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### Previous Works

- Studies of novel dry etching process for optical mask

Defect level comparison between standard etching and novel dry etching process (above 0.2um size)

Etch loading comparison

- A novel dry etching process was effective to reduce defect in the case of optical mask.

ENGR: Jeong Chan Kim

### Small defects in EUVL photomask

- EUV small defects in the conventional EUVL mask etching process
  - Proportional to the number of etched masks.
  - Over 60 small defects showed up after 10 masks were etched.

- Need to develop novel dry etching process to reduce defects for EUVL mask !!

ENGR: Yuseok Jeong, Jae-Min Song

### Small defects in EUVL photomask

- Size, shape, and composition
  - >250~300nm, Al<sub>2</sub>O<sub>3</sub>

-. The typical SEM images of the small defects

ENGR: Yuseok Jeong, Jae-Min Song

### Particle's motions in a plasma

- I'm sorry, but the contents in this slide is blinded on the issues of copyright.

ENGR: Jeong Chan Kim

### Novel dry etching process for EUV mask

- Defect level comparison
  - Effect of the novel dry etching process for EUV mask
  - Old chamber vs. new chamber
  - Novel dry etching process vs. conv. process

Configuration	New chamber Novel process	Old chamber Novel process	Old chamber Conv. process
Defect map			
Etch small defect	2	5	113

- The combination of new etch chamber and the novel process showed the best result for reducing small defect caused by etching process.

ENGR: Hoon Kim, Young-Keun Kim, Il-Yong Jang, Jeong Chan Kim

### Novel dry etching process vs. conv. etching process

- Etch-bias uniformity & linearity
  - Unif. 3σ: better than the result of conv. process
  - Lin.: similar to each other
  - Difference of etch-bias: ca. 1nm

ENGR: Hoon Kim, Jae-Min Song

### Defects of patterned EUVL photomask I

- Defect classification
  - Real defects: 15 ea.
  - No etch small defect

ENGR: Hoon Kim, In-Yong Kang

### Defects of patterned EUVL photomask II

- Defect classification
  - Real defects: 22 ea.
  - No etch small defect

ENGR: Sukho Joo, Sung-Min Huh

### Defects of patterned EUVL photomask III

- Defect classification
  - Real defects: 34 ea.
  - No etch small defect

ENGR: Sukho Joo, Jeong Chan Kim

### Defects of patterned EUVL photomask IV: analyses

- Blank small defect (less than 20nm, small spots, small dots, white dots, etc.)

-. The typical SEM images of the small defects less than 20nm

- Issues for analyzing blank small defects
  - Only to be analyzed by TEM
  - Essential to mark around the small defects to preparation TEM samples
  - Back-side CrN layer and multi-layer prohibit using a conventional marking technique.
- New marking technique is needed and being developed.

ENGR: Yunsong Jeong, Sanghyun Kim, Jeong Chai Kim

### Summaries & Conclusions

- Small defect free novel dry etching process for EUVL photomask was developed and shown advanced etch-bias uniformity.
- The concept of controlling the electrostatic force of the particle's motion in plasma is effective to reduce defects.
- New small defect seemed to come from its blank, we are trying to analyze composition of the blank's small defects.

- Adopting the novel dry etching process was highly effective to prevent defect generation during plasma enhanced dry etching.
- In the future, the remained issues of defect in manufacturing the EUVL photomask will be focused on reducing blank's defects, and improving advanced repairing skill.

ENGR: Jeong Chan Kim

Jeong Chan Kim, Yuseok Jeong, Sangsuk Park, Jae-Min Song, Il-Yong Jang, Hoon Kim, Young-Keun Kim, In-Yong Kang, Sukho Joo, Sungmin Huh, Yunsong Jeong, Sanghyun Kim