Solid State Cesium Ion Beam Sputter Deposition

Hong Koo Baik
Department of Metallurgical Engineering, Yonsei University, Seoul, Korea

The solid state cesium ion source is alumino-silicate based zeolite which contains cesium. The material is an ionic conductor . Cesiums are stably stored in the material and one can extract the cesiums by applying electric field across the electrolyte. Cesium ion bombardment has the unique property of producing high negative ion yield. This ion source is used as the primary source for the production of a negative ion without any gas discharge or the need for a carrier gas.

The deposition of materials as an ionic species in the energy range of 1.0 to 300eV is recently recognized as a very promising new thin film technique. This energetic non-thermal equilibrium deposition process produces films by "Kinetic Bonding / Energetic Condensation" mechansim not governed by the common place thermo-mechanical reaction. Under these highly non-equilibrium conditions meta-stable materials are realized and the negative ion is considered to be an optimum particle or tool for the purpose. This process differs fundamentally from the conventional ion beam assisted deposition (IBAD) technique such that the ion beam energy transfer to the deposition process is directly coupled the process.

Since cesium ion beam sputter deposition process is forming materials with high kinetic energy of metal ion beams, the process provides following unique advantages:(1) to synthesize non thermal-equilibrium materials, (2) to form materials at lower processing temperature than used for conventional chemical or physical vapor deposition, (3) to deposit very uniform, dense, and good adhesive films (4) to make higher doposition rate, (5) to control the ion flux and ion energy independently.

Solid state cesium ion beam sputter deposition system has been developed. This source is capable of producing variety of metal ion beams such as C, Si, W, Ta, Mo, Al, Au, Ag, Cr etc. Using this deposition system, several researches have been performed. (1) To produce superior quality amorphous diamond films (2) to produce carbon nitirde hard coatings(Carbon nitride is a new material whose hardness is comparable to the diamond and also has a very high thermal stability.) (3) to produce cesiated amorphous diamond thin film coated Si surface exhibiting negative electron affinity characteristics.

In this presentation, the principles of solid state cesium ion beam sputter deposition and several applications of negative metal ion source will be introduced.

Contents

- Solid state cesium ion source
- Negative metal ion beam source
- Deposition system and application
- Carbon Nitride

Energetic Condensing - Dr Jerome J. Cuomo

- Process where the condensing particle carry in the range of 1.0-300eV.

Kinetic Bonding - Dr. J. Ishikawa

KINETIC BONDING

Negative Ion Beam

- Low surface charge-up voltage
  - several Volts
  - No breakdown of the insulator
  - ULSI and TFT fabrication
- Deceleration without accelerated particles
- Electron affinity : about 1 eV
- Absorbable neutralization : Cool
- Seperated effect of kinetic energy from electron affinity

