Nanoimprint Technology for Large Area Patterning and Its Applications

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Outline

- Introduction of CNMM program
- Key issues for Nanoimprint lithography
  - UV & Thermal NIL processes
  - Imprinting Mechanism
  - Overlay & Alignment System
- Stamp Fabrications
  - E-beam lithography
  - Interference lithography
- Applications
Center for Nanoscale Mechatronics and Manufacturing

To develop technologies on nanoprocesses, nanofabrication equipments, and nanoscale analysis/design/control/measurement to manufacture commercial nanoproducts smarter, cheaper, and faster

Final Goal

- Fabrication technology of 2D/3D shapes composed of 100~10nm level nanowires, dots and structures
- Fully 3D shape nanofabrication
- Nano-applications: Nanoelectronics, RF communication components, bio sensors, etc
- 10nm level nanopatterning equipment
- Analysis/control/measurement of nanostructures
Nano Imprint Lithography Technology

- UV Nano Imprint Lithography (UV-NIL)
- Thermal Nano Imprint Lithography (TH-NIL)

Nanostage for Overlay/Alignment in NIL

6 DOF Nanostage

XYθ Stage

θxθyθz Stage

Resolution: 1nm
Stroke < 120um
1st Alignment: Moiré Fringe Analysis (1)

- Remove Background image (or Noise) to enhance the Contrast of Moiré fringe
- Remove Concentric Circular Grating Image
- Raw Image
- Subtraction Reference Image (Mask Image) from Raw one
- Moiré fringe extraction & Calculation of fringe center and boundary

Aligning Signal by Dual Grating

Gap: ~45um

Fine Alignment (0°) 180°Position  Fine Alignment (360°)  
Stamp Grating (Movable)  Wafer Grating (Fixed)

Estimated Aligning Accuracy: < 20nm
Multi-layer NanoImprint System: ANT-6Ho

- Overlay/Alignment Unit
- Stamp/Wafer Holder Unit
- Imprint Unit
- Linear Stage
- Nano/Micro Stage Unit

Nanoimprinted Pattern Uniformity

- 6in Wafer
- 4in Wafer
- 52nm (1:5)
- 50nm (1:5)
- 50nm (1:1)
- ANT-6Ho Imprinting Uniformity
Quartz Stamp Fabrication for UV-NIL

Resolution & Chemical stability

After Pirana solution test,
- 20 nm line array
- 40 nm line array

Pirana solution test:
- \( H_2SO_4 : H_2O_2 \ 4:1 \)
- 10 min dipping

Device application

Fabrication of Si Stamp using Interference Lithography

Aperture J launderer (310 x \( \mu \text{m} \) linewidth)
- Laser beam direction
- Optical filter
- Chemical solution (Resist)
- Photosensitive wafer
- Thin glass wafer
- Microladle
- 2 inch finite power ratio 98:1 (tol 7 to 200\%)
- 2 inch interference ratio 98:1 (tol 45° and 165° wavelength)
Interference Lithography

1st expo. (0˚): line pattern
1st expo. + 2nd expo. (single rotation): oval dot pattern
1st expo. + 2nd expo. + 3rd expo. (double rotation): triangular dot pattern

Experimental Results using PC Replica

Polycarbonate replica
- Blue Ray Disc pattern
- CD = 100~300nm

Resist pattern
- T Resist = 100nm
RNIL system for Flexible Electronic Devices

RNIL conditions
- Stamp: 6” Si wafer (micro pattern)
- 2” Si wafer (nano pattern)
- Flexible substrate: PC film with 0.38mm(T) x 150mm(W)
- Temperature: 165°C
- Moving speed of the press roller: 15 mm/min
- Maximum pressing force: 45 kgf

Key factors
- Heating and cooling conditions
- Pressing force and pressure conditions
- Tension of the flexible substrate
- Moving speed of the press roller

Micro patterned PC film by RNIL process and its SEM image.

300nm dot on PC
300nm line on PC

NanoImprint Lithography Applications

Tools: ANT-6H
NIL Results: 40G Bragg Grating Device

250nm/50nm Grating

NIL Results: Blu-ray Disc

100~300nm BD Pattern
NIL Results: Terabit HDD (10^12)

- 50nm pitch, 0.26Tb/in^2
- 40nm pitch, 0.4Tb/in^2
- 30nm pitch, 0.72Tb/in^2
- 25nm pitch, 1.1Tb/in^2

- 20 billion USD (Current)
- 500 million units (2007)

NIL Results using Si Stamp (3:1)

- Si Stamp (SNU)
- NIL Results (ANT-6H): KIMM
30nm Stamp-NIL-Etch barrier Etching: MOSFET

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NIL using 2G PUA Replica: 30nm patterns

Master Stamp: Si 30nm Pillar
PUA replica
Resist pattern
Resist pattern
Thanks for your attention!