Ion beam sources for surface modification

André Rosenkranz
24.08.2015 – ICIS 2015
Customer requirements

**specific characteristic for the industry**

<table>
<thead>
<tr>
<th>Throughput</th>
<th>Ion current density, process time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic feasibility</td>
<td>CoO: total costs, maintenance effort, rate and time</td>
</tr>
<tr>
<td>Adjustability</td>
<td>Current, energy, process gases</td>
</tr>
<tr>
<td>Quality</td>
<td>Reproducibility, uniformity, beam spot size</td>
</tr>
</tbody>
</table>

---

Fig 1: RF ion source cyberis 350-f

Fig 2: RF ion source cyberis 40-i,
IonScan provides solutions for:

Problems in film homogeneity that significantly reduce the yield of a device.
Configurations of IonScan 800

**Fig 1:** Wafer handling of IonScan 800

**Fig 2:** System Layout of IonScan 800

- Configurations
  - Source chamber
  - Water distribution
  - Transfer chamber
  - Load lock
  - Axis controller
  - Robot
  - Cassette elevator
  - Faraday array
  - Wafer chuck

**Fig 2:** System Layout of IonScan 800

**Fig 2:** System Layout of IonScan 800

- Configurations
  - Source chamber
  - Water distribution
  - Transfer chamber
  - Load lock
  - Axis controller
  - Robot
  - Cassette elevator
  - Faraday array
  - Wafer chuck
Principle of ion beam trimming

- Raster scan of wafer by axis stage in front of focused ion beam
- Control of local material removal by calculated velocity profiles
- Individual wafer specific velocity profiles for optimum process performance
- 4-axis system to scan, focus adjust and wafer tilt
cyberis 40-i for IBE

- Compact (d = 100 mm; l = 300 mm) internally mounted UHV compatible broad beam ion source with different types of spherically shaped grids (C, Mo) for beam focus control
- Inductively coupled 13.56 MHz operation with source integrated RF matching network
- Compatible for noble (Ar, Ne, Xe) and reactive gas (O\(_2\), N\(_2\), NF\(_3\)) operation
- Ion energy between 100 … 1.800 eV, beam current up to 100 mA (standard 6 … 50 mA)
- Beam profile gaussian shaped σ between 2 … 8 mm

Fig 1: RF ion source cyberis 40-i, Fig 2: maintenance of the plasma chamber
Trimming of Bulk Acoustic Wave Devices (BAW)

Thickness Trimming of Molybdenum Contact

- Trimming of 8" Film Bulk Acoustic Resonator (FBAR) molybdenum contact thickness
- Reduction of standard deviation of 2.8 nm to 0.2 nm in one run
- Adjustment of target thickness of 280 nm by 0.2 nm
Optimization of the source lifetime

- regulation to the set point ion current with a adjustable RF power
- simplification and standardization of the maintenance
- prevention of back sputtering material

**Graph:**
- **Y-axis:** Ion Beam Current / mA
- **X-axis:** RF Power / W
- Lines for different Ar$^+$ Ion Beam currents (2 sccm, 3 sccm, 5 sccm)
- Beam hours / h vs. plasma chamber
Process stability and repeatability

80 beam hours

- Beam energy: 1200 eV
- Working distance: 65 mm
- Standard deviation: 52 µm

RF power vs. plasma chamber

- RF power: 80 beam hours
- Beam spot size: σ
Objectives and next steps for the development of the cyberis 40-i

- MTBF for process with parameter adjustment from 400 to 600 beam hours
- Avoidance of early failures
- Improvement of the maintenance
- Extraction current increase for cyberis 40-i up to 150mA
- Focused ion beam with a footprint of 2mm FWHM
- High current density up to 50mA/cm² on focused ion beam
Configuration of IonSys800

- Wafer based ion beam milling of up to 200 mm wafer size
- Ion beam milling (350 mm RF ion beam source)
- Dual ion beam sputter deposition (120 mm RF ion beam source)
- Reactive ion beam sputter deposition (RIBS)
- Target drum for 4-6 targets (100 … 300 mm)
- Wafer based handling from cassette
- Aligned handling and processing
- Wafer chuck with tilt, rotation (0 … 20 rpm)

Fig 1: configuration of IonSys800
source characteristics and parameters:

- filamentless inductively coupled RF-discharge by atmospheric coil (4 MHz)
- beam diameter of 350 mm
- ion energy up to 1.5 keV
- current densities up to 1 mA/cm²
- ion current up to 1 A
- RF-power up to 1600 W (1000 W for long-term operation)
Test of different grid configurations

Grid design 1

Grid design 2
Ion beam milling and uniformity test

- Ion beam source: cyberis 350-f
- Process time: 5 min
- Sample Material: SiO2
- Process: Ar⁺ ion milling
- Ion incident: perpendicular
- Ion energy: 400eV
- Ion current: 550 mA
- Neutralizer current: 600 mA
- Wafer rotation: 15 rpm

**Uniformity**
Min-Max/(2*Mean) = 3.1%
THANK YOU FOR YOUR ATTENTION

Meyer Burger ST MicroSystems

Address: Roth & Rau AG
       BU MicroSystems
       An der Baumschule 6-8
       09337 Hohenstein-Ernstthal
       Germany

Phone: +49 (0) 3723 671 - 1564
Fax: +49 (0) 3723 671 - 1000
Email: info@microsystems.de
Web: www.meyerburger.com
Dual Ion Beam Deposition (DIBD)

**Sputter Ion Beam Source**
- Control of material deposition rate by ion flux and energy
- Variable inert gas (Ar, Xe, ...) for optimized energy transfer to the target atoms

**Assist Ion Beam Source**
- Substrate pre-cleaning
- Film microstructure control (stress, density, morphology)
- Ionization or excitation of reactive gas for reactive ion beam sputtering
- Ion beam etching

Technology powered by MEYER BURGER