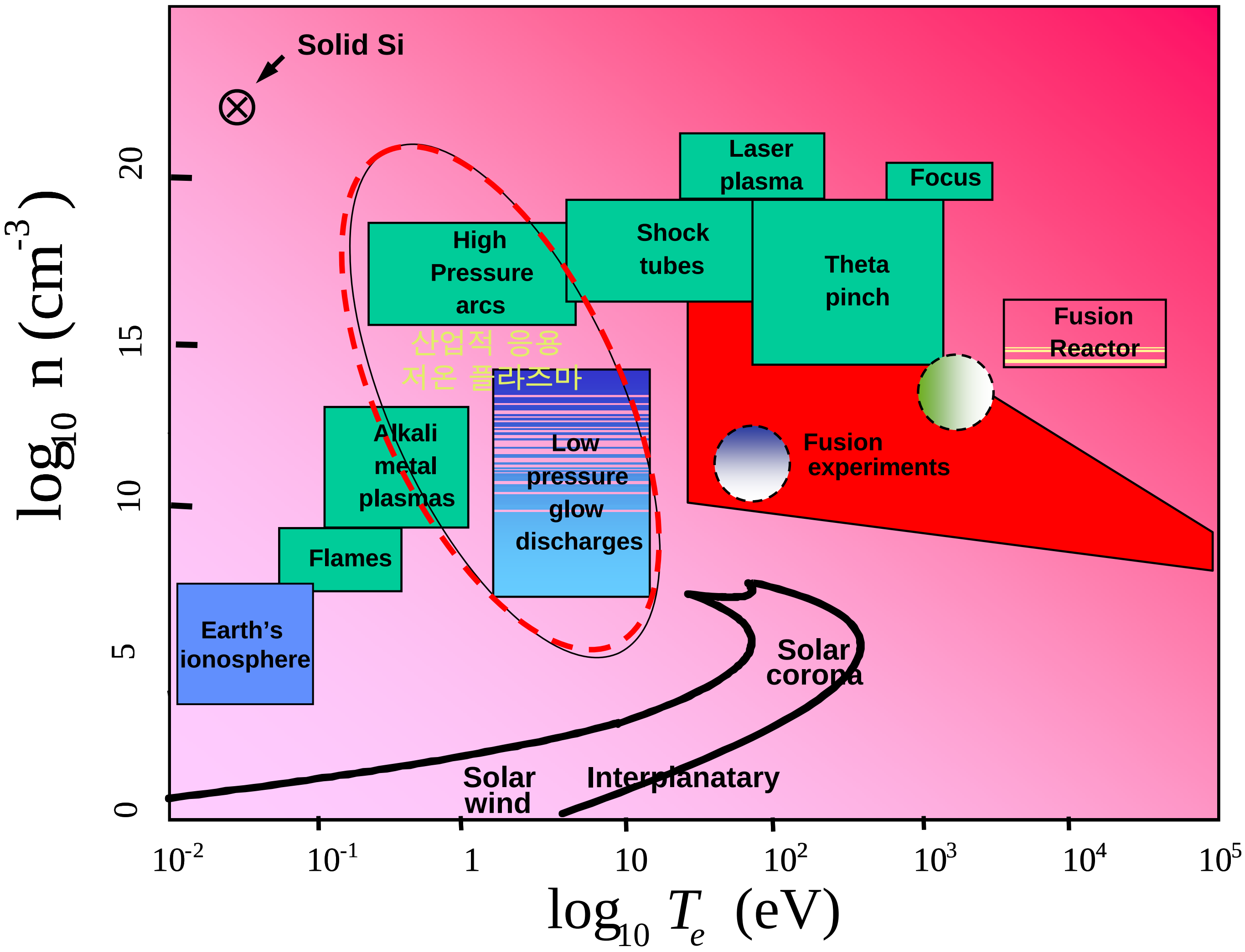
금속-폴리머 접착력 증진을 위한 플라즈마 표면처리

KIST

Advanced Metals Research Center

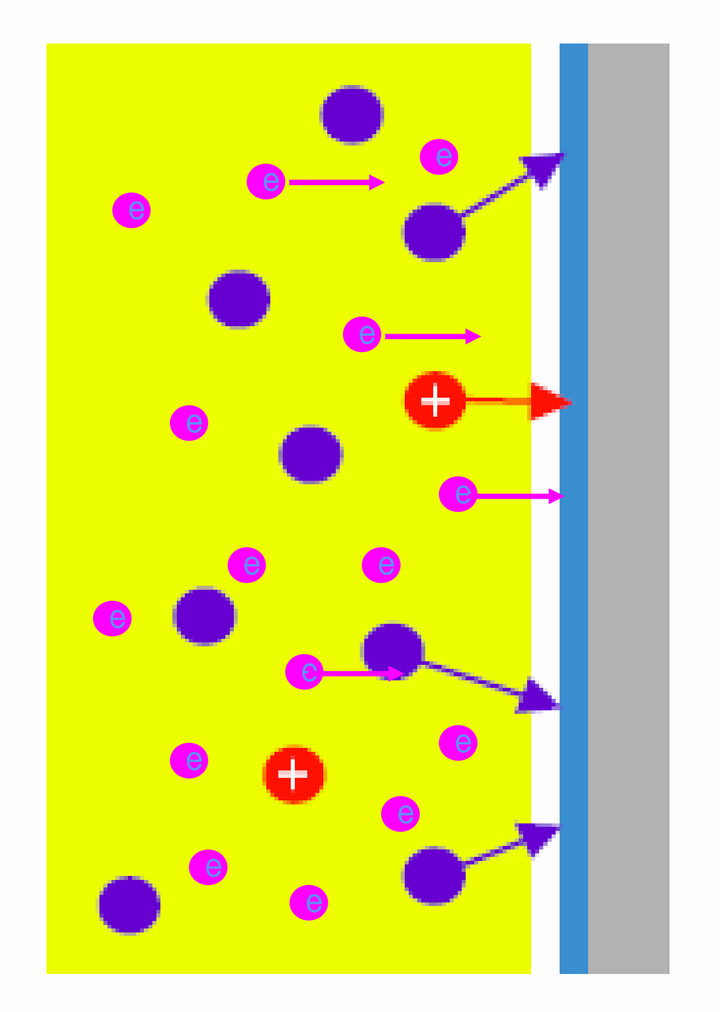
<u>Seunghee Han</u>

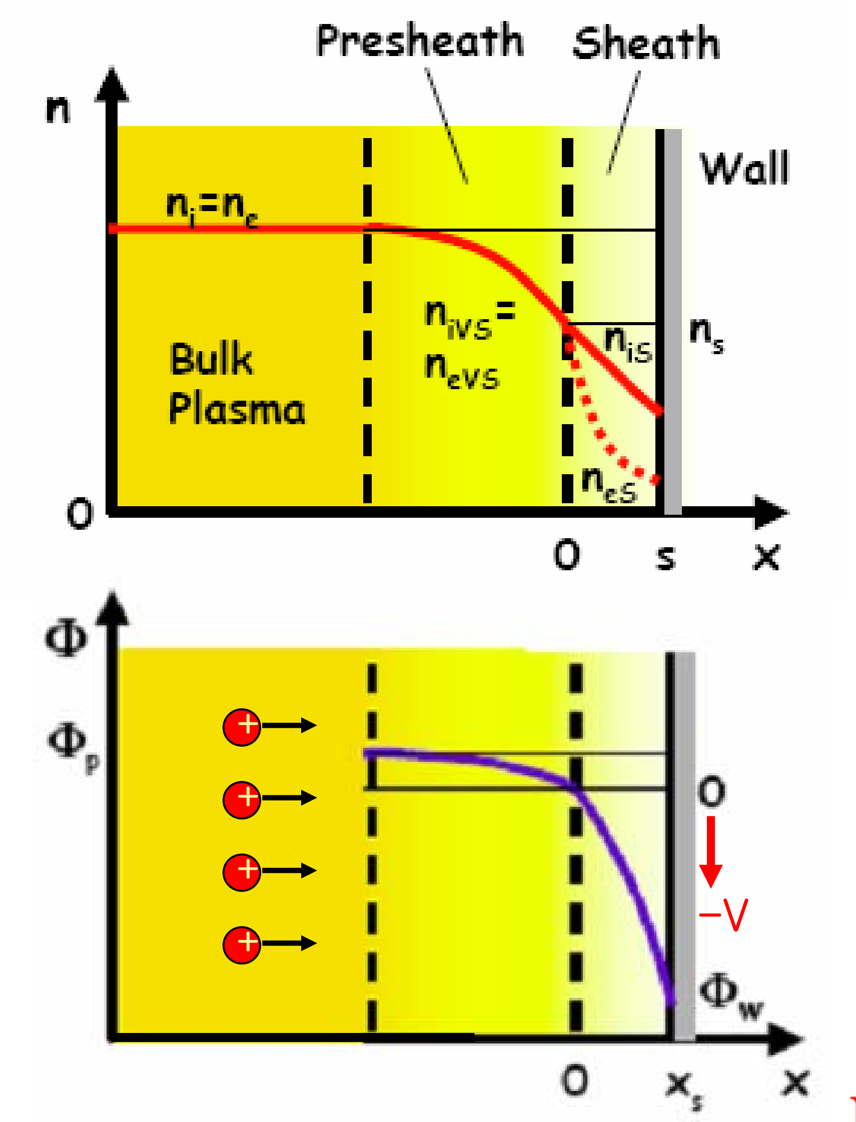
Plasma Properties



- 1 eV = 10,000 K
- T_i ,T_n << T_e
- η<1 %
- Radical species

Plasma Sheath

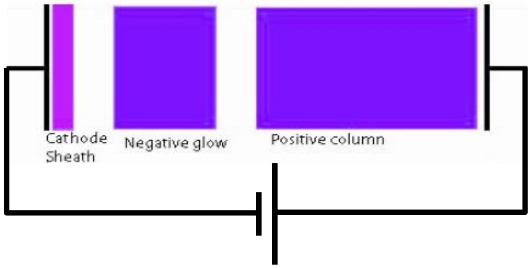




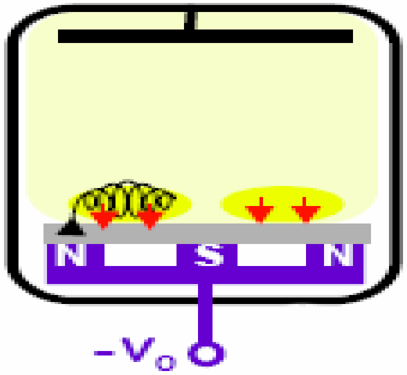
Plasma Generation

DC

DC

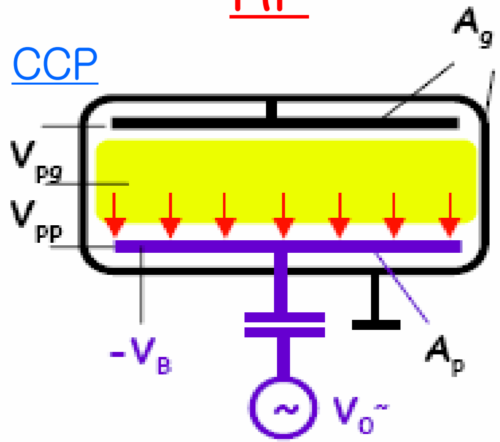


DC-Magnetron

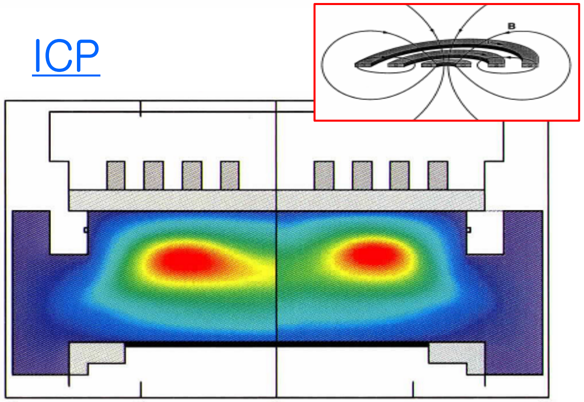


RF

CCP

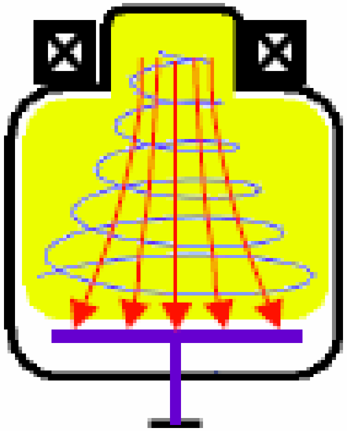


ICP



MW

