Circular Ion Sources for pre-treatment, etching and ion assistance

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Structure of the Presentation

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- Ion Source Principles
- IMC75 Principle
- IMC75 Operating Range
- Power Supply/Feedback Control
- Etching Results
- DLC Coating Results
- Summary
Reach your full potential with Gencoa’s unique tools

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Gencoa IM75 plasma source for **Research and Development**

**A multi-functional plasma beam**

- A powerful new tool for thin film research.
- Fits into the space of a typical magnetron and has head tilt adjustment.
- Self neutralized plasma - no substrate surface charging.
- Variable plasma energy.
- Automatic gas feedback control via the IM300 power supply (any gas).
- Robust design with no maintenance.
- Can replace RF substrate etching.
- Multiple uses - ion assistance, patterning, pre-cleaning, coating stripping, PECVD
Introduction

Ion sources for vacuum applications are a product of Hall Effect Ion Thrusters developed by USSR & USA during the space race of the 1950s/60s.

Courtesy of NASA
Surface Modifications - Nanotexturing

Coating removal
Improving Coating Adhesion

Etching prior to deposition on semiconductor applications

ITO & Silver Deposition Assistance
Ion Beam Deposition (IBD)

Scratch resistance test on uncoated and coated glass

Source: Guardian Glass GPD 2009
• Filament erosion leads to sample contamination
• After a limited number of hours the filament needs to be replaced
IMC75 Self-neutralization Principle

Gencoas's Ion Sources – Anode Layer Gridless

Anode

Electric Field

Plasma

Cathode

Self-neutralization via tunnel effect

Tunnel effect electron extraction

Ion beam
Ions travelling near a cathode would deform the electric field. With a strong deformation electrons would be able to be extracted by tunnel effect.
Gencoa IMC75 plasma source neutralized beam via tunnel effect electron extraction

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Full plasma beam when substrate is grounded
A floating potential is generated on a non-conductive substrate, e.g. glass substrate, a retarded field will appear to slow down ions so that the number of electrons and ions arriving at the surface neutralise each other without building of more charge.
This type of ion source is specially suited for complex substrate as it will automatically adapt to the substrate electrical nature.
IMC75 Characterization

Operation Range for IMC75 Ion Source

This area required high flow and secondary plasma made it unstable.

- Normal operation area
- Extended operation area
- Low energy area
- Very Low energy area

Operation Range equivalent to industrial large area Linear Ion Sources.
Ion Energy Distribution for IMC75 Ion Source

No. of ions

~ e.(\(V_A/2\))

Energy, eV

e.\(V_A\)

(V_A = Anode Voltage)
Etching Area

No Etching Area

Etching Area
Etching at different distances

Ion Source

Substrate

165 mm

60 mm
Copper on glass

StSt on glass
Source to Substrate distance affects the area of etching. The integrated etching rate is practically constant over a very large distance range.
Crystal Sensors were coated with 1 µm Cu coating and arranged in a static array in front of the Ion Source. Etch rates were evaluated by the loss of Cu mass in different etching conditions.
60 mm - Argon

- Etching at 60 mm
- Redeposition

- Cu etching rate at 2kV
- Cu etching rate at 1.5kV
165 mm - Argon

- **Cu etching rate at 2kV**
- **Cu etching rate at 1kV**

Distance (mm)

Etching Rate (nm/min)
IMC75 Ion Etching

Etching Stainless Steel

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165 mm

60 mm
AFM was proven to be the best tool to visualize the effect of the ion treatment.

The sample here is as received with no treatment.
Diamond-Like Deposition

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Ethylene DLC
Gencoa provide a unique customer built power supply that automatically regulates two gas flow for ease of operation.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output voltage</td>
<td>Up to 2500V (3000V ignition voltage)</td>
</tr>
<tr>
<td>Output current</td>
<td>550 mA</td>
</tr>
<tr>
<td>Output Power</td>
<td>1750W @ 2500V</td>
</tr>
<tr>
<td>Output polarity</td>
<td>Positive</td>
</tr>
<tr>
<td>Regulation Mode</td>
<td>Current 0-0.7A</td>
</tr>
<tr>
<td>Output connector</td>
<td>Fischer, type 105, 10kV rating for RG213 coax cable</td>
</tr>
<tr>
<td>Weight</td>
<td>3kg</td>
</tr>
<tr>
<td>Cooling</td>
<td>Forced air cooling</td>
</tr>
<tr>
<td>Working temperature</td>
<td>15-35 °C</td>
</tr>
</tbody>
</table>

Active Front Panel - Touch screen display, 240x128 pixel. Automatic voltage tracking by dynamic flow adjustment for constant voltage (requires MKS 1179A MFC) (VT) - 2 channels, analog 0 to 5V, supply +15V, max supply power 10 Watts.
Input 240 AC or 115 ac switch selector inside max 500va
Size 3UI rack mount L=480mm H=178mm D=300mm
CE Mark
Schematic of the ion source with power supply and automatic gas regulation

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Removes beam variation – I & V regulated

- **IM300 Power Supply**
- **Power Cable**
- **MFC cable (for MKS's MFC), D9-D15 Shielded**
- **Gencoa IMC75**
- **Chamber**
- **Pump**
- **MFC Spec:**
  - MKS 1179A
  - Db15
  - ±15V

**Gas**
Oxygen could also be added to the process in order to harden the DLC in a more sp$^3$ structure.
IM600 at 300mA - gas Ar - Example of voltage tracking feature via auto control of gas

Started in constant flow and not feedback
Then switched to feedback control to maintain both current and voltage of the Ion Source

1.6 kV maintained by auto-gas feedback

Ar flow % of 50 sccm

Time, s
Diamond-Like Deposition

**IMC75**

- Current: 45 mA
- Pressure: 0.4 – 3 mTorr

**Process Control:** feedback mode

**Adhesion**

**DLC deposition**
Diamond-Like Deposition

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IMC75 DLC – Berkovich Nanoindentation tests

Loads from 100 µN to 10000 µN

Acknowledgement: Dr José Fernández Palacio & Dr Satishkumar Kulkami
AIN (www.ain.es)
Loads from 100 µN to 10000 µN

Reduced Modulus, Er (GPa)

Contact Depth (nm)

Glass

DLC-06

DLC thickness: 220 nm

Acknowledgement: Dr José Fernández Palacio & Dr Satishkumar Kulkami
AIN (www.ain.es)
- Inverted Magnetron Ion Beam
- Grid/Filament-less Ion source – Long maintenance & no contamination.
- Self-neutralised ion beam
- Operating pressure in large pressure range (E-4 to E-3 mbar)
- Tilting head – ion angle control.
- Stable ion beam current and ion energy distribution due to integrated closed loop feedback control
- Variety of gas feeds possible
- Suitable for pre-treatment of both metals, polymers and ceramics
- Scalable to linear ion sources for large scale production equipment due to similar operating characteristics
THANK YOU FOR YOUR ATTENTION

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