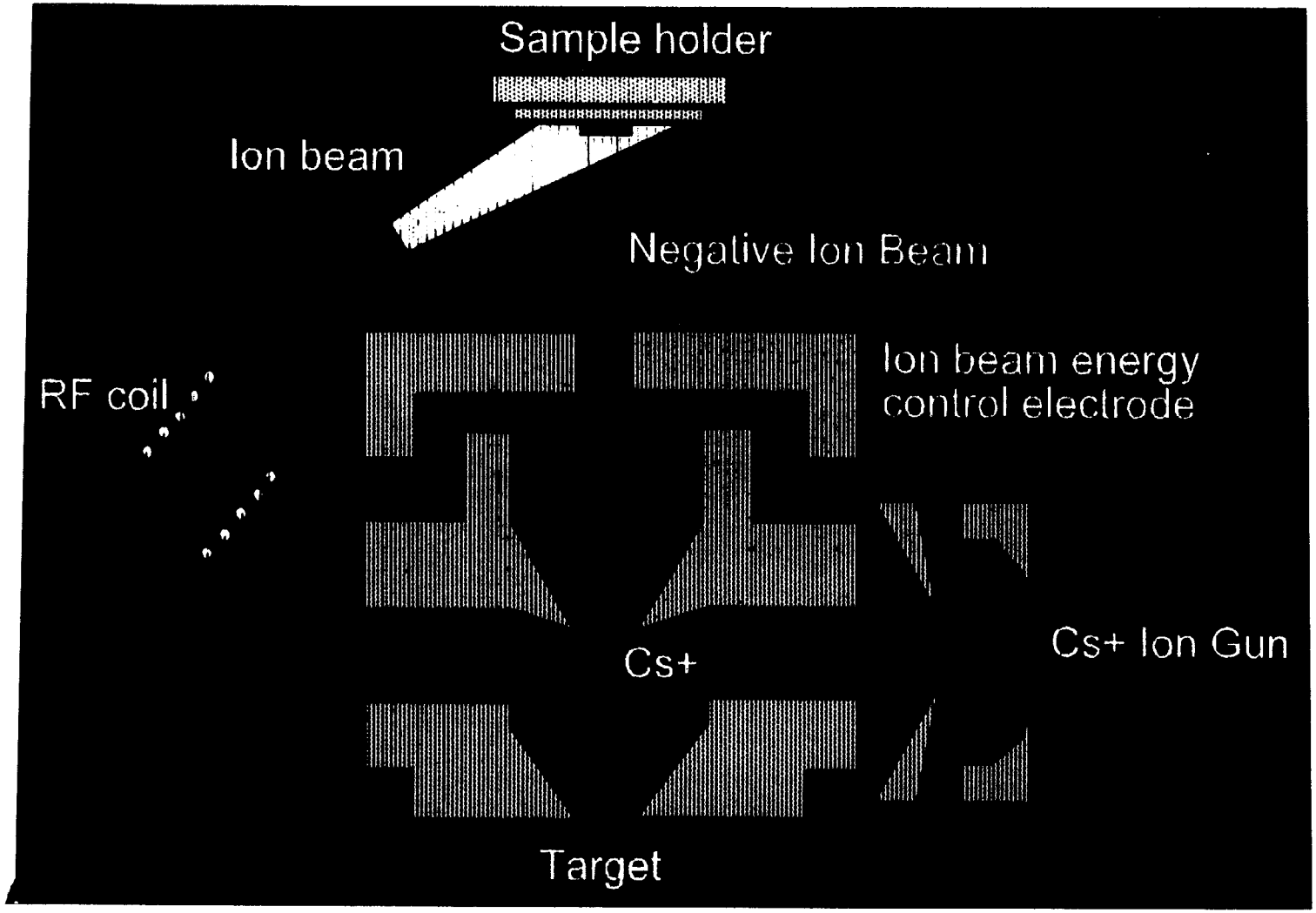
Positive Ion Beam

- High surface charge-up voltage
  - acceleration voltage
- Deceleration with accelerated electron
- Ionization potential : about 10eV
- Ejective neutralization : activation
- Mixed effects from ionization potential and kinetic energy

for clarifying the atomic-bonding formation mechanism through kinetic energy

Solid state cesium ion source

- Cesium Mordenite (Cs_2O Al_2O_3 $10SiO_2$)
- Solid electrolyte
- 100 hours operation at cesium ion current 0.1mA
- Compact and Economic


Sample holder
Ion beam
Negative Ion Beam
RF coil
Ion beam energy
control electrode
Cs+
Cs+ Ion Gun
Target

