Exogenesis Corporation

Innovations in Surface Processing

SPIE Advanced Lithography Conference 2014

Accelerated Neutral Atom Beam (ANAB)
EUV Lithography applications
Agenda

• Company
• Technology
• Surface mechanism
• Applications
• Questions
Company

- Privately funded company employing platform technology enabling new generation of medical devices, photonics, solar, and semiconductor products.
- Vast experience in ion beam technology.
- Design, manufacture, and support automated HVM tool...Multiple tools in operation > 1 year
- Commercializing technology, with multiple customers in various industries
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ANAB Technology

Accelerated Neutral Atom Beam (ANAB):
• Vacuum-based particle accelerator.
• Low energy particles (10-100+ eV).
• Single atom particles
• Electrically neutral.
• Highly collimated, no divergence.
• Non-contact dry process
• High density flux rate (1e17 atoms/sec).
• Surface penetration 1-3nm

30,000kV / 1,000Atoms = 30eV per atom
Ionized and accelerated
Collision with gas atom makes cluster unstable
Atoms released from unstable cluster
Electrostatic deflection

deflector field
Coincident energetic neutral atoms
Energetic neutral beam configuration

accel

deflector

charged species

neutral atom beam

pressure sensor

thermopile

HV
TEM Images of bottoms of 100 nm deep trenches in Si produced by Accelerated Neutral Atom Beam (ANAB)
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Surface mechanism of ANAB

- Unique Lateral sputtering effect
  - Quartz sputter rate (~ 15-20 Å/sec)

GCIB’s lateral sputtering has been well documented.

ANAB retains these properties, but is more sensitive.
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EUV Lithography
mask blank substrate pit defect removal

Pit Defect (Quadrant +/-)

Before

After Global ANAB Process

Pit dimensions (~15 total)

2-15 nm

FWHM 30-50nm

*GCIB was evaluated and shown to be ineffective
EUV Lithography
mask blank substrate pit defect removal

Exogenesisis process

Ra 1.219 nm
Rz 11.221 nm

After Accelerated Neutral Atom Beam

Ra 0.133 nm
Rz 1.406 nm
EUV Lithography mask blank substrate pit defect removal

• Next step: characterize & optimize process

Dave Balachandran and his team *Engineered* pit defects into EUV MBS
EUV Lithography

Optics
EUV Lithography
Optics - Fused Silica

- **Dry Process** – No slurries to clean off
- **No Normal forces** – No sub surface damage

Cleans surface
- Polishing compound
- Organic material

**AR**
- \(Ra=0.150\)
- \(Rz=4.381\)

**ANAB**
- \(Ra=0.122\)
- \(Rz=1.941\)
EUV Lithography
Optics - Calcium Fluoride

- **Dry Process** – No slurries to clean off
- **No Normal forces** – No sub surface damage

**AR**

Ra=0.289  
Rz=6.190

**Exogenesis process**

**ANAB**

Ra=0.121  
Rz=1.355
EUV Lithography
Optics - Sapphire

- **Dry Process** – No slurries to clean off
- **No Normal forces** – No sub surface damage

Ra=1.40
Rz=13.90

Ra=0.11
Rz=1.10
EUV Lithography
Optics - BK7

- **Dry Process** – No slurries to clean off
- **No Normal forces** – No sub surface damage

Exogensis process

- **AR**
  - $Ra=1.671$
  - $Rz=21.248$

- **ANAB**
  - $Ra=0.150$
  - $Rz=1.260$
EUV Lithography

Optics - Aluminum mirror

- **Dry Process** – No slurries to clean off
- **No Normal forces** – No sub surface damage

Ra=5.672
Rz=47.331

Ra=0.595
Rz=5.413
Others

all between 0.20-0.10nm Ra (Atomic Force Microscope)

- **Dry Process** – No slurries to clean off
- **No Normal forces** – No sub surface damage

ZnS

Polycrystalline Diamond

MgF2
EUV Lithography
Thin Film
EUV Lithography
Thin Film

Sacrificial Carbon material
EUV Lithography
Thin Film

ANAB Process

Sacrificial Carbon material
EUV Lithography
Thin Film

**Self-limiting** process

2nm thick densified layer

Sacrificial Carbon material
EUV Lithography
Thin Film

2nm thick Carbon film

Remove sacrificial layer
EUV Lithography
Thin carbon films

• Visualized with 30,000x TEM
• Measured electron transparency = 0.95
  • Graphene measured transparency = 0.93
• ~1-3nm thick
• Uniform/high quality
• Free standing

40micron openings
EUV Lithography
Thin Film

• Proof Of Concept EUV pellicle

Single hole: 1mm Dia.

Thin film to be tested
Others

- Increases surface hydrophilicity

- Nano texture surfaces
Many thanks to the SEMATECH team lead by
Frank Goodwin & Dave Balachandran

Thank you
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Please stop by and visit us at booth328