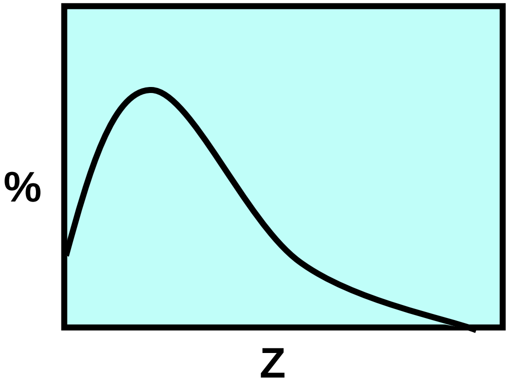
ECR



◆ Helicon, SW, Laser, Arc, etc

Ion Implantation

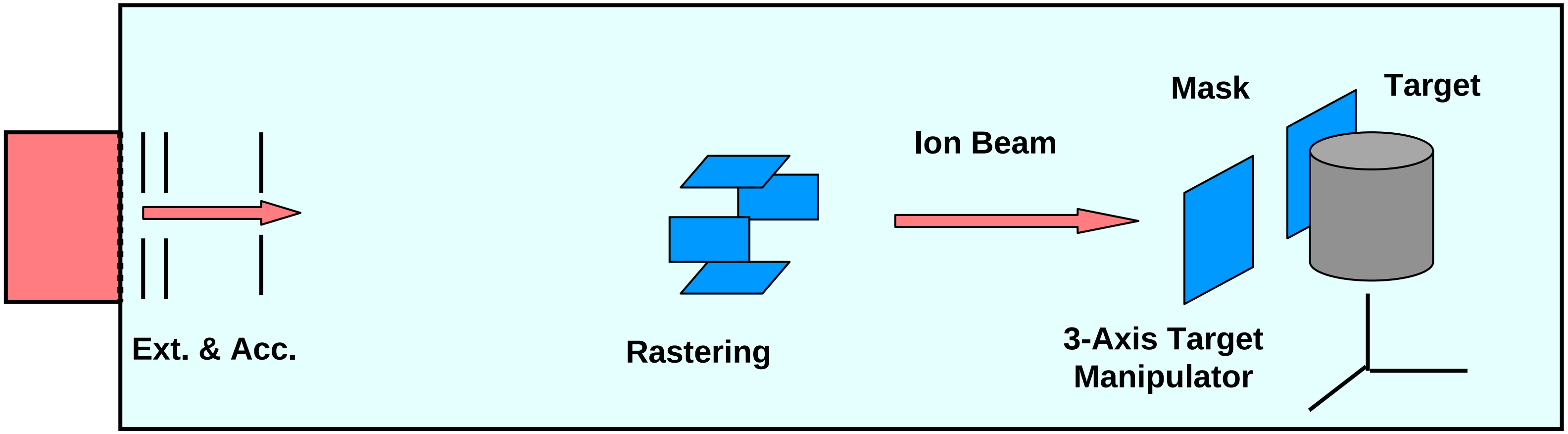
- Injection of high energy ions into materials surface



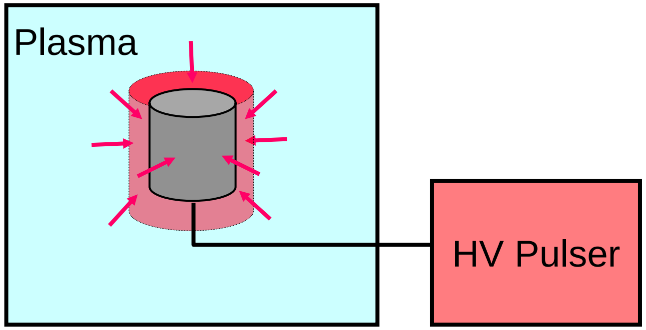
Advantages of ion implantation

- Selective improvement of surface region
- No sharp interface
- No dimensional change or distortion
- High-energy / non-equilibrium process
- Easy process control

Ion-beam ion implantation

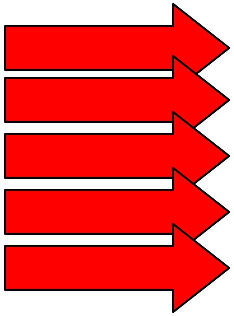


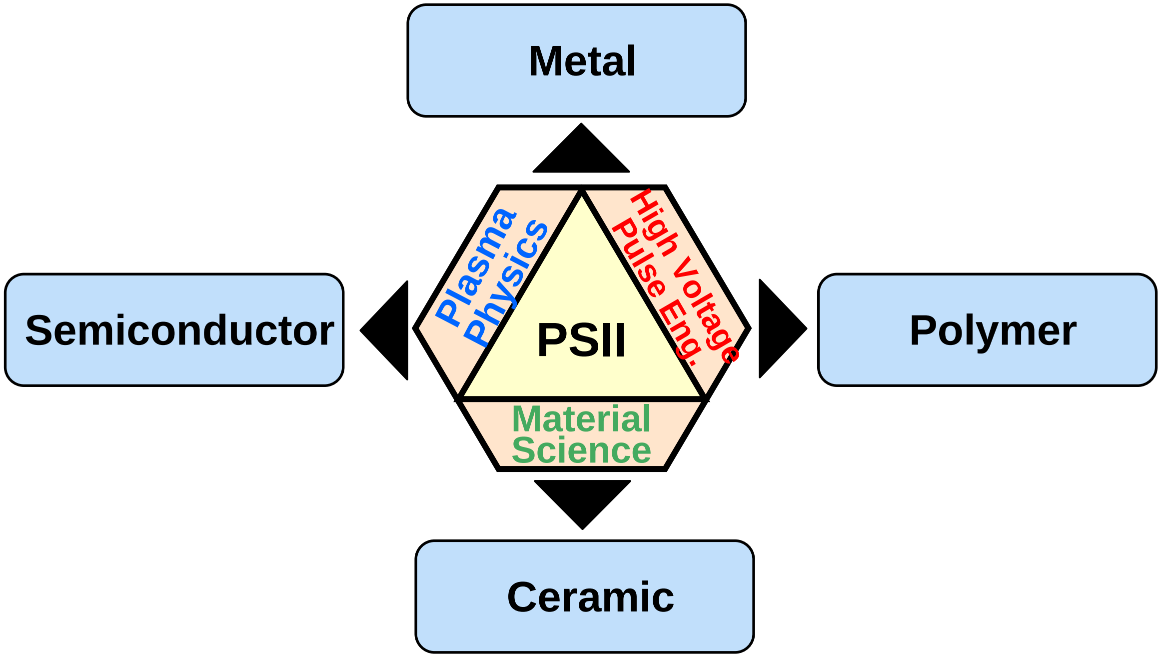
Plasma Source Ion Implantation (PSII, PIII)