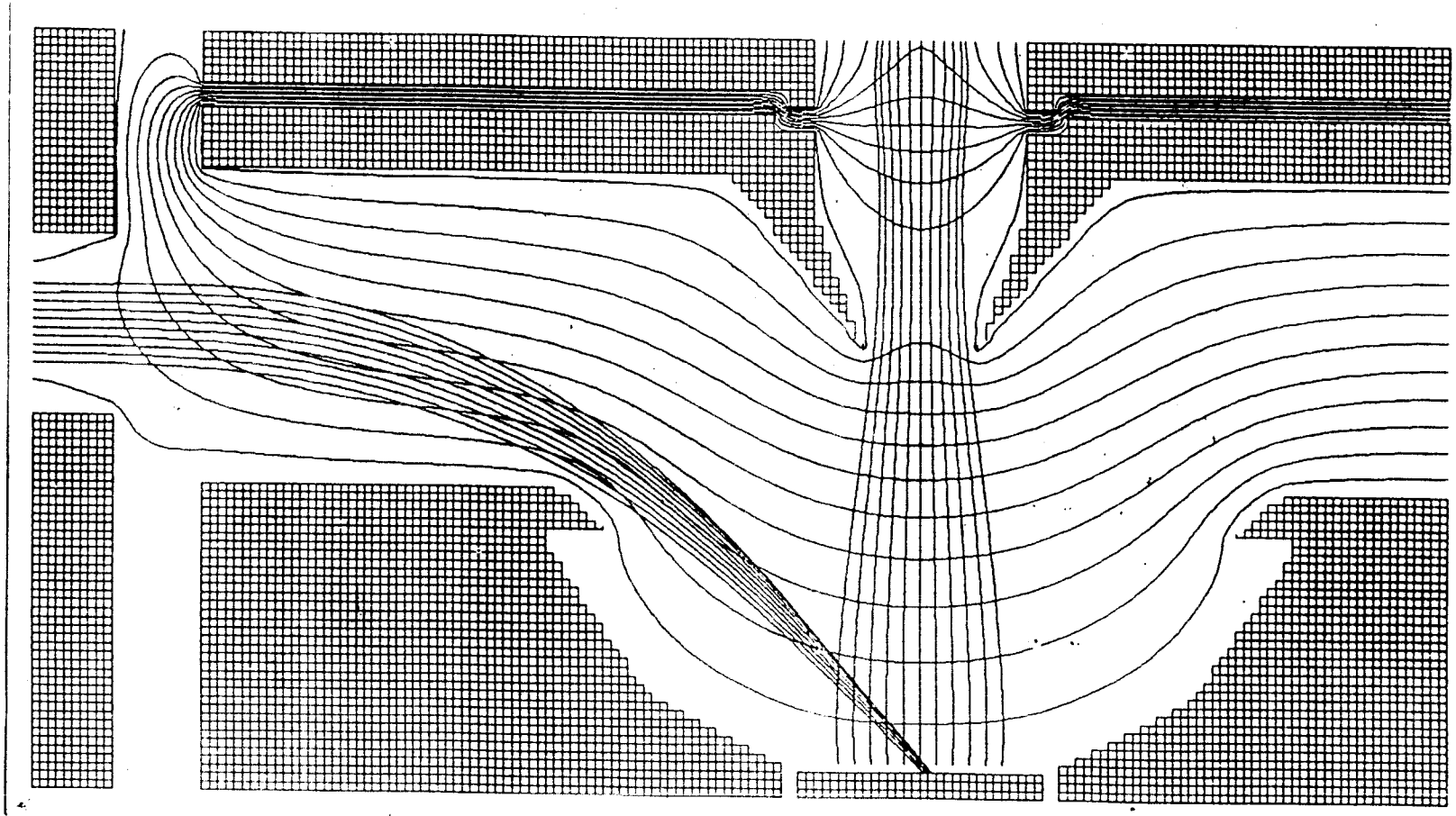


Fig. Cs^{+} and C^{-} Ion Beam Trajectory by SIMION

Cs+ Ion Gun Sputter Depositioin System

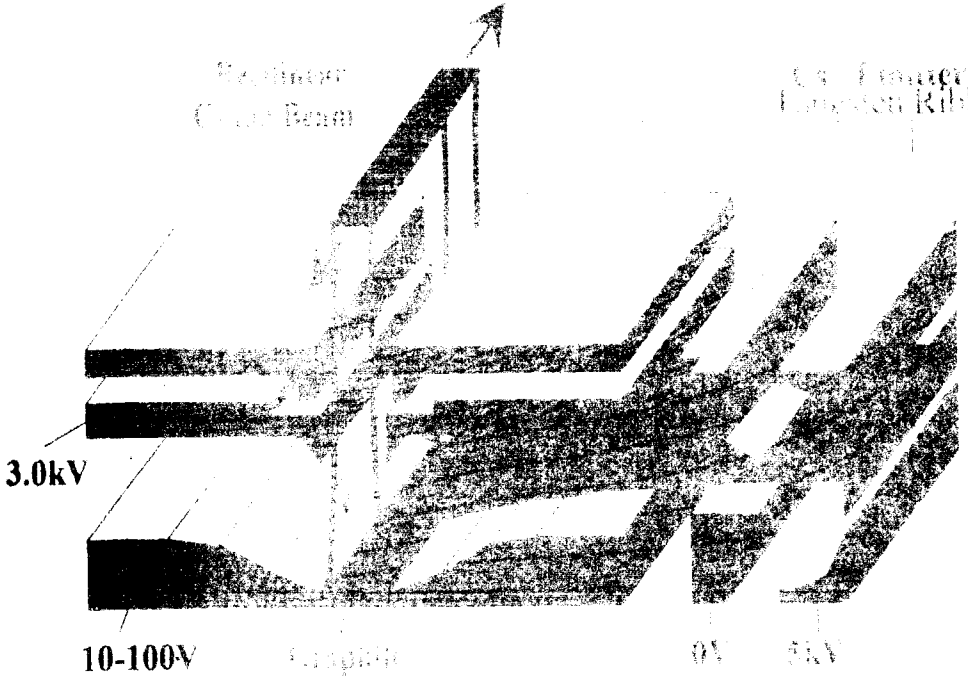
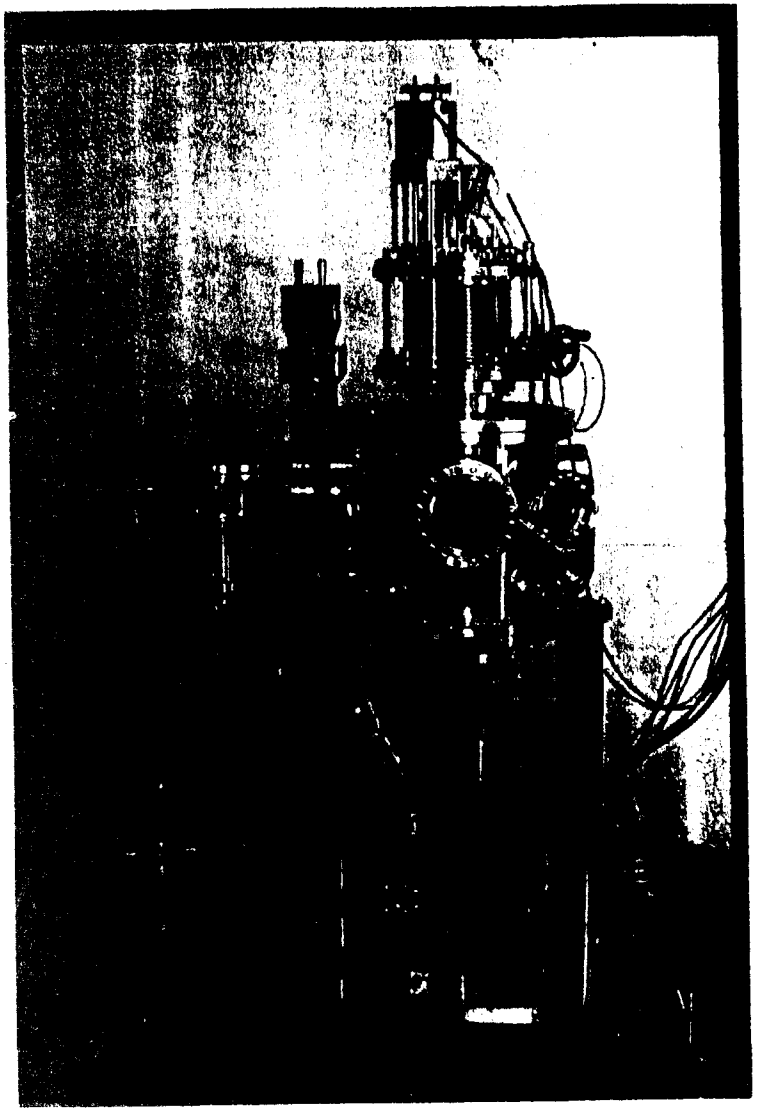


