shape
● Rectangle
○ Ellipse
○ Polygon
☐ Surface 3D

Section
○ Horizontal line
○ Vertical line
○ User line

Center
X 0 mm
Y 0 mm

Dimension
Rx 1000 mm
Ry 250 mm

Maximum
Value 3.494e+004 W/m2
X -6.000e+000 mm
Y 6.000e+000 mm

Minimum
Value 3.668e+003 W/m2
X 4.980e+002 mm
Y 1.140e+002 mm

Average 1.845e+004 W/m2
Flux 4.462e+003 W
Sigma 2.700e+002 mm
Sigma 5.416e+001 mm
Barycentre X 1.575e-001 mm
Barycentre Y 6.268e-003 mm
Sigma 8.839e+003 W/m2
Contrast 0.8100

150528Long Arc Lamp 1020W_Scan Optics(Elliptical Mirror,Collimating Lens)_v26_2.sop:2

RAY TRACING

Object definition

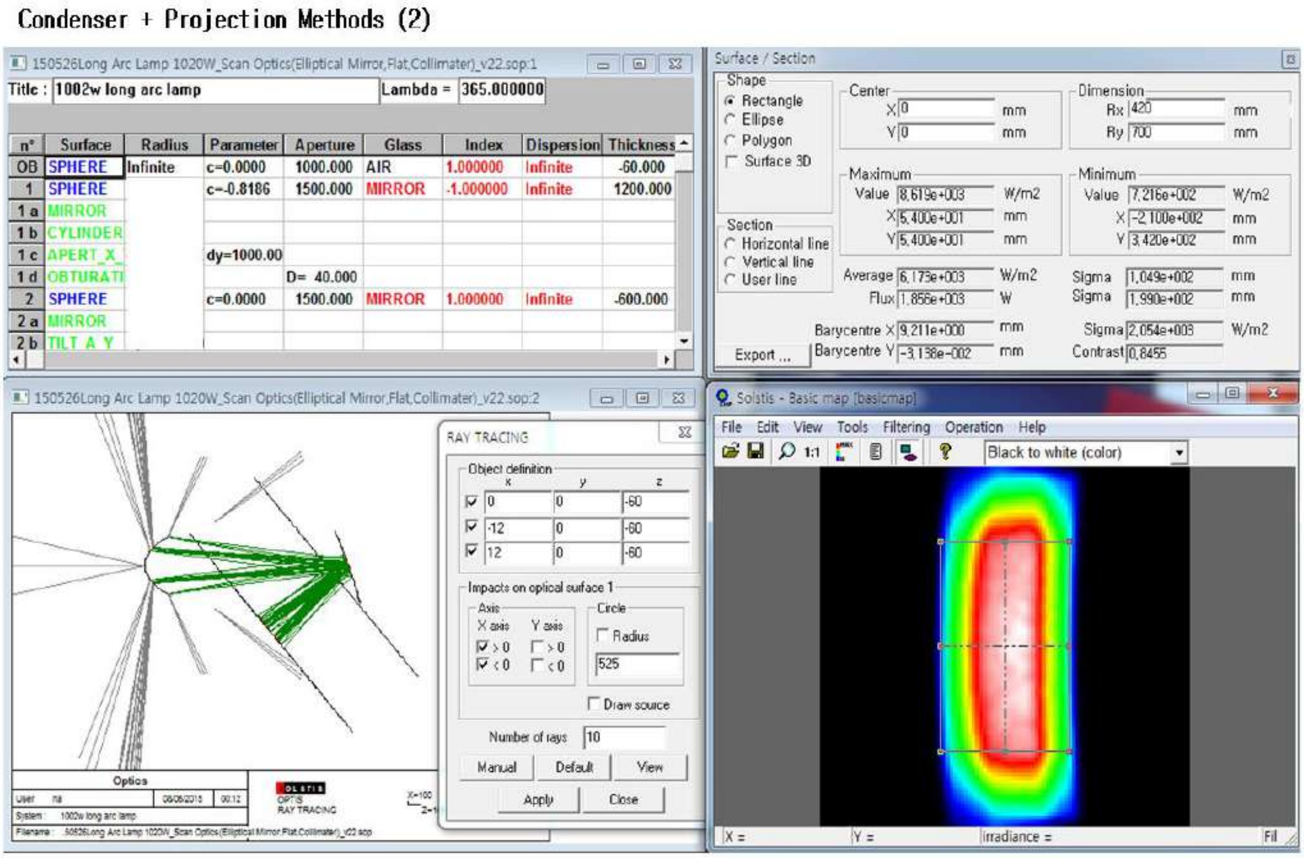
	x	y	z
☑	0	0	-62
☑	-12	350	-62
☑	12	500	-62

Impacts on optical surface 1
Axis
X axis ☑ > 0 ☑ < 0
Y axis ☑ > 0 ☑ < 0
Circle
☐ Radius
525
☐ Draw source
Number of rays 100

Solstis - Basic map (basicmap)
Black to white (color)
X = 341.925 mm Y = 534.375 mm Irradiance = 0 W/m2

Figure 9. Wide angle correction Lens Methods

Figure 9. Apply a long-axis optical correction reflector to reflect the light parallel to the result of simulation and collect it into a 3rd mirror.