Advantages of PSII

- Uniform implantation over 3-D & large target
- Simple and economic
- High dose rate
- Implantation capability on insulators
- Modular design





Metal

Semiconductor

PSII

Plasma Physics

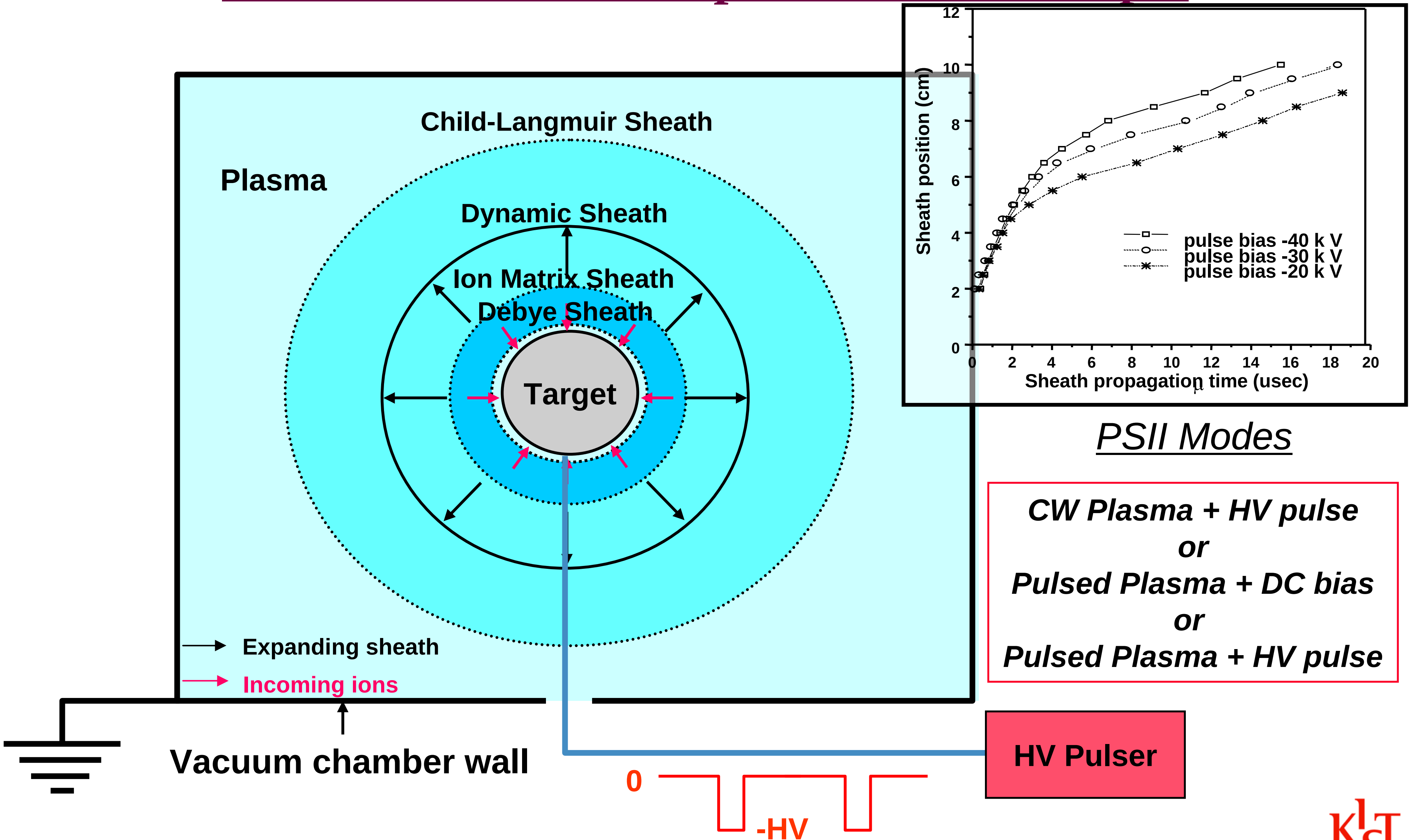
High Voltage Pulse Eng.

Material Science

Polymer

Ceramic

Plasma Source Ion Implantation - Principle



PSII Modes

CW Plasma + HV pulse
or
Pulsed Plasma + DC bias
or
Pulsed Plasma + HV pulse

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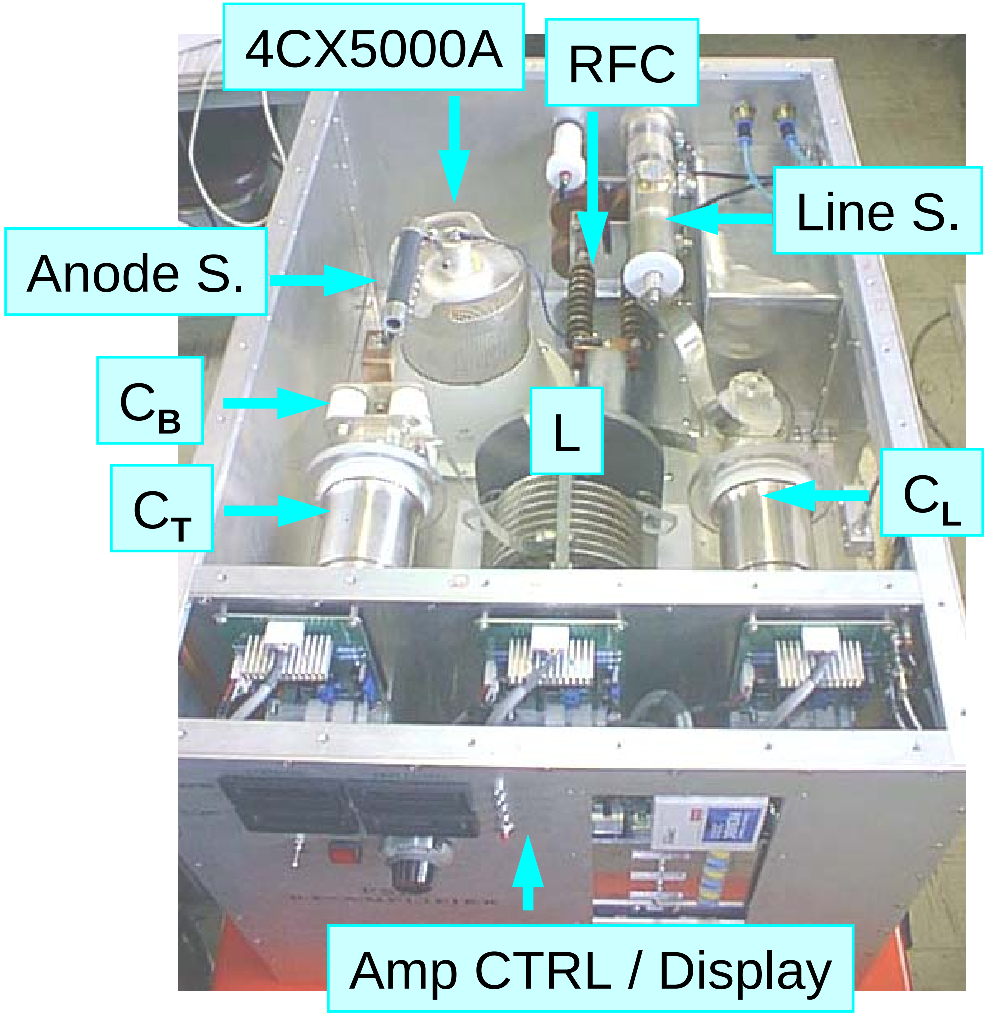
Advantages of Pulsed Plasma

Pulsed plasma has been widely used in many processes because it has several advantages over continuous (CW) plasma.