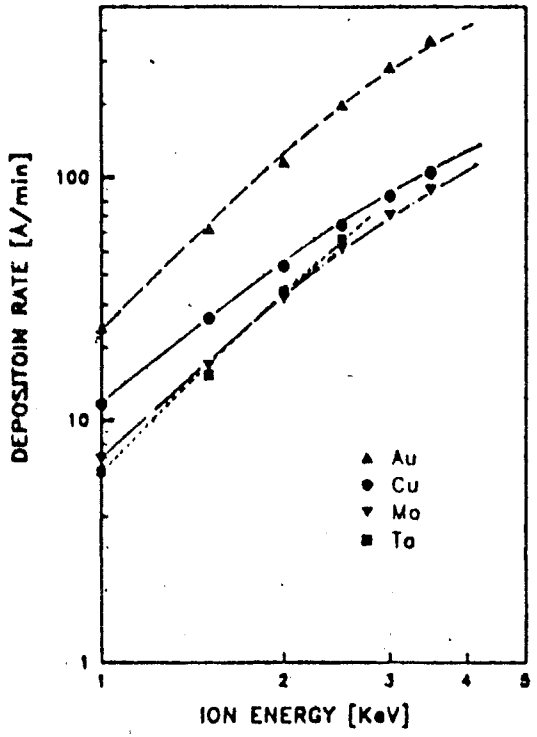
Fig.



3.2 Significance of the Cs+ IGSDS

- (Rectlinear Ion Beam source)
- (up to 100 um/hour)
- No material consumption
- Room temperature deposition (plastice substrate)
- Exact
- Negative carbon (metal) ion source
  - Maintane the electric field
  - No charge build-up
- No hydrogen : No CH_4
- Good adhesion and low stress of the film

Deposition Rate



Data from:
S.I. Kim, Y.O. Ahn, & M. Seidl,
"Solid State Cesium Ion Gun for Ion Beam Sputter Deposition"
Review of Scientific Instrument,
63(12), p.5671, 1992

I. Application

- Wear resistance coating for high speed cutting tool
- High temperature material : Thermal stability(1000°C)
- Protective coating for VCR head and drum
- Protective coating for IR window
- Missle radome
- Heat Sink for electronic device
- Field emitter of FED

Deposition System and Applicaion

Application

- to synthesize non thermo-equilibrium materials
- to form materials at lower processing temperature
- to deposit very uniform, dense, and good adhesive films
- to produce thin films with new metastable phase
  - Carbon Nitride