Condenser + Projection Methods (2)

150526Long Arc Lamp 1020W_Scan Optics(Elliptical Mirror,Flat,Collimater)_v22.sop:1

Title : 1002w long arc lamp Lambda = 365.000000

n°	Surface	Radius	Parameter	Aperture	Glass	Index	Dispersion	Thickness
OB	SPHERE	Infinite	c=0.0000	1000.000	AIR	1.000000	Infinite	-60.000
1	SPHERE		c=-0.8186	1500.000	MIRROR	-1.000000	Infinite	1200.000
1 a	MIRROR							
1 b	CYLINDER							
1 c	APERT_X_		dy=1000.00					
1 d	OBTURATI			D= 40.000				
2	SPHERE		c=0.0000	1500.000	MIRROR	1.000000	Infinite	-600.000
2 a	MIRROR							
2 b	TILT A Y							

Surface / Section

Shape: ● Rectangle ○ Ellipse ○ Polygon ☐ Surface 3D

Section: ○ Horizontal line ○ Vertical line ○ User line

Center X 0 mm
Center Y 0 mm
Dimension Rx 420 mm
Dimension Ry 700 mm

Maximum Value 8,619e+003 W/m2
X 5,400e+001 mm
Y 5,400e+001 mm

Minimum Value 7,216e+002 W/m2
X -2,100e+002 mm
Y 3,420e+002 mm

Average 6,173e+003 W/m2
Flux 1,856e+003 W
Sigma 1,049e+002 mm
Sigma 1,990e+002 mm
Barycentre X 9,211e+000 mm
Barycentre Y -3,138e-002 mm
Sigma 2,054e+003 W/m2
Contrast 0,8455

150526Long Arc Lamp 1020W_Scan Optics(Elliptical Mirror,Flat,Collimater)_v22.sop:2

RAY TRACING

Object definition

	x	y	z
☑	0	0	-60
☑	-12	0	-60
☑	12	0	-60

Impacts on optical surface 1

Axis: X axis ☑ > 0 ☑ < 0; Y axis ☐ > 0 ☐ < 0

Circle: ☐ Radius 525

☐ Draw source

Number of rays 10

Solstis - Basic map [basicmap]

Black to white (color)

Figure 10. Condenser Mirror Methods

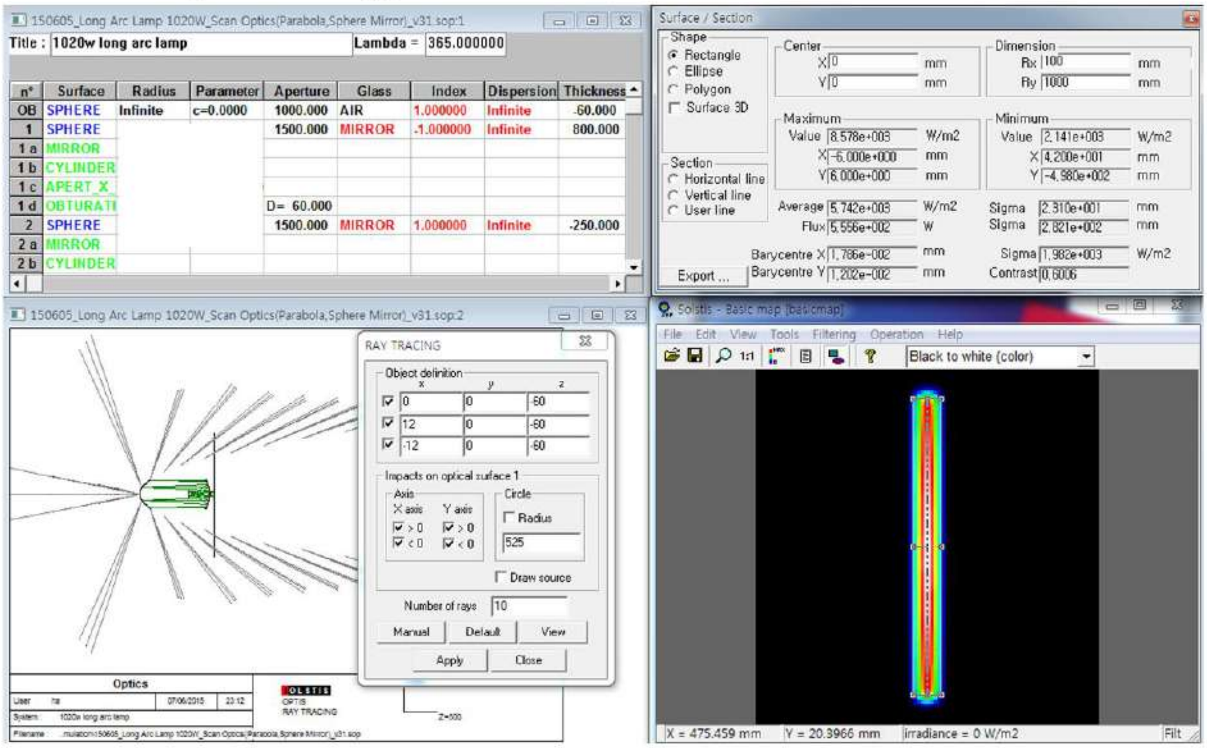
Figure 10. is the result of simulating with the Condenser Mirror.

Figure 11. is the result of simulating with the Collimation Mirror. * Design the light at each A angle so that it is reflected at the lower radiation angle and at the upper radiation the energy efficiency is designed to be increased by the square multiple, and to restore 60% to 70% of the lost light considering the reflector reflectivity.