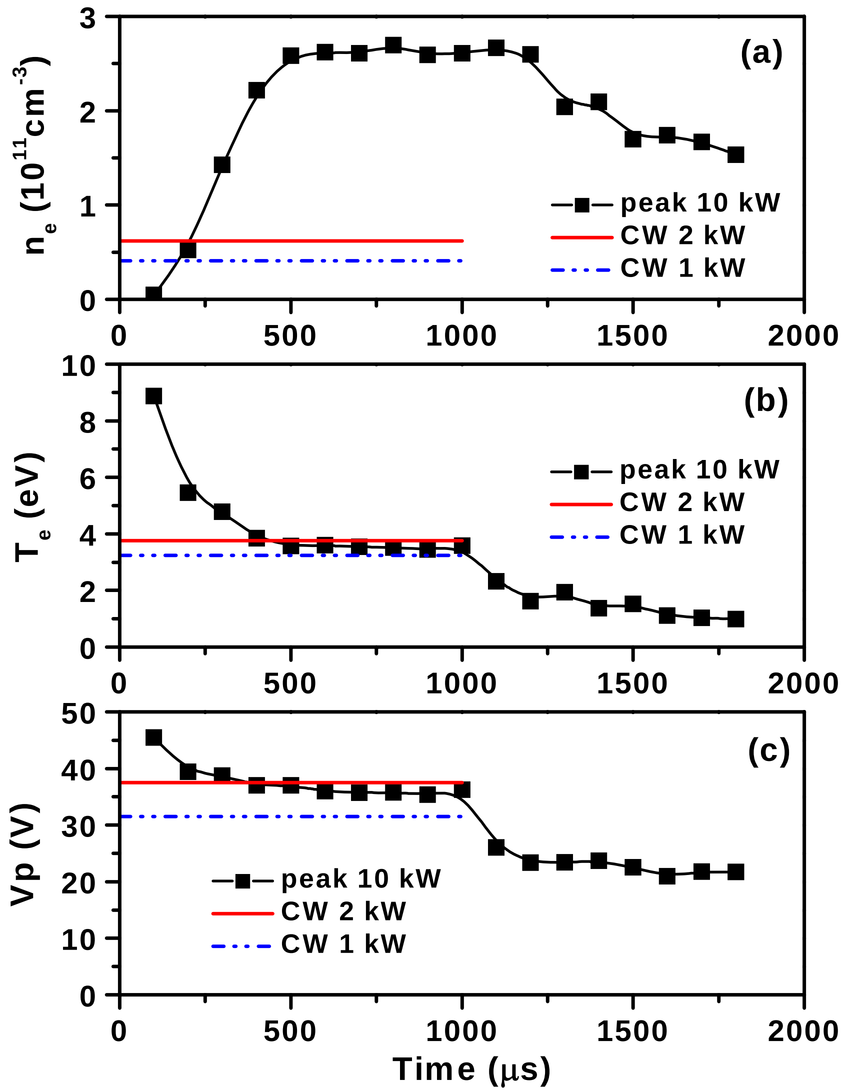
- Ion species can be varied.
- Discharge chemistry is changed.
- Charging damage is low.
- Film quality is improved in deposition.
- Etch and deposition rate increase.
- Very well suited for pulsed-process nature of PSII.

Amplifier RF-Deck



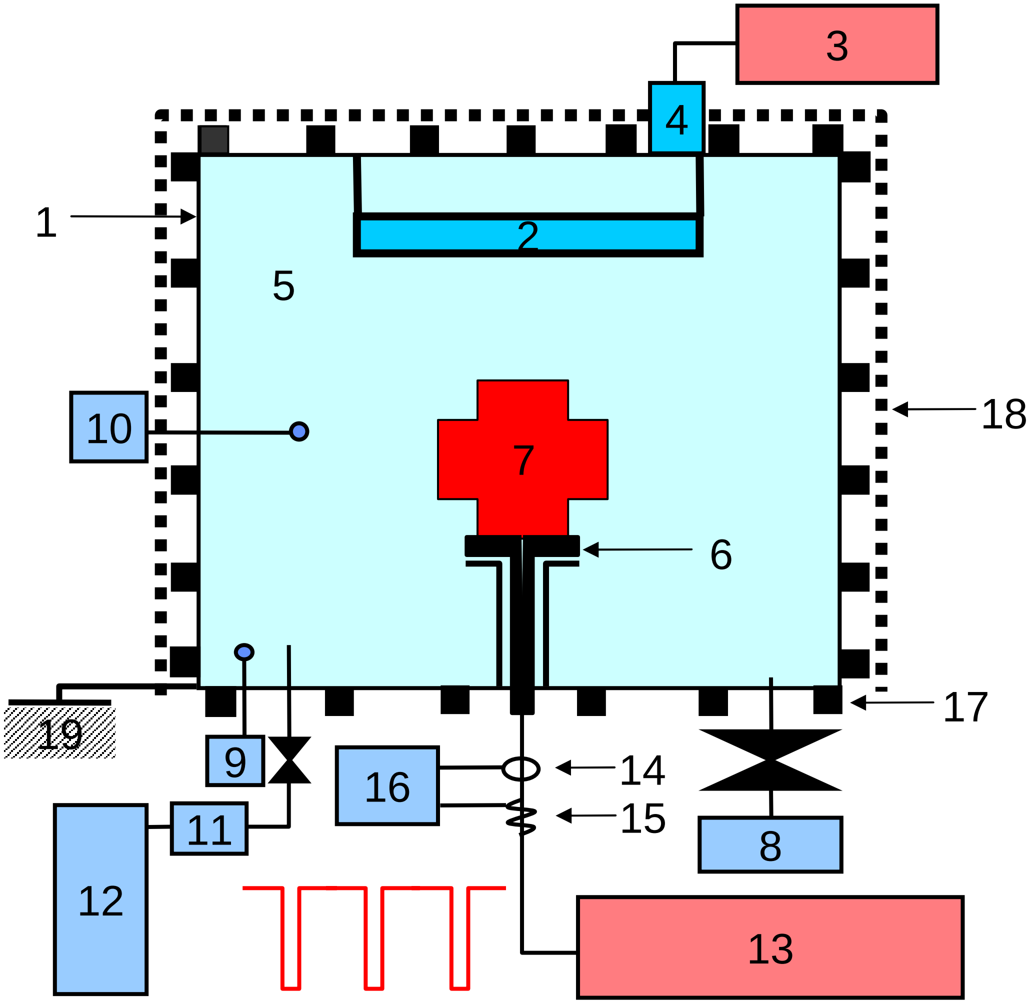
- 13.56 MHz, 50 kW peak, 3 kW avg.
- 4CX5000A RF Tetrode
- Pi-tank matching network to 50 Ω (2 vacuum caps / roller inductor)
- L-R anode parasitic suppression
- Forward / reflected RF power monitored using 1-5/8” rigid LS and Bird RF elements
- Microprocessor-controlled power measurement and SWR protection
- Easy and safe tuning with stepper Motors

Time-resolved Plasma Parameters



- Peak RF power : 10 kW, RF pulse width : 1ms, pulse repetition frequency : 25 Hz
- At early stage, the electron density is low and electron temperature and plasma potential is high.
- During the RF pulse on time, plasma parameters reach the steady state after about 500 μs.
- Plasma parameters are similar to continuous wave (CW) operation from about 500 μs to the end of the RF pulse except the electron density.
- After the RF pulse is turned off, plasma parameters decrease gradually.

Schematic Diagram of PSII Equipment



1. Vac. chamber 2. Antenna
3. RF generator 4. Matching box
5. Plasma 6. Target stage
7. Target 8. Vac. Pump
9. Ion gauge 10. Langmuir probe
11. MFC 12. Working gas
13. HV pulse gen. 14. CT
15. HV divider 16. Oscilloscope
17. Magnets 18. Lead shield
19. Chamber ground

