Standardization of Fiducial Mark on EUV Blankmask

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5. Summary
What is fiducial mark?

- Required defect density is 1 ea @ 25nm PSL for mass production. This will increase blankmask cost significantly.
- If we can know exact information of defects, we can make defect unprintable on the wafer.
  - 1 ea @ 25nm PSL \(\rightarrow\) 5-10ea @25nm PSL
  - Significant reduction in blankmask cost
- Fiducial marks are starting point for this work
- Standardization
- Implementation technology
SEMI Ballot Proposal For EUV Blank Fiducial Mark
Proposed Roadmap for Fiducial Mark Standardization

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- **TFOF / TF Kickoff @SEMIcom West**
- **Fiducial strategy**
  - Layer
  - Implementation
- **Demonstrated methods**
- **Yellow Ballot**
  (Proposing to skip blue ballot)

**Workshop**

**Industry FM workgroup**
Proposed Scope

• What’s in:
  1. Marking area
  2. Mark design
  3. Mark readability
  4. ……

• What’s out:
  – Methods to make marks will not be included in the standard.
  – Mark depth is not specified, as long as meeting readability requirement.
  – It depends on the approach of each blank maker
1. Mark Location

• Mark areas locations
  – Four coarse marks centered at:
    (-68952, +68952)
    (+68952, +68952)
    (-68952, -68952)
    (+68952, -68952)
  – Four fine marks centered at:
    (-60400, +60400)
    (+60400, +60400)
    (-60400, -60400)
    (+60400, -60400)

• Position accuracy:
  ± 1 um (range)

• Absorber area containing marker should be opened
2. Mark Design

- **Mark rotation tolerance:**
  \[\pm 0.5\text{ degrees}\]

- **H-V line orthogonality tolerance:**
  \[\pm 0.5\text{ degrees}\]

- **Line CD**
  - Mean: \(4 \pm 100\text{ nm}\)
  - Delta CD: 10 nm (range)

- **LER:**
  10nm (one side peak to valley)

- **Line length:**
  - Coarse mark mean: \(4096 \pm 1\text{ um}\)
  - Fine mark mean: \(400 \pm 1\text{ um}\)
3. Mark Readability

- Mark readability TBD’d by TF for
  - Blank defect inspection tool before absorber deposition
  - E-beam after absorber and resist coating
  - Repair tool

(future AMIS tool need capability to read the marks)
Plan

• Request to SEMI NA Micropatterning Committee in its 2/28/09 meeting, for Cycle 6 yellow ballot voting (9/14-10/14/09).
• Draft yellow ballot review by TF, at SEMICON West (July, 2009)
• Yellow ballot submission on 8/31/09
• In the meantime, develop/demonstrate marking methods.
Accelerating the next technology revolution

AR during last meeting
Action Items From 2/08 Workshop

1. Provide draft proposal of fiducial mark requirement based on e-beam tool detection requirement (Nuflare) (Done)
   - Mark attributes requirement (e.g., mark width, depth, slope, CD control, LER, etc)
   - Mark location requirement (preferable close to blank edge if possible)
2. Discuss with blank venders on possible impact using edge shielding during absorber deposition (Intel) (On-going)

   ![Diagram of ML and absorber with fiducial marks]

3. Conducting more experiments on Laser heating induced marks on ML with absorber shielding and resist EBR (Intel/Samsung/SMT) (On-going)
4. Conduct direct marking with material ablation on ML and evaluate particle contamination with and without cleaning (Intel/Samsung/SMT) (On-going)
5. Invite AGC and Hoya to the future taskforce meeting (Done)
6. Request for TFOF approval for EUV Reticle Fiducial Mark Task Force by SEMNA Micro-Patterning Committee (SEMATECH). (Done)
Action Items From 7/15 TF & EUV Symposium

1. Experiments with following requirements (owner: Intel) (Done)
   - Place fiducial marks outside quality area.
   - Assess defect performance in clean room environment.
   - Propose defect mitigation strategy.

