

Capping layer materials selection and future investigation direction - A summarization

EUV optics contamination/protection
Committee

Summarized by

Intel Corp: Ming Fang, Manish Chandhok

Univ. of Gissen: Herbert Over

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1. Material characters must to have list

- High reflectance
- Oxidation/reduction resistance
- hydrophobic, carbophobic
- Trans capping layer diffusion resistance
- low residual stress
- thermal expansion coefficients
- One of as below:
 - resistant to cleaning procedures
 - self cleaning/healing capabilities

2. What promising materials (<5 nm) can be grown under 200 C ?

- Metal oxide and Silicates
 - TiO_2 , ; RuO_2 ; Nb oxide
- Metal carbide
- Metal silicide
- C-based lubricant (Concern: F-escaping)
- Metal:
 - Ru; Pt; Pd etc..(Concern: film continuity for heavy metals)
- Carbon nanotube (EHS concern)

3. How to prevent O₂/H₂ diffusion through capping layer?

- Grain boundary elimination
- Grain boundary block
- Minimize O₂, H₂, HC in the tool
- Capping layer surface treatment
- Sacrificial object adjacent to the mirrors (or cryopump, Ti-sublimation pump)

4. HC accumulation on the capping layer

- Oxide selection
- Electrical bias
- Surface modification (lewis acid)
- Passivation (H or OH)
- Hydrogenation environment
- Sacrificial object adjacent to the mirrors

May requires a combination solution

5. EUV radiation impact to capping layer?

- Diffusion
- Defects
- Catalysis
- HC cracking/polymerization
- Cracking of water
- Pesting (on small defects in the capping layer)

Supporting data are significantly lacking
to all above



6. Compatibility with last ML layer

- Adhesion/bonding
- Thermal coefficient
- Smoothness interface transition
- High contrast of interface

Oxide/Silicide/carbide have close similarity to substrate material

In summary

- Team is inclined to think ionic bonded binary materials are more promising cap layer materials compared to Ru
- Amorphous materials are better suited since they are free of grain boundaries
- Capping layer surface modification should not be ignored as a part of the solution
- The understanding of the impact from EUV radiation is lacking
- Knowledge of the HC's in the EUVL tool will be a great help to identify the solution of Carbon contamination.
- The progress of capping layer development is significantly gated by the availability of standard capping layer life time test technology.



Tasks and next steps

- Fundamental study of the impact of EUV radiation, including frequency, and interactions between EUVL tool environment and capping layer material
- Acceleration of development of standard technology of capping layer life time test. Bench marking and data feedback and sharing
- A strategy of capping layer cleaning
- Novel capping layer identification and development.