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PSII Equipments

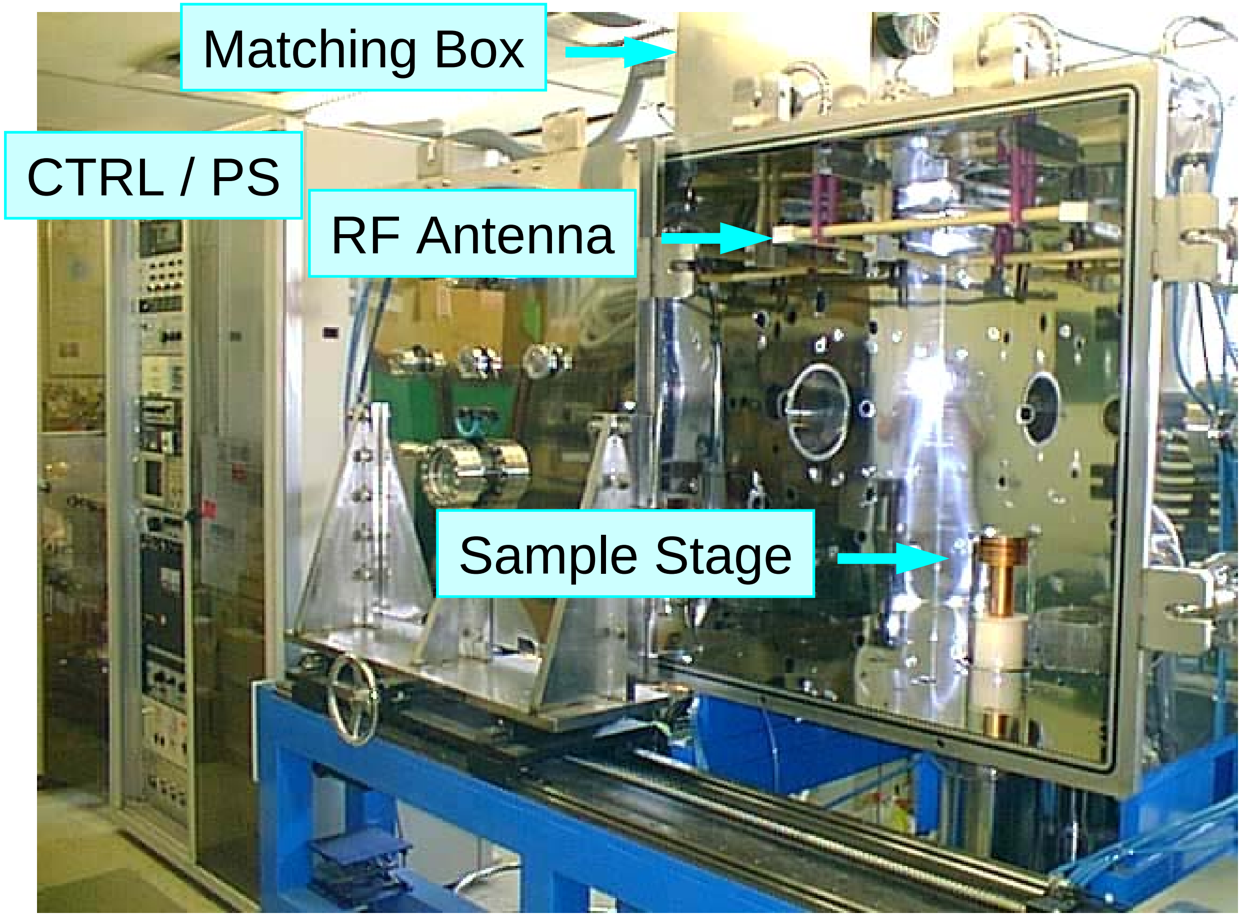
PSII - I (100L, 100kV, 10A)


Internal ICP Antenna

PSII - II (60L, 10kV, 2A)

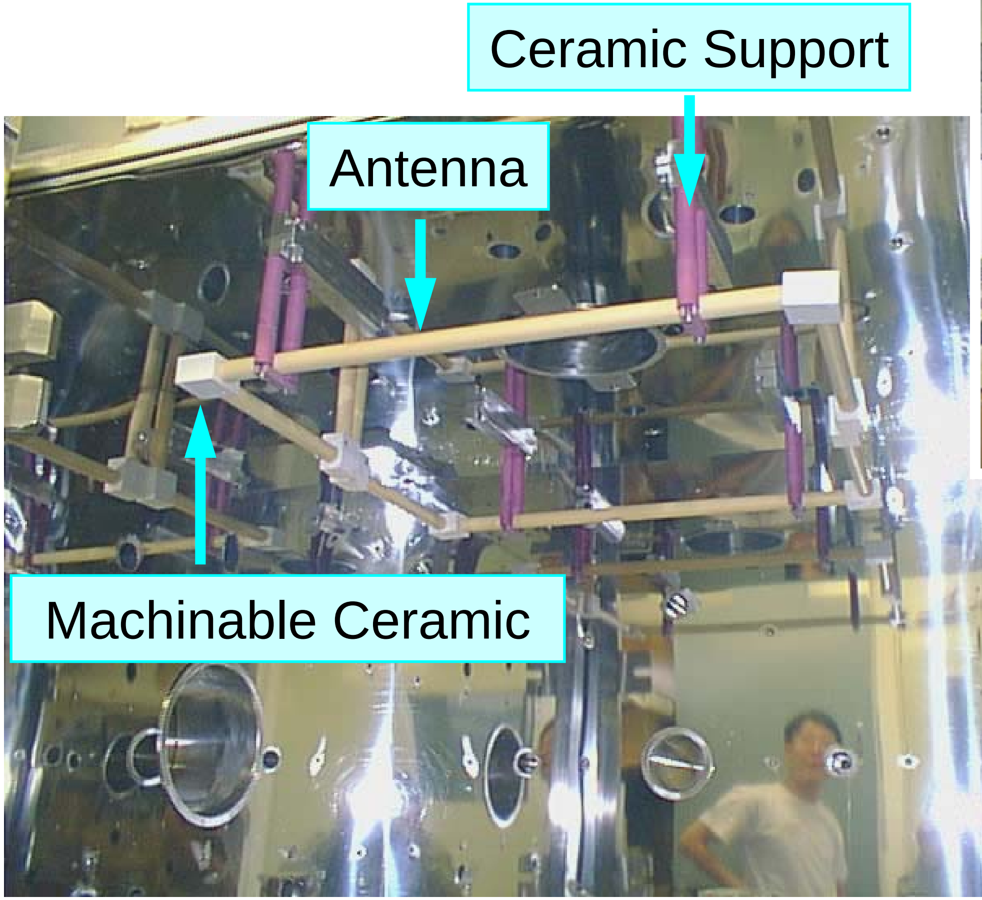
New PSII Facility for Large Sample Implantation

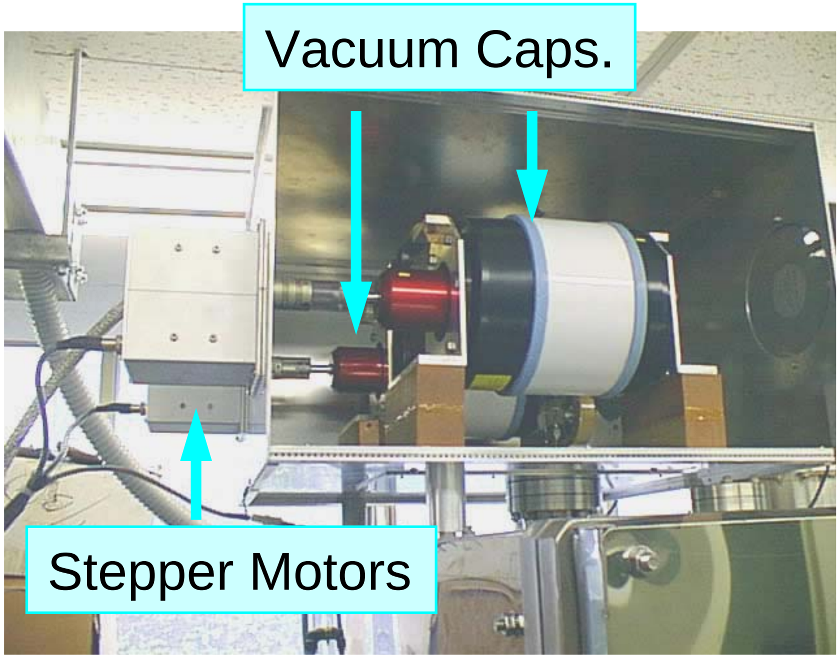
PSII - III (1000L, 100kV, 30A)



- 1m x 1m x 1m
- Nd-Fe-B magnet cusps
- Water-cooled walls
- 2000 L/s turbo-pumped
- Lead-shielded (6 mm T)
- Sliding-door type
- Ceramic-insulated, internal antenna (water-cooled)
- Protected by inner-liners
- Oil-cooled sample stage
- Oil-insulated HVFT