Computer Simulation Results is Table 1. Simulation Evaluation Companion Table produces results. Three types of pros and cons were compared. Three types of comparisons were selected for a three-way optical system, which is available for fine-patterning and highly economical. The assessment items are easy to manufacture optical parts, ease of mechanical implementation, economy, light source quality survey efficiency, irradiation Uniformity, optical quality – deviation, X/Y axis distribution, resolution, and other-heat exhaustibility items, with scores allocated at 3,2,1 points each above, middle and lower.

Condenser + Projection Methods(3)

Condenser + Projection Methods(3)



150605_Long Arc Lamp 1020W_Scan Optics(Parabola,Sphere Mirror)_v31.sop:1

Title : 1020w long arc lamp   Lambda = 365.000000

n°	Surface	Radius	Parameter	Aperture	Glass	Index	Dispersion	Thickness
OB	SPHERE	Infinite	c=0.0000	1000.000	AIR	1.000000	Infinite	-60.000
1	SPHERE			1500.000	MIRROR	-1.000000	Infinite	800.000
1 a	MIRROR							
1 b	CYLINDER							
1 c	APERT_X							
1 d	OBTURATI			D= 60.000				
2	SPHERE			1500.000	MIRROR	1.000000	Infinite	-250.000
2 a	MIRROR							
2 b	CYLINDER							

Surface / Section

Shape: ● Rectangle ○ Ellipse ○ Polygon ☐ Surface 3D

Section: ○ Horizontal line ○ Vertical line ○ User line

Center X 0 mm, Y 0 mm

Dimension Rx 100 mm, Ry 1000 mm

Maximum Value 8.578e+003 W/m2, X -6.000e+000 mm, Y 6.000e+000 mm

Minimum Value 2.141e+003 W/m2, X 4.200e+001 mm, Y -4.980e+002 mm

Average 5.742e+003 W/m2

Flux 5.556e+002 W

Sigma 2.310e+001 mm

Sigma 2.821e+002 mm

Barycentre X 1.786e-002 mm

Barycentre Y 1.202e-002 mm

Sigma 1.982e+003 W/m2

Contrast 0.6006

150605_Long Arc Lamp 1020W_Scan Optics(Parabola,Sphere Mirror)_v31.sop:2

RAY TRACING

Object definition

	x	y	z
☑	0	0	-60
☑	12	0	-60
☑	-12	0	-60

Impacts on optical surface 1

Axis: X axis ☑ > 0 ☑ < 0; Y axis ☑ > 0 ☑ < 0

Circle: ☐ Radius 525

☐ Draw source

Number of rays 10

Solstis - Basic map (basicmap)

Black to white (color)

X = 475.459 mm   Y = 20.3966 mm   irradiance = 0 W/m2

Figure 11. Collimation Mirror

Table 1. Simulation Evaluation Comparison Table

Items	Condenser + Projection Lens Methods(1)	Condenser + Projection Mirror Methods(2)	Condenser + Projection Mirror Methods(3)
Ease of development (including part difficulty)	1	2	2
Ease of Equipment (Mechanical Design)	3	1	3
Estimated Cost (lower)	1	2	2
Light quality (illumination efficiency)	3	3	2
Light quality-illumination distribution	2	1	3
Optical Quality-Distortion	2	1	3
Optical Quality-X, Y Axis Wide Angle Deviation	2	1	3
Optical quality-resolution	2	2	3
Cold Mirror-heat exhaust	3	1	3
Sum	19	15	24
Score ; High = 3, Medium = 2, Low = 1			

4. Designing experimental models and producing exposure machine

Target specifications are shown in Table 2.Special Table. Using the Long Arc Lamp, high quality Line Beam Generation lighting optics are implemented to create a furnace that performs a glow test.

Table 2. Specification Table

items	Spec.	Others
Exposure Area	610 ㎜ * 510 ㎜	Substrate Size
Effective Area	610 ㎜ * 50 ㎜	Beam Size
Lamp	Long Arc 10.2 ㎾	Electrode 200 ㎜
Intensity	20 ㎽/㎠	ORC MO2
Uniformity	< ±10%	
Exposure Method	Vacuum Hard Contact	