2. Identify potential tool makers (laser, e-beam repair, etc…) (SEMATECH) (On going)

3. Propose defect location accuracy specification (Intel, AGC, SEMATECH) (Done)
   - Defect location accuracy.
   - Analyze existing data, for defect location capability (of inspection tools).
   - Assess current defect location accuracy capability.

4. Propose location where to place fiducial mark marks (SEMAETCH) (Done)
   - Collect inputs from ASML and Nikon.
   - Check other mask keys.

5. Propose fiducial mark implementation strategy (substrate, ML, absorber). (SEMAETCH, Intel, AGC) (Done)

6. Propose specification on how much one can shift patterns on the mask (locally from defects). (ASML, Nikon, SEMATECH) (On going)

7. Coordinate with P37 TF on new specification of quality areas (flatness, optical, defect quality areas…). (SEMATECH) (On going by Kevin Orvek)

8. Update status and progress in EUV symposium. (SEMATECH) (Done)
Activity in SEMATECH
EUV Mask Defect Reduction Efforts

- LTEM frontside Bevels behind
- Polish/Clean improvement
- Flatness compensation: reduce polish defects

- Deposit ML/cap
- Deposition improvement
- ML smoothing

- Add Fiducials

- Mask Shop Sort for layer use by defect numbers
- Rotate Blank at Write step if helps to reduce defects
- Shift total write pattern X,Y to bury any remaining defects

- Map ML defects relative to fiducials
- Deposit absorber & resist and ship Blanks to Mask Shop

- Metal – moderate defects
- Contacts – many defects
- Gate – few defects

EUV exposure field
Proposed Mark Layout (Old)

- Shape and location is based on e-beam 2\textsuperscript{nd} alignment option
- There is overlap between scanner alignment key and fiducial mark.

Ref: ASML
New alignment key position is considering scanner key (ASML & Nikon) and blank rotation.
Overlap of ASML & Nikon Key & Blank Rotation

Red area are only possible area for fiducial mark to consider blank rotation.

- Large enough for coarse & fine alignment key of NuFlare
- Square area with the coronation of each corner of \((\pm 60000, \pm 60000), (\pm 71000, \pm 71000)\)

This area will be proposed to industry for SEMI standard.
Mark Dimension (Old)

Coarse alignment key

4096 µm

4 µm

Fine alignment key

400 µm

4 µm

• There is overlap between scanner alignment key and fiducial mark.
Proposal for Mark Dimension (New)

Options
- 4 coarse alignment key and 4 fine alignment keys.
- 2 coarse alignment key and 4 fine alignment keys.
- 2 coarse alignment key and 2 fine alignment keys.
Blank Mask Fabrication for Fiducial Mark

**Option 1**
- ML depo.
- Fiducial mark
- Absorber deposition screening fiducial mark
- Resist coating
- E-beam writing

**Option 2**
- ML depo.
- Fiducial mark
- Absorber depo
- Resist coating
- Exposure Fiducial mark open
- Absorber etch
- Resist coating

Blank maker
Mask shop
Fiducial Mark on Mask Blank

- **DPSS Laser**
  - Can be a solution for proto-type tool. However this company can’t have a technology for semiconductor industry.
  - Can implement stage with ~ um accuracy, and resolution down to 5um level with object lens.
  - Price will be less than ~$ 100K

- **Intel tool**
  - Uniformity of fiducial mark is not enough for ebeam application

- **CDC of Pixer technology**
  - Femto-second laser make damage on multilayer. However it shows best contrast.
  - They already have technology for semiconductor equipment.
Summary & Future Work

• SEMATECH is trying to collaborate with Industries, ebeam writing tool maker, and blankmask maker for basic test.

• One set requirement to address above attributes and specifications for all the tools involved
Discussion & Questions
(17:00 ~ 18:00)

• Development plan from Industry
• Discussion & Opinion
Thank you very much for your support on fiducial mark on EUV blankmask