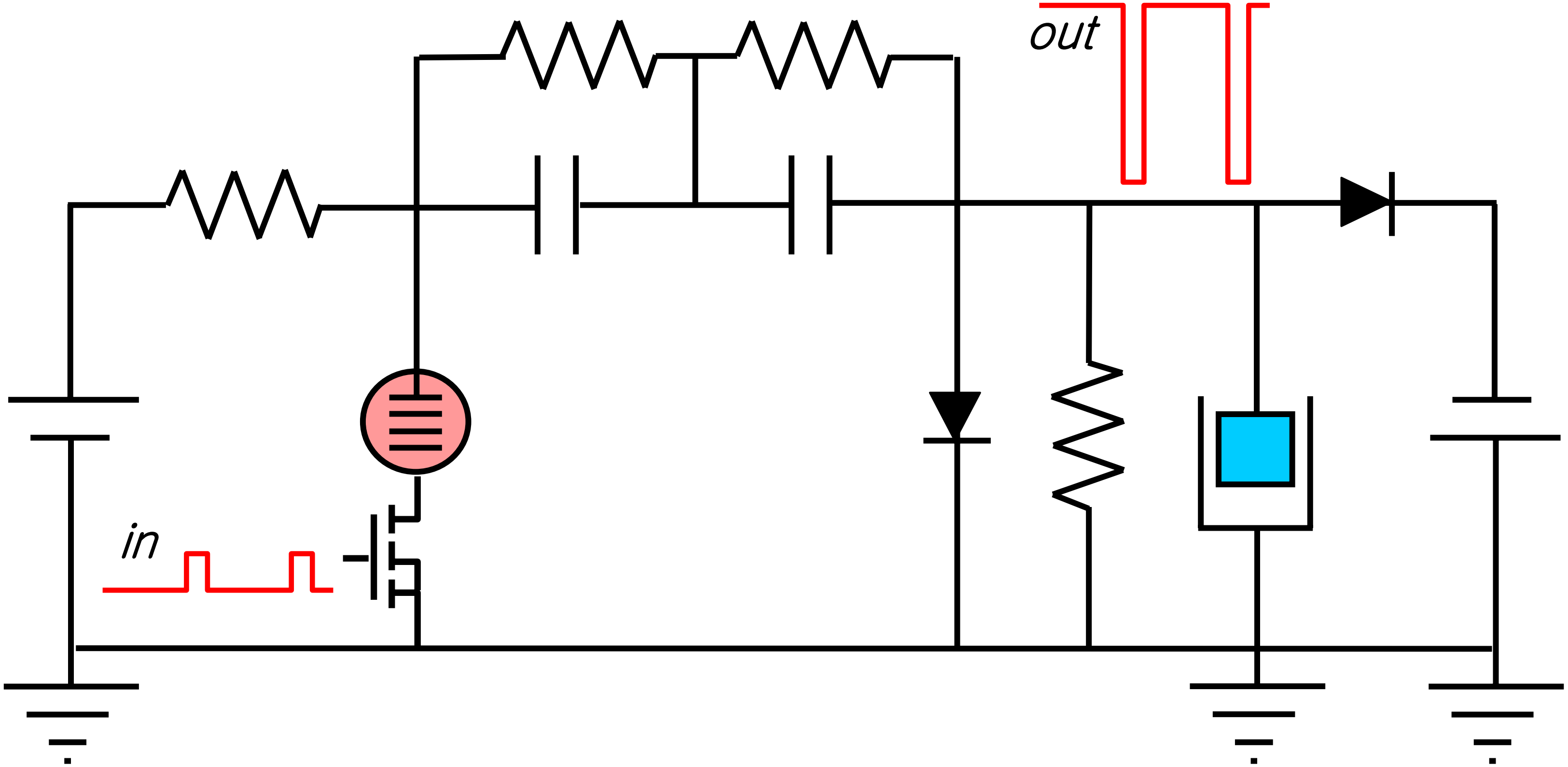
RF Antenna / Matching Box



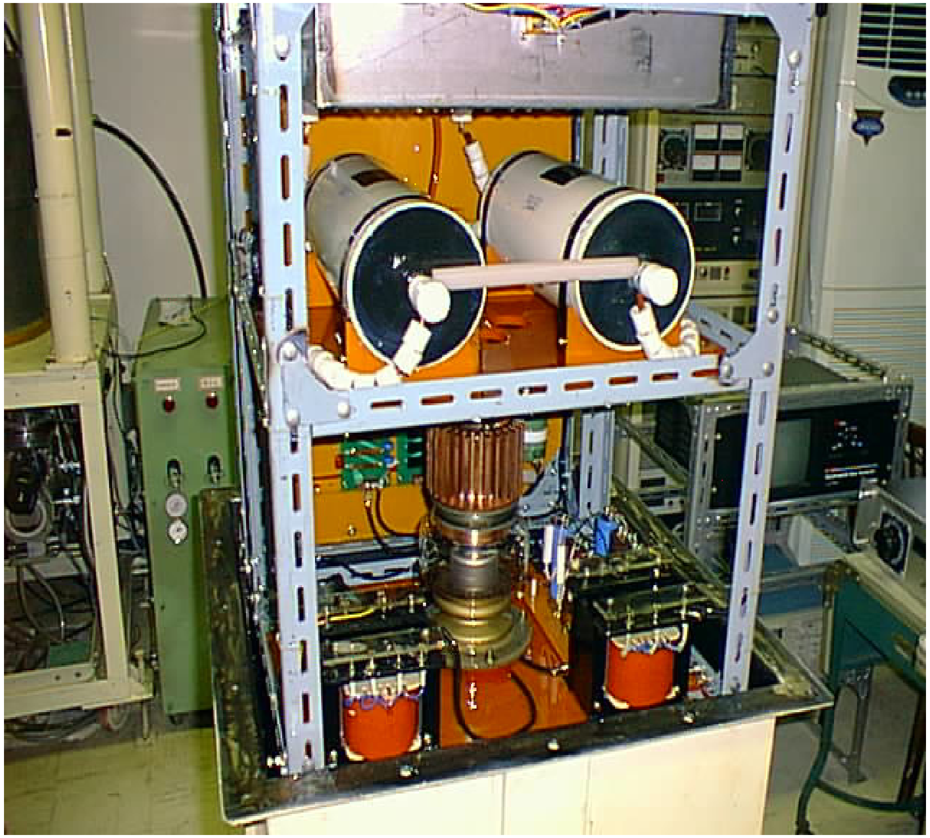


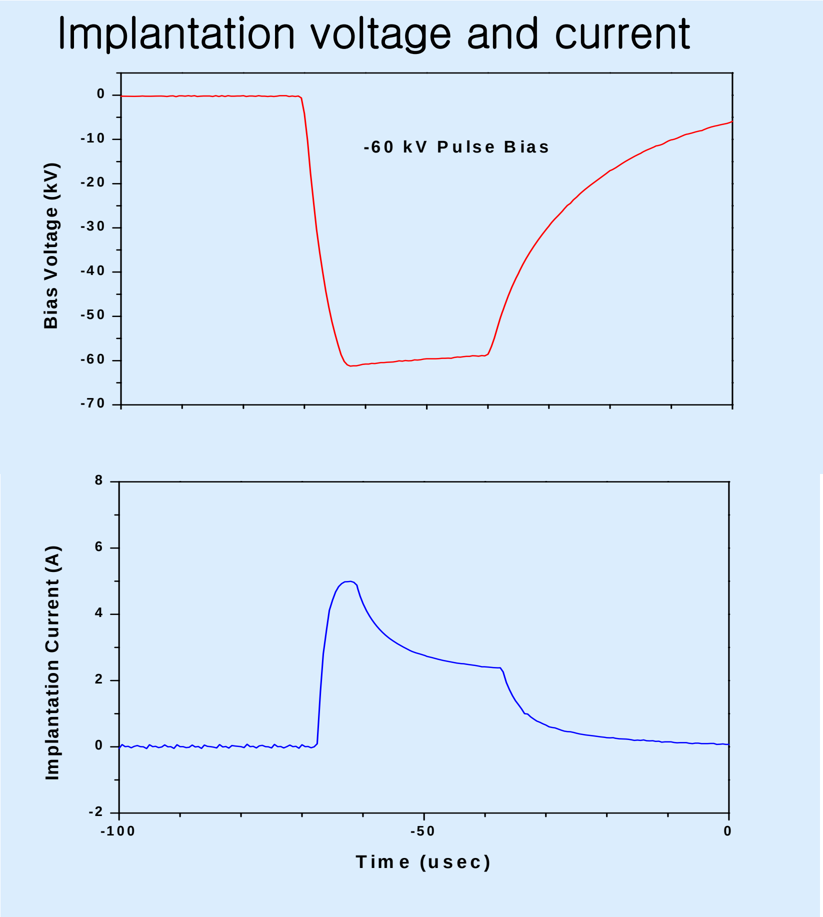
- Standard-type matching network
- Two vacuum capacitors and one ceramic capacitor
- Stepper-motor driven from remote controller