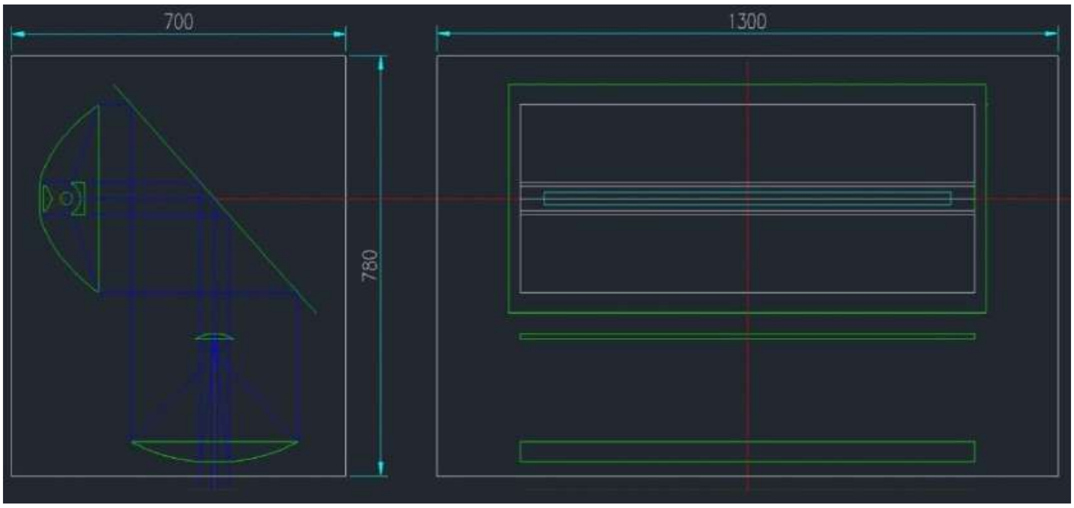


Figure 12. Mirror Layout

Use the Long Arc Lamp for the light source. Figure13. uses a block plate to improve aspect ratio to improve uniformity. The collimation angle is 5.3°. Figure14. shows the structure of an optical instrument with Lamp House Schematic. Use 1st Parabola Cold Mirror, Reflector Mirror, 2nd Parabola AL Mirror, 3rd Parabola and Block Slit as optical components. Optional Path is as shown in Figure 15. 1st Parabola 2nd Parabola →1st Reflector → 3rd Parabola → 4th Parabola → Block Plate.

