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# Process Enhancement of EUV Materials (Visit poster session, 9422-86, Tuesday)

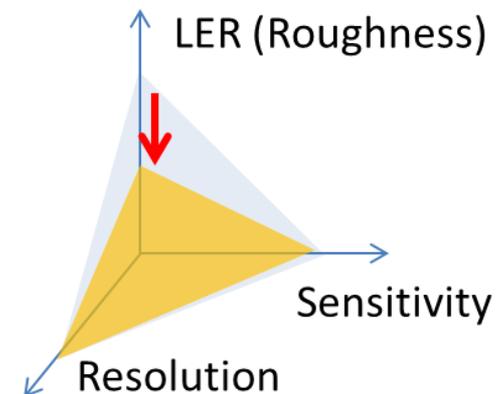
Shinji Tarutani



# 1. Motivation

- EUV source power is increasing, but it has not yet reached sufficient power levels for high volume manufacturing.
- High sensitive resists are desired, but there is a performance envelope, which is called the RLS trade-offs.
- We studied the ERC\* process, a post lithography treatment, that can improve resist pattern roughness regardless of RLS trade-off limitations.

(\*ERC = Edge Roughness Control)



## 2. METHOD AND MATERIALS

The ERC process is designed to make a resist thermal flow at a limited region that is near the surface of the resist pattern.

The key is to deliver ERC agents that exhibit fluidity at lower temperatures compared to the target resist. This fluidity is located near the surface region of the resist.

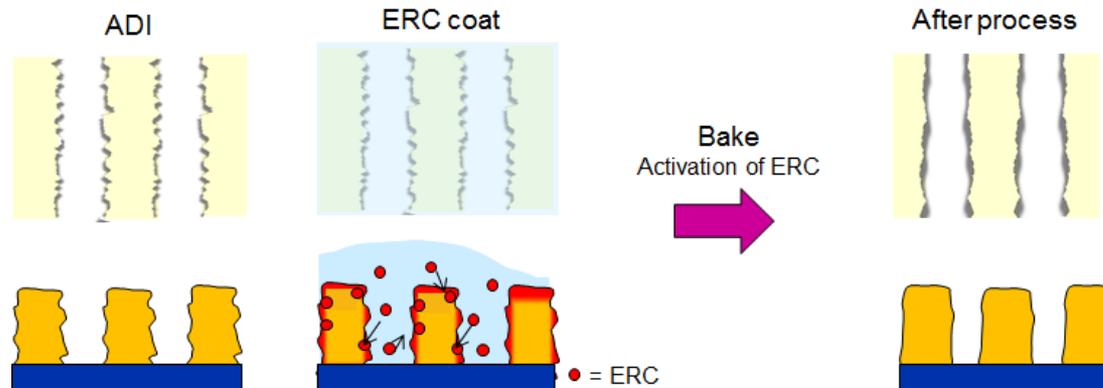


Figure 1. Schematic image of the ERC process. ERC solution is coated on prepared resist pattern and is activated by bake.

## 3. EXPERIMENT AND RESULT

The experimental conditions were as follows.

### [EUV resist process]

- |                 |                             |
|-----------------|-----------------------------|
| 1) Resist:      | EIDEC ESR1, FT=50nm         |
| 2) Patterning:  | EIDEC SFET                  |
| 3) Development: | TMAH 2.38% aqueous solution |
| 4) Rinse:       | DIW                         |

### [The standard ERC process]

- |               |                          |
|---------------|--------------------------|
| 1) ERC coat : | 10 sec puddle + spin dry |
| 2) ERC bake:  | 110°C bake for 60sec     |

\*As the solids content of the ERC solution is low enough, a develop process to remove the ERC is not necessary.

## 3. EXPERIMENT AND RESULT - CONTINUED

For the first step, we prepared a sample, ERC-A whose main functional group is n-Alkyl chain.

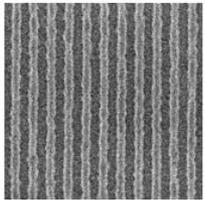
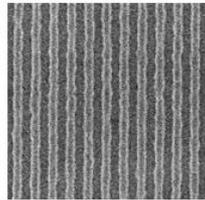
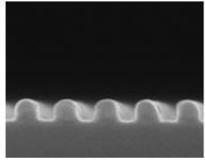
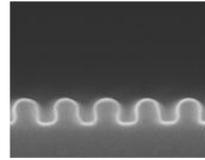
	ADI	ERC-A
CD size (nm)	30.2	31.0
LER (nm)	8.2	7.4
LER improvement (%)	-	9.8
Top View		
Vertical View		

Figure 3. Comparison of ADI (After Development Image) and after ERC process.

➤ LER could be improved from 8.2nm to 7.4nm (9.8% improvement) with no significant film loss..

## 3. EXPERIMENT AND RESULT - CONTINUED

### Process parameter study:

#### 1) Puddle time

There was no significant variation on LER improvement by each puddle time. We can conclude the following:

1. ERC agents penetrate rapidly enough when it is coated.
2. The penetration depth of ERC agents doesn't increase much.  
( No impact on CD shift or LER improvement.)

