프로젝션 노광기의 조명 광학계 설계
The Optical Design of Illumination System for Projection Stepper

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1. Introduction

Stepper is a core device for photolithography process. The essential element of the main technology that decides the resolution of this device is the illumination system. The illumination system in a stepper must have sufficient energy to overcome any obstacles that may absorb or diffuse light, preventing uniform light reaching the final wafer from the source.[1),2),3),4)] In order to construct this illumination system, many factors such as shape and capability of light beam collector, diffuser or lens array, condenser and field lens, filters, mirrors and mechanical frame should be considered thoroughly.[5)]

2. Component Explanation and Design

The essential element of the main technology that decides the resolution of this device is the illumination system. In order to build an illumination system several components are required as shown in Fig 1. While each component performs their respective functions, in the case of the light source a lamp that allows arc discharge was used to obtain high energy and a mirror is used for efficient integration. While there are parabolic and elliptical mirrors, in our study we used a ellipse mirror as shown in Fig 2.

When the first focus of the light source is placed on the first focus, the beam passes the ellipse mirror and reaches the second focus. The beam focused at the second focus shows a double gaussian distribution, so by using a FEL(fly eye lens) composed of Kohler illumination and lens array the beam should be made uniform in the desired mask area.(Fig 3,4) The beam that has passed FEL passes the condenser lens (Fig 5) to reach the desired area which then achieves uniform exposure in the desired mask area by the Kohler illumination. The beam that has passed the mask is magnified by the projection lens and reaches the wafer with uniform exposure.

But each factors mush not only perform their relative functions but combine with each other to perform an integrated function. As shown in Fig 6, because the light source used is not a simple point-like source, beam from the focus of the ellipse mirror does not enter the second focus. Therefore by considering the spatial distribution and the angular distribution of the lamp, lamp modeling is necessary and the size and incident angle of the second focus is determined by the size and focus length of ellipse mirror and lamp modeling. The beam size and the incident angle of the second focus are interrelated so if the beam size increases the incident angle decrease and vice versa as shown in

Fig 7. The angle of the beam changes as it passes the FEL which then is directed towards the condenser lens. The beam passing the mask must have an angle that is related to the projection lens NA so a condenser lens should be designed. Therefore, all components do not only perform their respective functions independently but also interact with each other and perform an integrated function so the actual system should be designed accordingly.

3. Layout and Design & Simulation of Total System

In this paper, we will study the illumination condition where the exposure area is 33mm and magnification is 4:1 by using G-line and I-line light source (436,365nm). To satisfy these conditions, we made a study of the characteristics of each illumination optical system and chose simple sequential factors for improving the illumination system. By using a lens design program as shown in Fig 8 we have designed an actual system and accordingly carried out simulation as shown in Fig 9.

4. Reference

1. M. Bass, *Hand Book of Optics,* McGraw-Hill, 2001, pp. 2.33 - 2.38.
2. Dnald C. O'shea, *Elements of Modern Optical Design*, 1985, pp. 384 - 390.
3. Robert F. Fischer, *Optical System Design*, McGraw-Hill, 2008, pp 289 - 300.
4. Warren J. Smith, *Modern Optical Engineering,* McGraw-Hill, 2007, pp 245 - 246.
5. 류재명 외 4인, “Fly eye lens를 사용하는 액정 projector용 조명 광학계의 설계” 한국광학회지 13, 3 (June 2002)

Fig 1. Illumination system

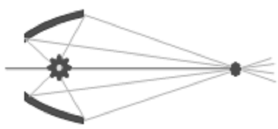

Fig 2. Ellipse mirror

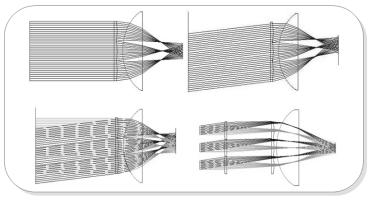

Fig 3. Lens array and Tandem lens array

Fig 4. FEL

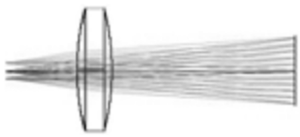

Fig 5. Condenser lens

Fig 6. Lamp modeling

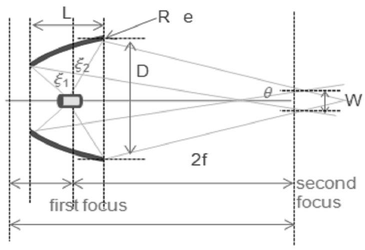

Fig 7. Incident angle and Beam waist

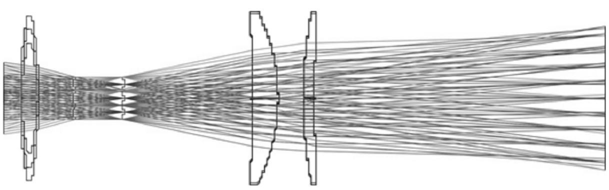

Fig 8. FEL and Condenser lens Integration

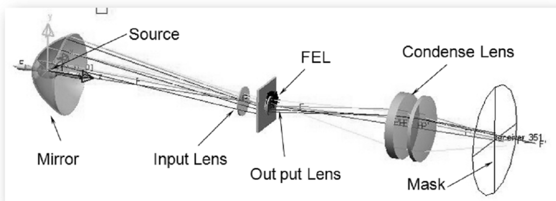

Fig 9. Simulation layout