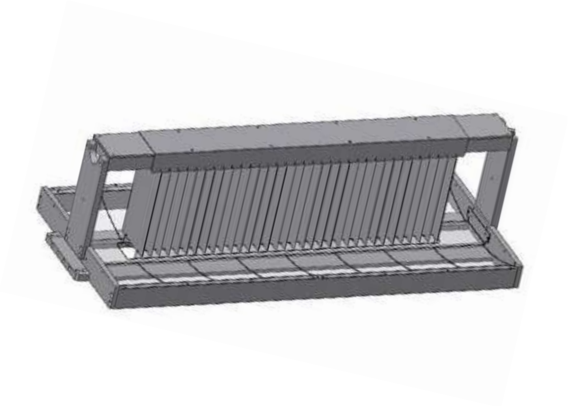


Figure 13. Block Plate

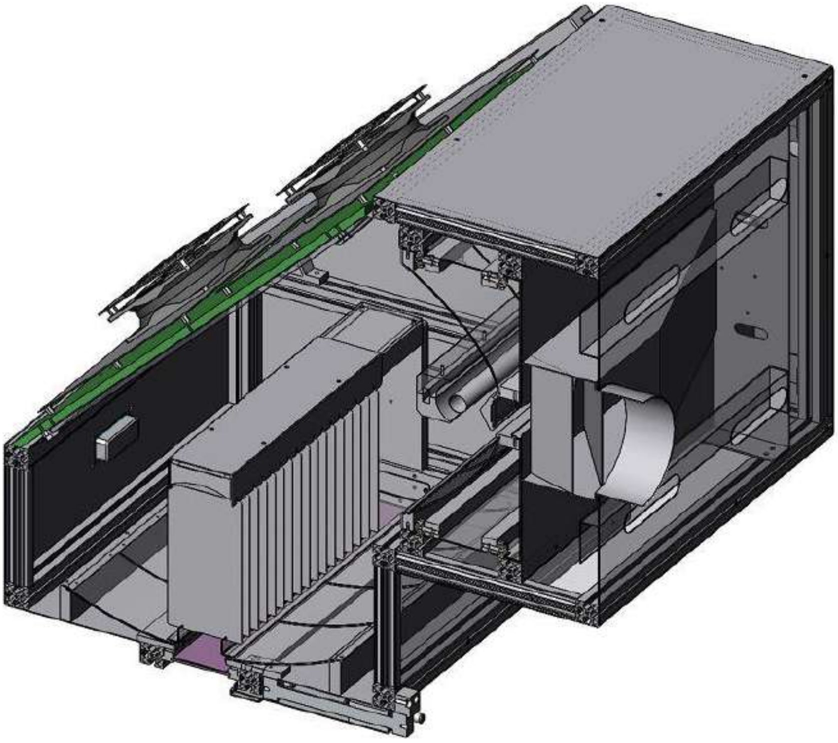


Figure 14. Lamp House Schematic

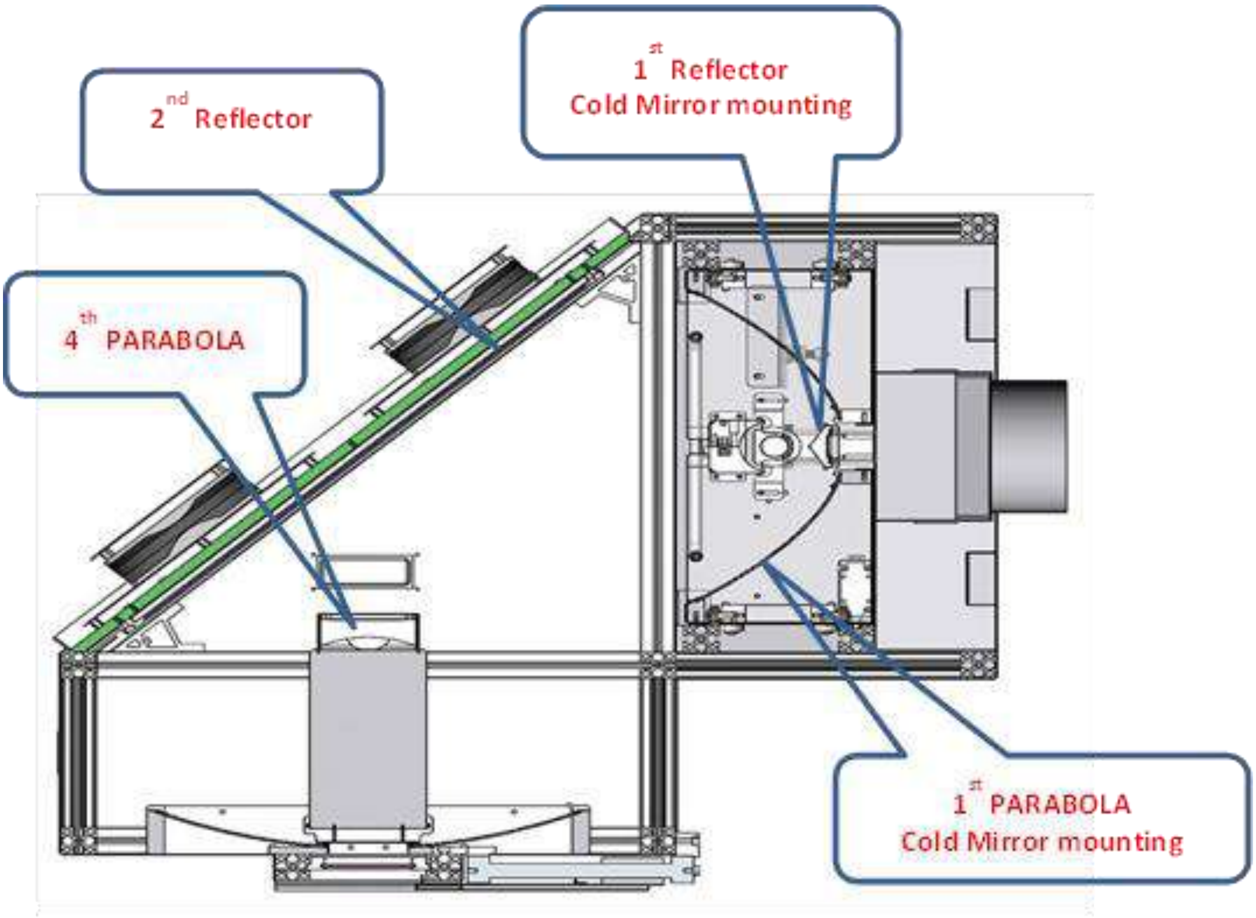


Figure 15. Lamp House Schematic Side View.

The base of the mirror is an aluminum reflector with good cooling, and a position mirror plate with good UV reflectivity is used inside. The mirror and Lens design of a typical parallel light exposure detector is designed to reflect the numerical and error. It is designed without application in this experiment. However, only the wavelength reflectivity and the line reflectivity are considered. The reflective mirrors used in the exposure used by the German Annalod Company.

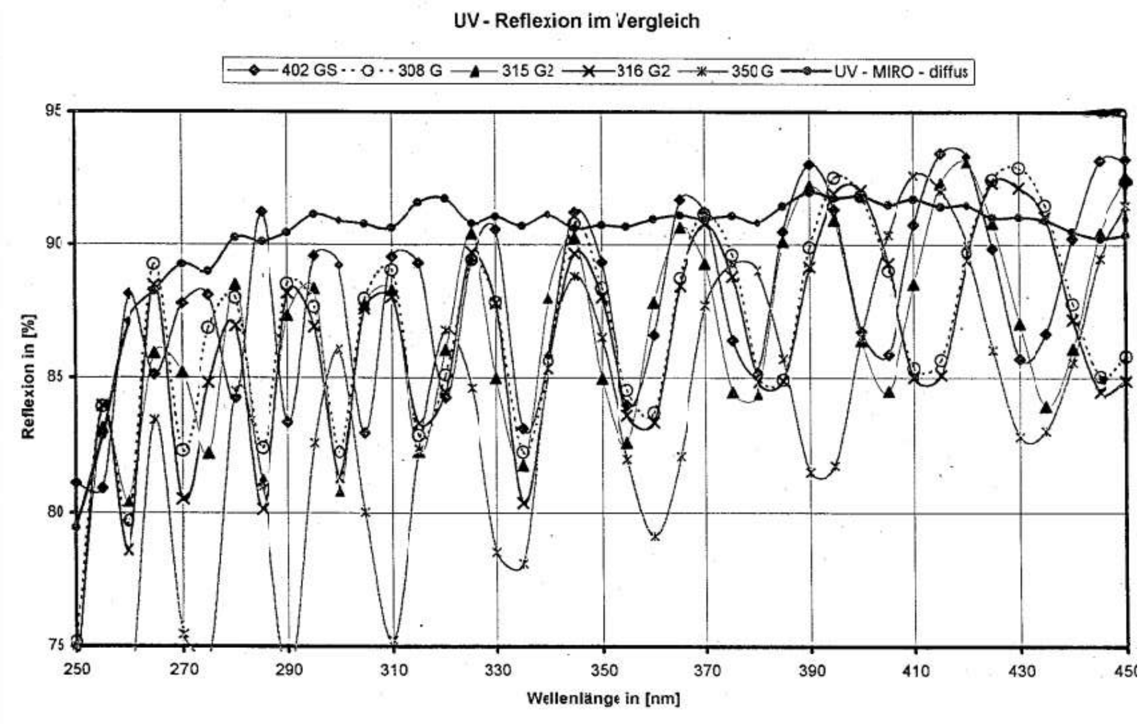


Figure 16. UV Wavelength Reflection Rate

UV reflectivity of dielectric coated thin plate aluminum plate.

