Manufacturing Challenges for Lithography in the Textured Disc Paradigm

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Toshiba: DTR drive level demo 333 Gb/in²
400 Gb/in²
150 Gb/in²

TDK: DTR 602 Gb/in²

Manufacturing
Research
Roadmap

Optical disk
1996: DVD (4.7 GB)
1982: CD (700 MB)
Technologies for DTR implementation

- Pattern replication using Nano-Imprint
  - Stamp (Mold) Manufacturing process
  - Polymer coating on media
  - Imprint Lithography on both side of the media
  - Pattern-transfer
Lithography solution for High Volume DTR manufacturing

Stamp fabrication

- Producing One Master stamp
- Producing multiple copies from the master called Mother-stamp

1st stamp

Mother stamps

Final imprints on HDD substrates

- Producing multiple copies from each Mother-stamp called Intermediate polymer stamps (IPS)
- Use IPS for final imprints

Mother stamp

Intermediate stamp

Final imprints
Electron Beam Recorder, EBR

- System (EBR)
  - Rotation Stage (θ-x)
  - Thermal Field Emission (TFE)
  - 50 kV

Software for On Fly Pattern generation
- HDD pattern writer
  - DTR, BPM, Concentric patterns

- Optical disc writer
  - BluRay, HD-DVD, Next generation optical disc, Spiral patterns

Final output data is calculated on the fly during exposure
Electron Beam Lithography

Stage movements

Spiral writing

Concentric writing

Writing field
Active feed-back systems to improve accuracy

- **Beam Current**
  - Measured after several track recording to control the beam to ensure the Dose uniformity and long time exposure capability

- **Beam position, “Sub beam Deflection within 1 micron”**
  - <1 nm beam deflection resolution
  - High speed X-Y beam deflection

- **Linear stage**
  - Laser interferometer including interpolator to reach 0.5 nm resolution
  - Linear positioning accuracy 1.5nm 3sigma

- **Rotational Air bearing**
  - High accuracy rotation encoder including interpolator for 1 nm resolution
  - Rotation positioning accuracy 2nm 3sigma

- **Other measurements**
  - Capacitive measured substrate topography to maintain focused beam on the substrate
  - Measured unbalance and Run Out
Pattern definition and Writing strategy, DTR

Data Tracks

- Burst B
- Burst C
- Burst A
- Burst D

Sector No. S(x)
- Track Address T(n-1)
- Track Address T(n)
- Track Address T(n+1)
- Track Address T(n+2)

Servo Address
- Preamble

Writing track

Sector 0

Sector 1

Sector 2

Data Tracks
E-Beam exposed resist (70 nm pitch)
# Quartz/ Silicon Stamp Fabrication

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**Imprint stamp:** etched SiO$_2$ on Si.
Nickel Stamp Fabrication for HVM

- High resolution E-beam resist is spin coated
- Exposure of the DTR structure using Polar E-beam recorder (EBR)
- Develop the exposed resist
  - positive structure profile using Xylenes developer
Nickel Stamp Fabrication for HVM

- Sputter Metal seed-layer
- Electroplate 300um thick Nickel layer
- Separate the Nickel metal from the Master

This nickel stamp is called Father-Stamp
Nickel Stamp Fabrication for HVM

- Apply a mono-layer Oxide on the Father-stamp, serving as separation-layer

- Electroplate new Nickel-stamp (Mother-stamp) from the father

- Repeat the last electroplating process to produce several Mother-Stamps
Nano Imprint Lithography Process
Solution for HDD

Intermediate polymer stamp (IPS®)

Mother Stamp

IPS® (Intermediate Polymer Stamp)

IPS® (UV-transparent film)

STU®

UV-radiation
IPS ® -polymer

Constant working temperature

STU ® -polymer
Substrate

UV

UV-radiation
IPS®
UV monomer

UV-polymer
Substrate
Double side imprint (IPS®-Disk-IPS®)

Constant working temperature

UV-radiation

IPS® #1
STU®-polymer
StU®-polymer
IPS® #2
HDD disk

STU®-polymer
HDD disk

STU®-polymer

STU®-polymer
Double side imprint (IPS-Disk-IPS)

DTR structure

Optical disk structure

Side A

Side B

STU-polymer

2.5” disk

Side A

Side B
Double side imprint (RRO measurement)

Radial Run Out measurements made in an Optical Disk test system showing RRO < 30nm
Thank you for your valuable time