EUV Mask Substrates polishing developments at SAGEM

S. Chaillot, X. Bozec, B. Pinot, R. Geyl
REOSC SAGEM SA
Avenue de la Tour Maury
91280 Saint Pierre du Perray
FRANCE

EUV Mask Substrate Specs

- **Main Specifications** :
- Three main optical criteria have to be achieved together for a successful mask substrate according to SEMI P37-1101 specifications.
- Among this the main critical quality criteria for a mask substrate are:
  - Very low flatness : < 50 nm PTV
  - Very low MSFR : < 1 mrad PTV
  - Very low roughness : < 0.15 nm RMS
  - Defects of size > 50 nm in quality area : None

Work Approach:
Polishing means specific adaptation
Work on lower roughness - lower defects
Work on flatness & parallelism correction by IBF
Specific polishing, cleaning, handling development

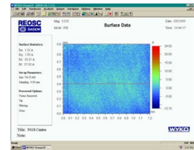
Metrology equipment

Goal : To Optimize metrology tools and know how

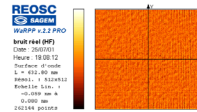
Results: The full Power Spectral Density spectrum is covered

LSFR 250 mm - 1 mm => Interferometry
MSFR 1 mm - 2 µm => Micro-interferometry
HSFR 2 µm - 0.01 µm => AFM

Specific Control Equipment:
Zero-G and Zero-stress fixing and positioning
No backside interaction



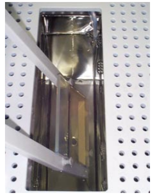
0.05 nm MSFR noise



0.04 nm HSFR noise

Cleaning

Low defect level requires high performance cleaning on different material substrates during all the manufacturing process

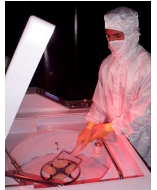


Multi stage cleaning process :

Wet bench
Multi-step specific chemical treatments
(Ultrasonic assisted)

Jet spinning
Combined chemical and HP jet cleaning

Works :
Handling, storage and carriering in one-to-one ultraclean solutions

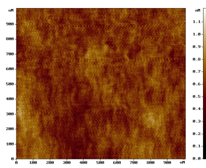


Flatness Correction With IBF

Ion Beam Figuring is a deterministic way to achieve Flatness and parallelism Specs

Tested Material	: Quartz, Zerodur, ULE, Clearceram
Low roughness	: < 0.1 nm on Silica and ULE materials
Dimensions	: 6" x 6"
Flatness	: Before IBF = 300 nm PV typical
	: After IBF = 50 nm PV typical

Substrate figuring < 50 nm PTV

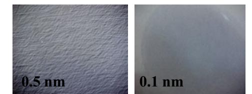


Figuring keeps 0,1 nm roughness

Key issues
- **To keep the 0.15 nm RMS Roughness**
- **To control the defect density increase**

Super smooth finishing

Two Polishing Process are developed and tailored on Silica, Clearceram ™, ZERODUR ™, ULE ™ .

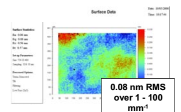


Large area optical inspection

Low roughness

Results :

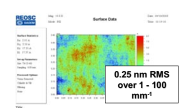
1st :	Low HSFR	0.1 nm RMS
	Extremely low MSFR	0.08 nm RMS
	Defect number (higher)	100 u / cm² (< 500 nm)
2nd :	Low HSFR	0.1 nm RMS
	Low MSFR	0.25 nm RMS
	Defect number (lower)	1 u / cm² in progress



Very low MSFR level

Both processes are ion-beam figuring available : roughness and defect level are preserved during LSFR correction step on parts of materials

Only 2nd process will be selected to pursue development to reduce MSFR and defect level .



Low MSFR level

Output : samples and first batch of photomask substrates

Defects counting on cleaned mask substrates

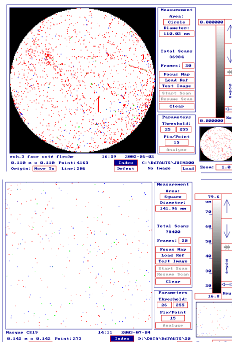
Goal :
To monitor the defect level density for improving our polishing process

Equipment :
Laser scattering optical microscope analyzer

Cooperation :
Development of collaborations with laboratories for defect inspection (CEA LETI, Université de Lyon)

Results :
Measurements on Silica, ULE and Clearceram Mask substrates after polishing and cleaning Ł 0.1 to 1 defects /cm² > 300 nm

SAGEM is now installing a mask inspection test bench for monitoring defects which have a size > 500 nm.



Process 1 on ULE

Process 2 on ULE

Conclusion

- Efforts have been placed to explore the various fabrication steps : Polishing - testing - figuring - cleaning - defect counting
- New equipment for cleaning, control and inspection are now installed and operational
- Process 2 selected for lower defect density advantage
- Our roadmap is to improve the defect density by a factor of 10 and to produce a first batch of 5 to 10 photomask substrates before Q4/2003

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