Apply a dielectric coating on the Aluminum Plate. For efficient UV reflection and linear reflection. In the optical character analysis of the reflector plate, constant reflectivity to ultraviolet light is very important. Liner selection ratio is important for each ultraviolet wavelength. Use reflector with UV Wavelength Reflection rate of 90% or more as shown in Figure 16.

5. Micro-pattern exposure experiment

5.1 Equipment used in the exposure process

The equipment used in this experiment is Figure 18. a photometer produced by the results of the experiment. Figure 19 is a laminator for lamination of the DFR.(Dry Film Resist) Film. Figure 20. is a developer. Figure 21. is a spin-coater that Coats LPR(Liquid Photo Resist).

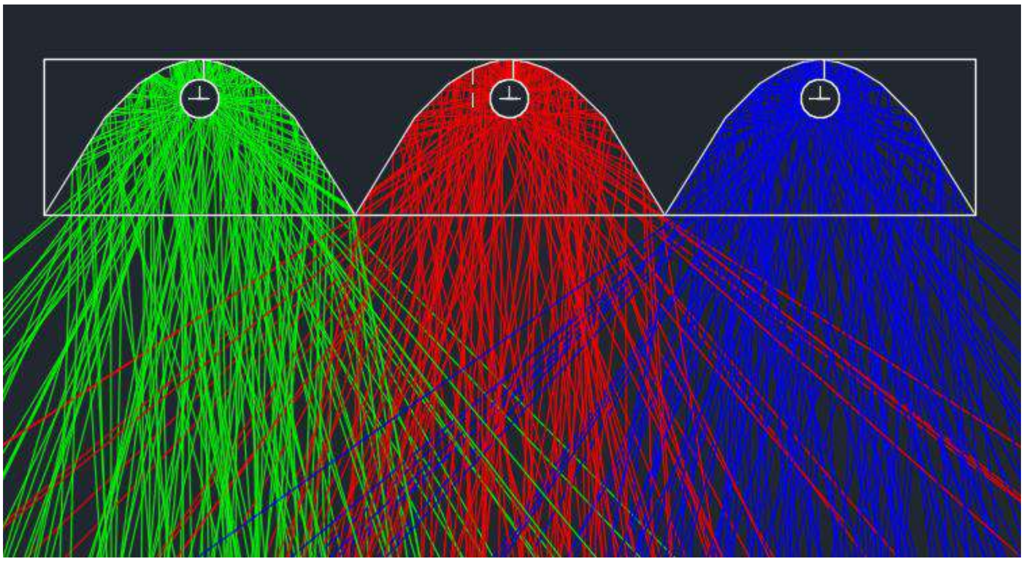


Figure 17. Linear Reflection rate

Figure 18. Line Beam Exposure **Figure 19. Laminator**

Figure 20. Developer **Figure 21.Spin Coater**

5.2 Exposure Process procedures

1.The sequence of general exposure processes is as shown in Figure 22. → UV Lighting → Development → Etching → Strip is the basic process sequence. Some add new processes while repeating the exposure process.
2. The PR Coating process applies a photo-register over the substrates to ensure that the mechanical reaction conditions are applied.
3. The UV lighting process depends on the conditions of the light incident angle, Intensity, Wavelength, Dose, and Uniformity.
4. Development process refers to the process of removing PR.(Photoresist). from the part where light passed between masks is examined. Positive Photoresist disappears as UV light and photogenic PR. parts dissolve into the developer solution. Negative Photoresist is the opposite. Use according to purpose and purpose.
5. Etching process removes photoresist-free parts through corrosion through chemicals such as KOH and THMA.
6. The Strip process is the process of completely removing the Photoresist remaining on the substrate.