Circuit Diagram of HV Pulse Generator



Internal View of HV Pulse Modulator

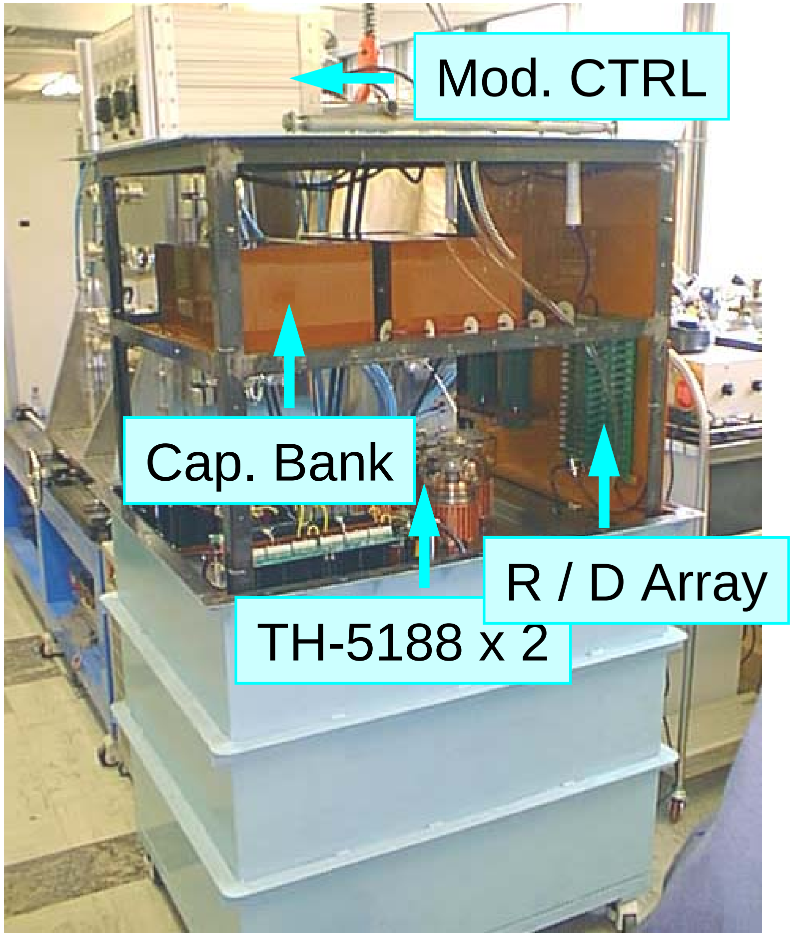




Implantation voltage and current

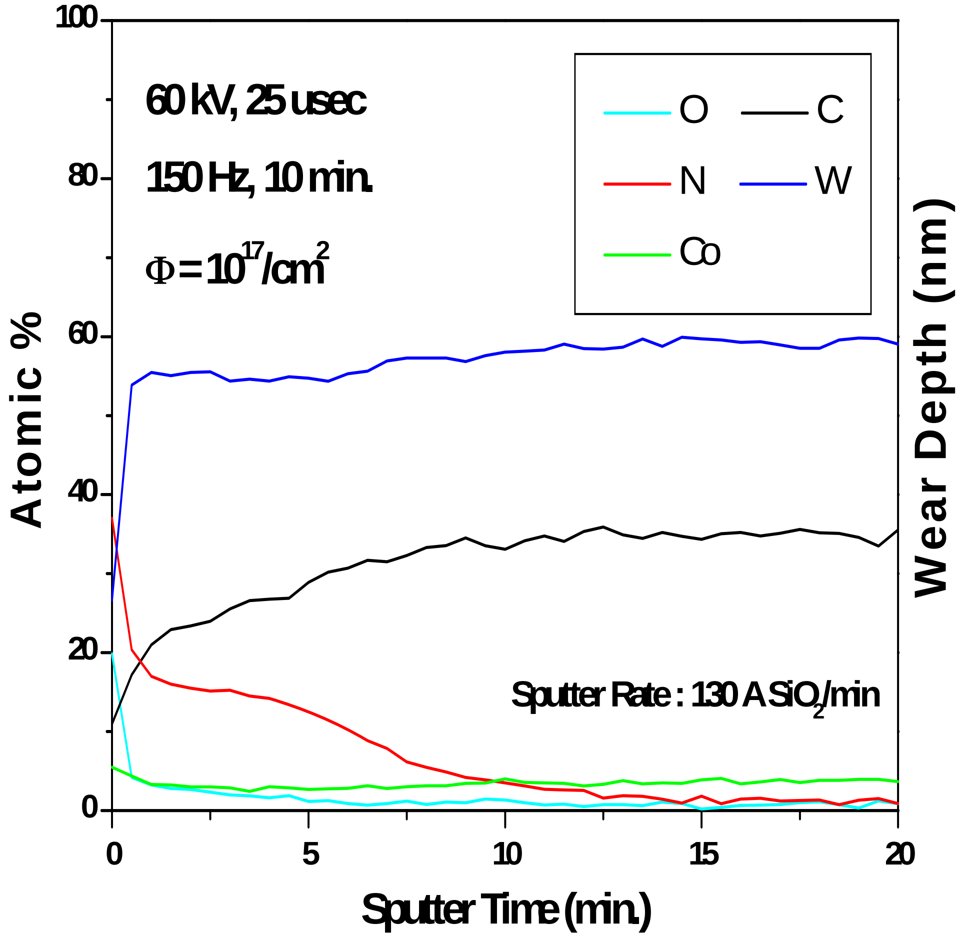
- Dual-mode hard tube type high voltage pulse generator.
- Using high voltage tetrode(TH-5188) and capacitor bank.
- 100 kV, 10 A, 10~60 μsec, 10~10000 Hz.

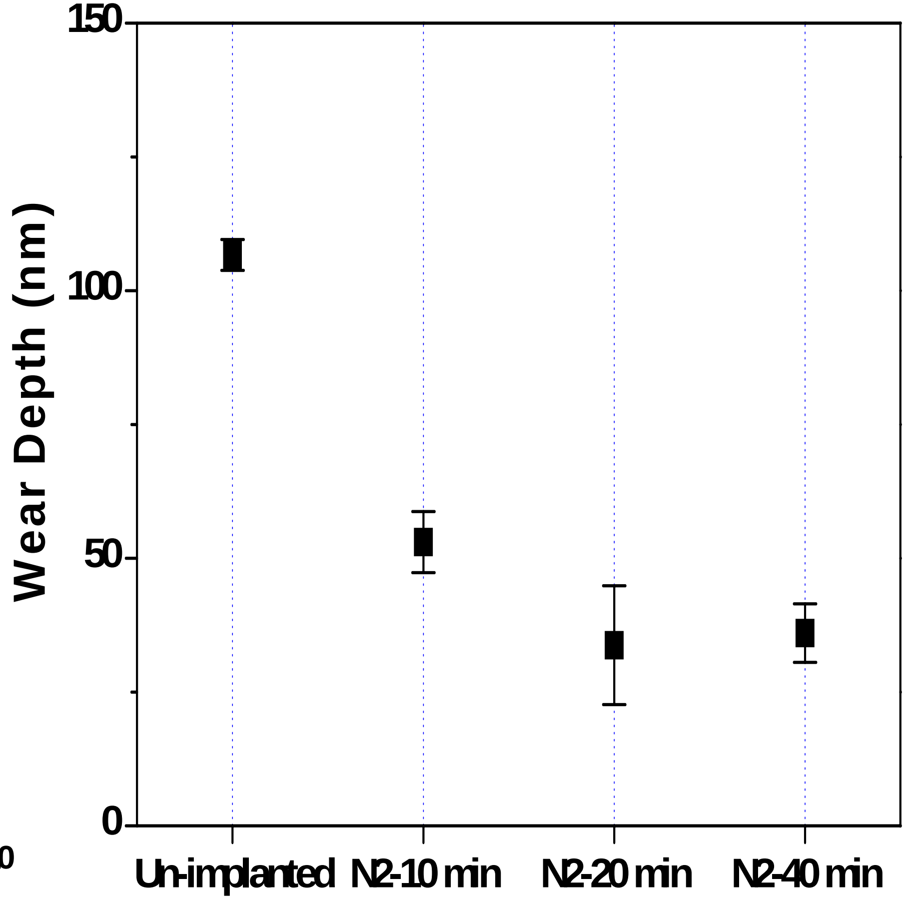
High Voltage Pulse Modulator



- Hard-tube type using CB and TH-5188’s
- 2 x TH5188 - MOSFET cascode circuit
- 100 kV, 30 A HV pulse
- DC-mode possible for sputter cleaning
- RC Voltage divider for V_i monitoring (10000 : 1)
- Immersed in oil tank
- Will be upgraded using IGBT stack

PSII N_2-implantation on Co-cemented WC





PSII N_2-implantation on Cr-plated SKD61

20 um Hard-Cr plating on polished SKD61

↓

N ion implantation

(N_2, 60 kV, 25 usec, 30 min.)

↓

Pin-on-disc wear tester

(100 g, 200 rpm, 10000 rev. 3 mm-Dia. Ruby ball)

↓

α-step Measurement of wear-track

Un -implanted	1 mTorr 200 W RF 100 Hz	1 mTorr 200 W RF 200 Hz	0.5 mTorr 100 W RF 200 Hz	0.5 mTorr 100 W RF 100 Hz
1059 nm	56 nm	101 nm	106 nm	56 nm

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PSII N_2-implantation on Nimonic (Cr-Ni, Al, Ti….)

Polished Nimonic

↓

N ion implantation

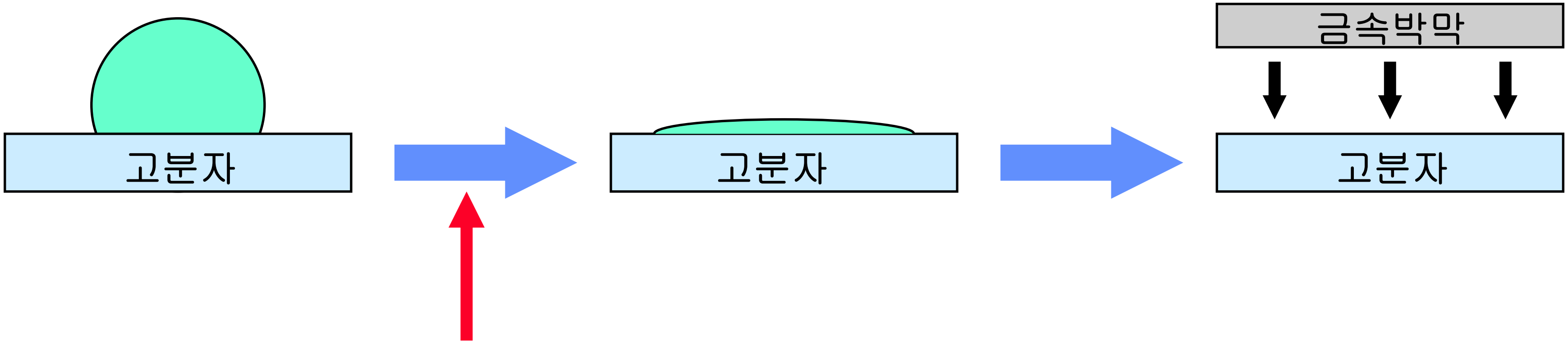
(N_2, 60 kV, 30 usec, 1 hr & 2 hr, RT & HT)

