



Extraction of an Aluminum-Nitride Ion Beam from a Planar Magnetron Sputter Type Ion Source

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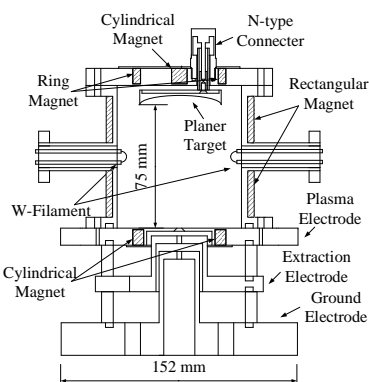
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INTRODUCTION

Ion beam based processes to prepare semiconductor devices open possibilities to further down size electronic components in future. Aluminum-Nitride (AlN) has many applications, and it has been often produced by deposition processes. Direct implantation of AlN molecular ions into other materials may realize a new semiconductor fabrication system. This study presents the results of efforts to realize stable AlN⁺ beam extraction from a planar magnetron sputter type ion source.

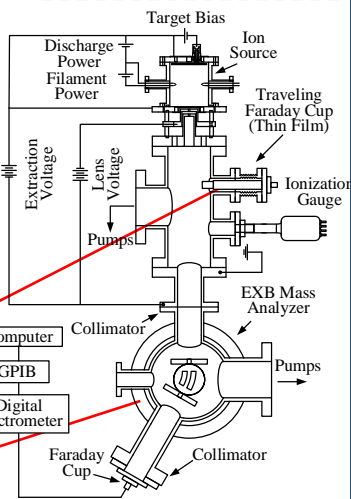
EXPERIMENTAL APPARATUS



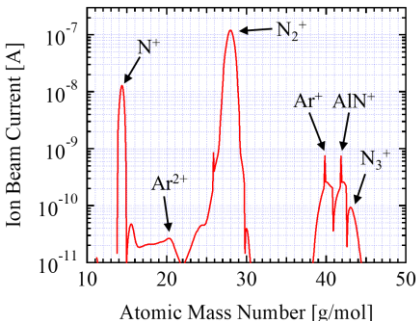
Discharge Chamber :

- Diameter 80 mm, Height 92 mm
- Hot cathode discharge (Φ 0.35 mm, 40 mm, Hair-pin type)
- Magnetic multicusp geometry
- Sputtering Target**
- Concave lens structure
- Diameter 60 mm, Thickness 12 mm, Concave radius 90 mm
- 5 mm thick ceramic insulation
- Extraction System**
- Composed of 3 electrodes: Plasma electrode, lens electrode, ground electrode.
- Electrode distance: 3 mm
- Extraction holes: Φ3 mm

- The resolution of the mass analyzer is about 60 at the maximum.
- The gas pressure at the ion source was measured to be 140 times the ion gauge reading of the downstream chamber.
- The shown pressure is the one in an ion source.

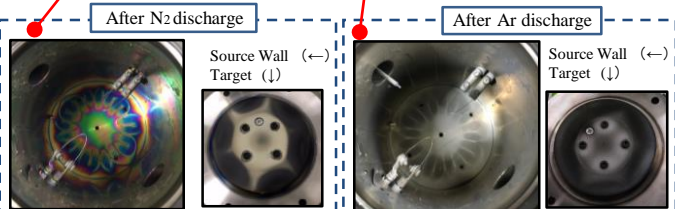
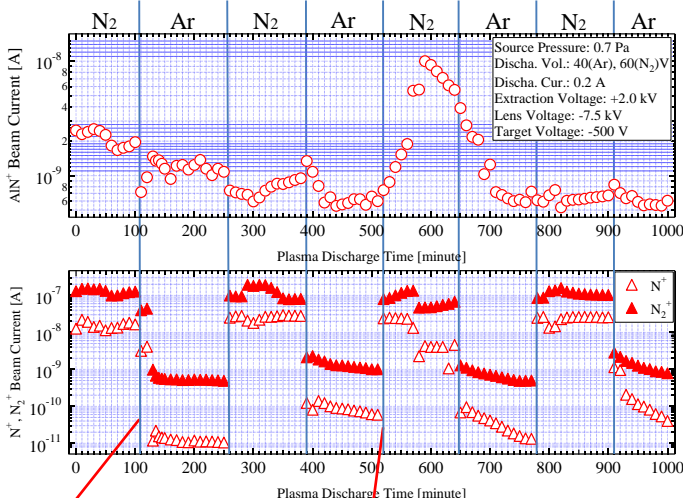


TYPICAL MASS SPECTRUM



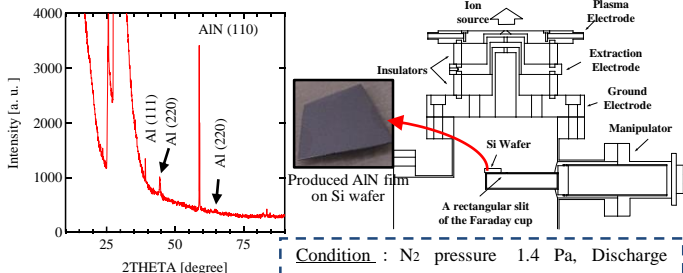
- Experimental condition**
- Discharge Voltage: 60 V
 - Discharge Current: 0.2 A
 - Extraction Voltage: 2.0 kV
 - Lens Voltage: -7.5 kV
 - DC target bias: -500 V
 - N₂ pressure: 0.7 Pa
- * Plotted beam current in the graph shows the value of the spectrum

AlN⁺ BEAM with DISCHARGE TIME



- 2 hour-interval experiment (every 2 hours: N₂ → Ar → N₂ → Ar :)
 - **After N₂ discharge:** Source wall covered with AlN layer (rainbow), formation of dielectric part on the target (one of AlN feature ?)
 - **After Ar discharge:** Source wall covered by Al layer (silver), cleaned Al target.
- * AlN⁺ beam current increased at the beginning of the Ar discharge after N₂ discharge.
→ The target covered with AlN layer prepared to produce AlN⁺ in the sputtering of Ar⁺ to AlN layer.

XRD ANALYSIS



- Condition :** N₂ pressure 1.4 Pa, Discharge current 0.5 A, Extraction Vol. 3.0 kV
- *Total beam injection to Si wafer for 3 hours

SUMMARY

- A planar magnetron sputter type ion source was operated to extract AlN⁺ beams.
- The peak of AlN⁺ was successfully detected in the mass spectrum. However, the peak was included in the Ar⁺ peak at the condition of high Ar pressure.
- Long time operation of the source exhibited the memory effect of the operation history upon the beam extraction.
- The result of XRD analysis showed the possibility of AlN layer production on the Si wafer by beam injection.