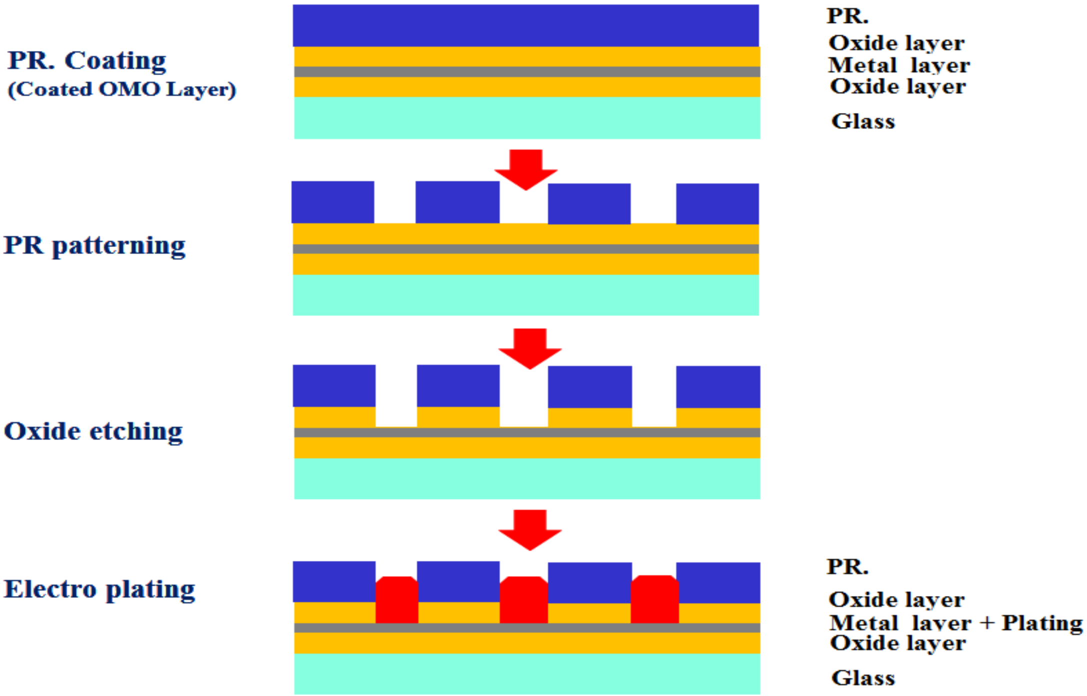


Figure 22. Exposure Processing Flow

6. Results of micro-pattern results

6.1 Exposure conditions

Conduct an experiment to improve the aspect ratio in the furnace using the Long Arc Lamp. The experimental conditions are as shown in Table 3.Table 4. is the Uniformity Aspect Ratio measurement data.

1) Table 4 is the measured value of Uniformity. Measured in 21 places in the effective light exposure area, the light exposure width is 600 ㎜. The average luminous intensity was measured at 0.78 mW/㎠. (9.1 ~ 12 mW/㎠).

2) The variation of the light intensity in a section of 600 ㎜ wide exposure shall not be less than ±13.74%.Uniformity is ±13.74% (86.26%)

Table 3. Exposure Equipment Condition (DFR. 10(t))

Items	*Conditions*		
Product	**Ni Sheet**		
Photoresist	**DFR. (Thickness: 10 ㎛)**		
Exposing	**Scan speed ㎜/s**	**Time (sec)**	**Dose mJ/㎠**
	1.05	**47.6**	**345.5**
	2.09	**23.9**	**158.2**
	3.14	**15.9**	**111**
	4.19	**11.9**	**83**
	5.24	**9.5**	**65.5**
Development	*15 sec*	*Develop ratio 7%*	

Table 4. Uniformity Aspect ratio measurement Data.

Position(㎜)	**300**	**270**	**240**	**210**	**180**	**150**	**120**
Intensity (㎽/㎠)	11.1	9.9	10.7	9.6	9.9	9.1	9.9
Percentage (%)	103	91.84	99.26	89.05	91.84	84.42	91.84
Position (㎜)	**90**	**60**	**30**	**0**	**30**	**60**	**90**
Intensity (㎽/㎠)	11.8	10.8	11.4	10	11	12	10.6
Percentage (%)	109.5	100.2	105.8	92.76	102	111.3	98.33
Position (㎜)	**120**	**150**	**180**	**210**	**240**	**270**	**300**
Intensity (㎽/㎠)	11.8	11.2	12	10.5	10.9	11.4	10.7
Percentage (%)	109.5	103.9	111.3	97.4	101.1	105.8	99.26

The improved exposure conditions by the above DFR. (Dry Film Resist) condition tests are L/S : 15/15 ㎛, and the optimal exposure conditions are 5.24 ㎜/s, exposure time is 9.5/s, and light weight is 65.5mj/㎠.

In the case of 15/15 ㎛ pattern, the best results are made in 100 experiments, with a speed of 2.09 ㎜/s.

Table 5. Exposure Test L/S : 15/15 (DFR. 10(t))

Items	Specifications
Product	Ni Sheet
Photoresist	DFR(10 ㎛(t))
Speed	5.24 ㎜/s
E.Time	9.5 sec
Dose	65.5 mj/㎠
L/S	15/15

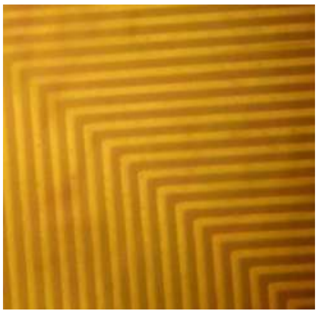


Figure 23. Fine pattern L/S : 15 ㎛ * 15 ㎛

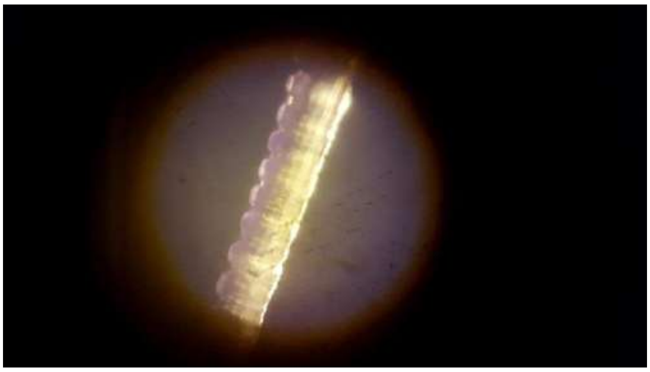


Figure 24. Cross-sectional microscopy with red section incision

6.2 Resolution 15um Test Result

Figure 23 shows a pattern of 15/15 ㎛(t) that is exposure and developed. An exposure experiment was conducted on the condition shown in Table 5. Figure 24 shows a picture of a picture after cutting with scissors to see the cross section of Figure 23. Generally, to check the shape of the section, a hardened liquid must be applied over the pattern, cured and then picked with a punch. The cut surface shall then be honed with a grinder to measure its dimensions when the boundary surface is clearly visible. I only saw through the side wall of the registry. The process, time, and cost were high, so we decided to cut it simply and see only the shape. The thickness of the register on the Ni-Sheet is 10 ㎛(t), as shown in Figure 24. Shape of the slop formed on the side wall could be identified. The slop looks clean.