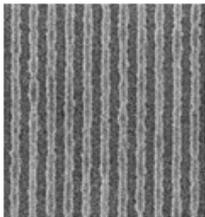
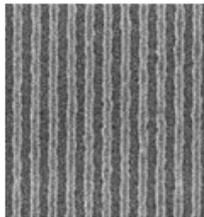
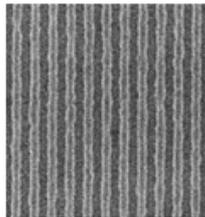
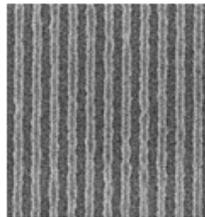
	ADI	ERC-A		
Puddle time (sec)	-	2	10	50
CD shift (nm)	-	0.8	0.0	-0.5
LER (nm)	8.3	7.0	7.4	7.5
LER improvement(%)	-	12	10	10
Top-View				

Figure 4. Puddle time dependency. The process flow is as follows.

- ERC coat : dispense + "x sec" puddle + spin dry, x= 2, 10, 50sec respectively
- ERC bake: 110°C bake for 60sec

## 3. EXPERIMENT AND RESULT - CONTINUED

### Process parameter study:

#### 2) Bake temperature

Improvement of LER and CD shift was stable with bake between 90°C ~ 110°C.

*CD shift of 3.2nm is observed at 130°C:*

*It may be caused by the thermal flow in the bulk of the resist.*

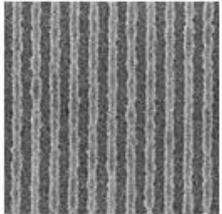
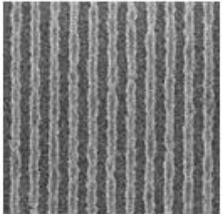
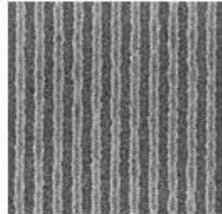
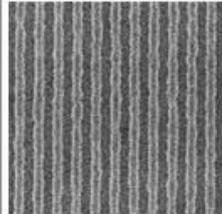
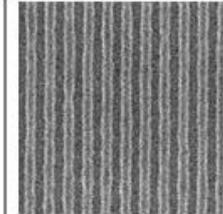
	ADI	ERC-A			
Bake temp. (°C)	-	RT	90	110	130
CD shift (nm)	-	0.5	1.1	0.8	3.2
LER improvement(%)	-	0.0	9.3	9.8	15.3
Top-View					

Figure 5. Bake temperature dependency

- ERC coat : 10 sec puddle + spin dry
- ERC bake: RT (no bake), 90, 110 or 130°C for 60sec

## 3. EXPERIMENT AND RESULT - CONTINUED

### Process parameter study:

#### 3) Pattern pitch

Consistent improvement of LER was seen at various pattern pitches. The CD shift was small and stable.

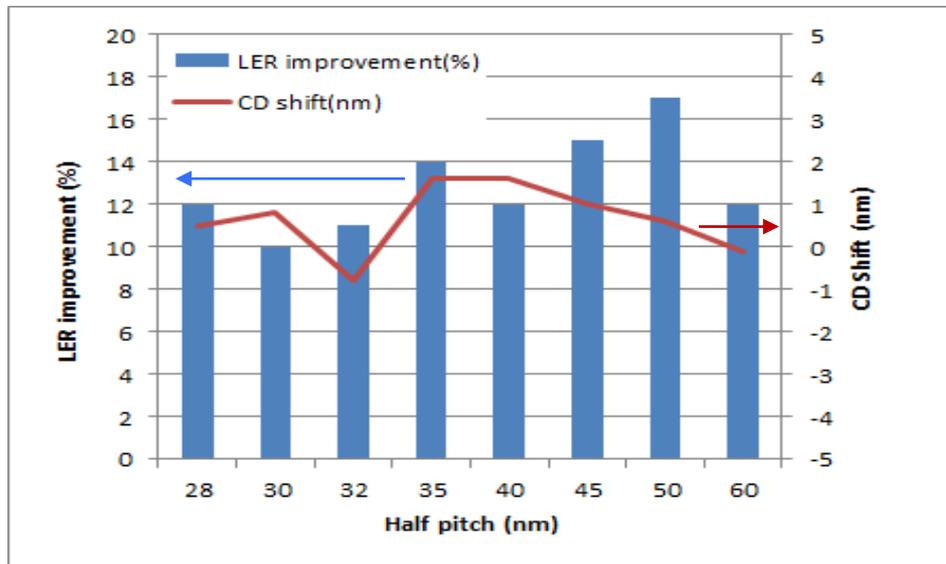


Figure 6. Pattern pitch dependency

LS patterns with several pitches were prepared and the ERC process was carried out. The ERC bake condition was 110°C for 60sec.

➤ ERC process is stable and robust with bakes from 90C to 110C.

## 4. CONCLUSION

- We discussed the ERC process to improve LER without giving any impact on lithography performance.
- We utilized the HSP distance and achieved LER improvement of 14.8% on an EUV resist in the second trial.

## 5. ACKNOWLEDGEMENT

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