Table 6. Exposure Equipment Condition 2 (LPR. 2 ㎛(t))

Items	Specifications		
Product	Ni SHEET		
Photoresist	LPR (t: 1 ~ 2 ㎛)		
Exposure speed Exposure time Dose	1.05 ㎜/s	47.6	345.5mJ/㎠
	2.09 ㎜/s	23.9	158.2mJ/㎠
	3.14 ㎜/s	15.9	111mJ/㎠
	4.19 ㎜/s	11.9	83mJ/㎠
	5.24 ㎜/s	9.5	65.5mJ/㎠
	6.28 ㎜/s	8.0	55.2mJ/㎠
	7.33 ㎜/s	6.8	46.9mJ/㎠
	8.38 ㎜/s	6.0	41.4mJ/㎠
	9.42 ㎜/s	5.3	36.6mJ/㎠
	10.47 ㎜/s	4.8	33.1mJ/㎠
Development	10sec		

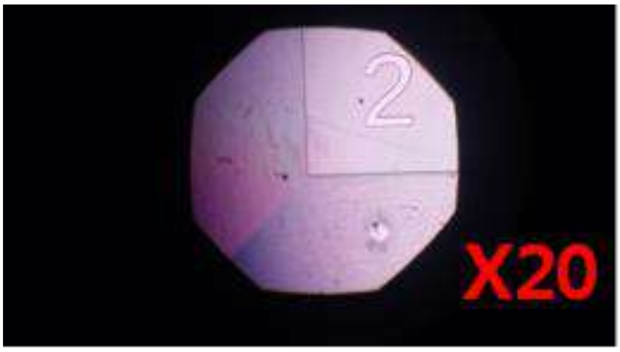


Figure 25.Magnify 2 ㎛ pattern by 20 times

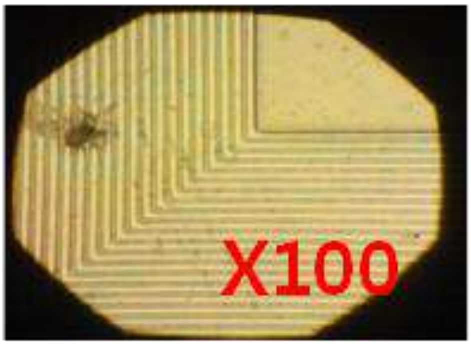


Figure 26.Magnify 2 ㎛ pattern by 100 *times*

6.3 Resolution 2um Test Result

As a final experiment, we did a pattern test on 2um & 2um. The exposure conditions are as shown in Table 6. The picture shows the result

of Scan Speed 8.38 ㎜/s As Figure 25. shows, it was difficult to analyze the circuit because the circuit could not be seen clearly. It has been magnified 100 times, as shown in Figure 26. Line and Space of the circuit are not clear. Thick lines are visible on the border between Line and Space, as shown well in Figure 26. In case of 2um pattern test result, Figure 26 shows the formation of a slop and different sizes of horizontal and vertical lines. It is well illustrated that the aspect ratio does not fit. This picture shows a lot of diffraction in the 90 degree angle. It shows that there are parts to improve for use with a width of 2um & 2um. As the results of the 2um experiment in Figure 26 show, the pattern of 2um can only be used by improving aspect ratio and improving uniformity. To compensate for this problem, the design of the Diffration at 1st Lens is supplemented.
If the block plate reflects the change of angle of refraction, a pattern of good shape can be obtained from the 2um pine pattern.

7. Conclusion

This paper is a study for the implementation of fine pattern by improving Aspect Ratio improvement and collimation Angle in ores using Long Arc Lamp. The exposure is based on the specifications of the 5kw parallel exposure that have been sold the most on the market. The exposure area is based on 610 ㎜ * 510 ㎜, the standard size of the PCB. Mirror design and layout design were optical simulation using Light Tool. The light efficiency was analyzed by generating 1 million light rays and the mirror design and location were changed according to the simulation results. The light optics meter selects the Condenser Projection Mirror method. The characteristics derived from computer simulation are the effective exposure area 610 ㎜ x 510 ㎜ and the collimation angles are 5.32°, Uniformity 86.26%, Intensity 10 ㎽/㎠. Manufacture and experiment with a photometer reflecting the concept of optical system studied in this paper. The produced furnace implements micro-patterns from 50 * 50um to 2um * 2um. After all, the light source of the existing micro-pattern exposure equipment came only using the Short Arc Lamp. In this study, using the Long Arc Lamp, high uniformity and collimation Angle were obtained to create fine pattern. As a result, it is very meaningful to expand industries that can apply micro-patterns by dramatically improving productivity and economics in implementing micro-patterns. The results of the Long Arc Lamp test in this paper will expand the field of large-area micro-pattern exposure and contribute to cost savings in existing applications such as TGV(Through Glass Via), MEMS, OLEDs, PCBs, and 5G Antennas. Future research needs to improve the Slit Plate to create various types of Microlithography, MEMS structures that apply Reverse Optic optics.

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