↓

Knoop Hardness Test, SEM, Auger

Un -implanted	RT 1 hr.	RT 2 hr.	HT 1 hr.	HT 2 hr.
350 HK	396 HK	405 HK	1129 HK	1246 HK

Polymer Surface Modification



- ● Chemical
- ● Flame
- ● Corona (UV, Laser)

⋮

- ● 플라즈마 (이온빔)
- ● 중간층 (Tie-layer)

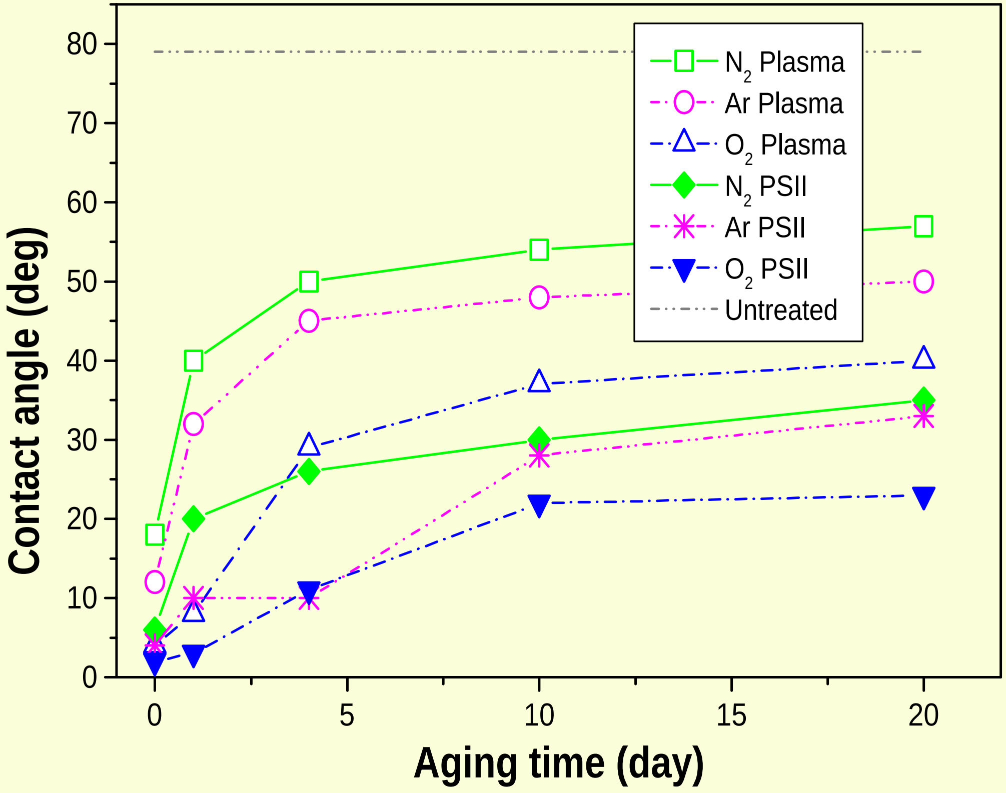
Polymer Surface Modification using PSII


Untreated PET

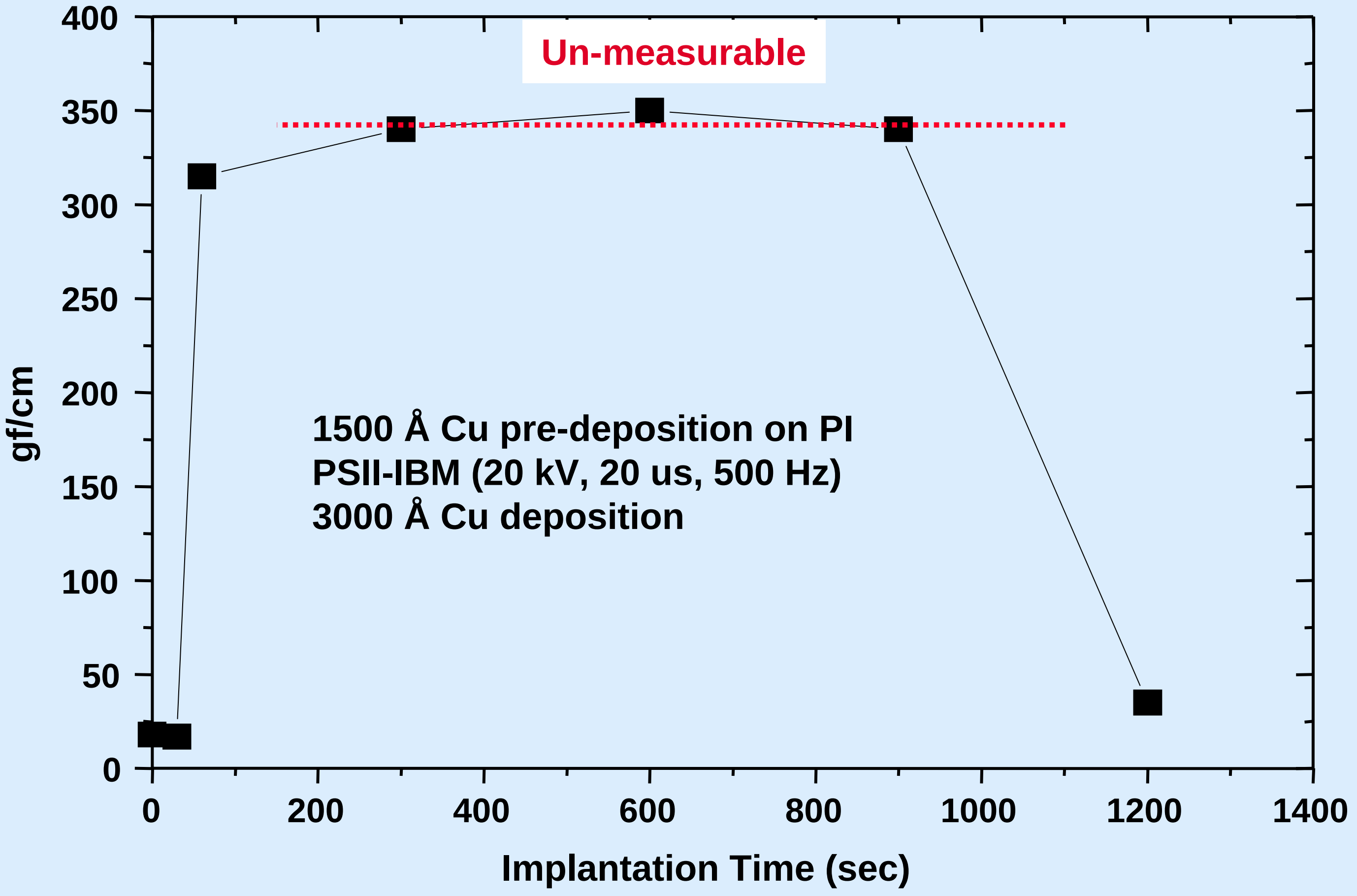

O_2-treated PET


CF_4-treated PET

Water contact angles of PS as a function of aging time



Improvement of Cu-PI adhesion using PSII



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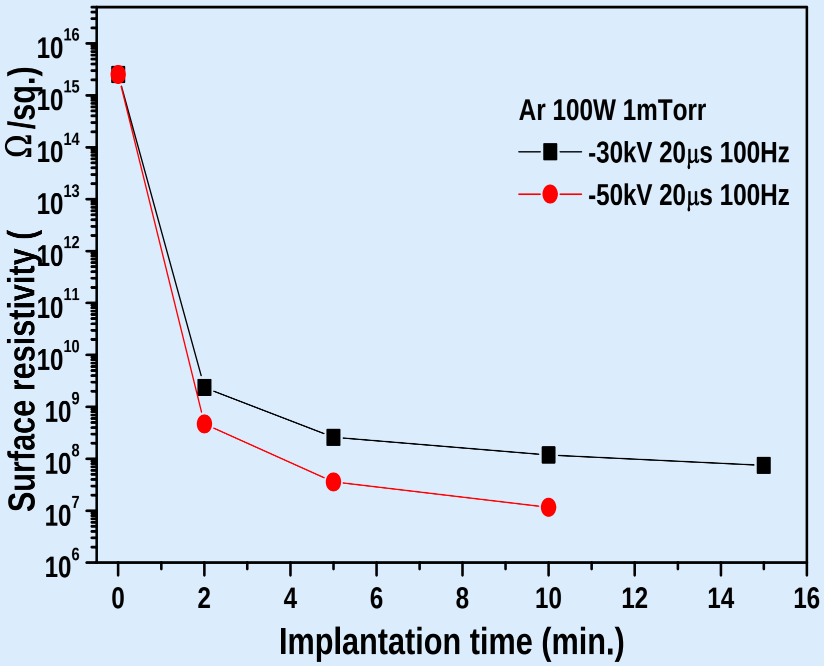
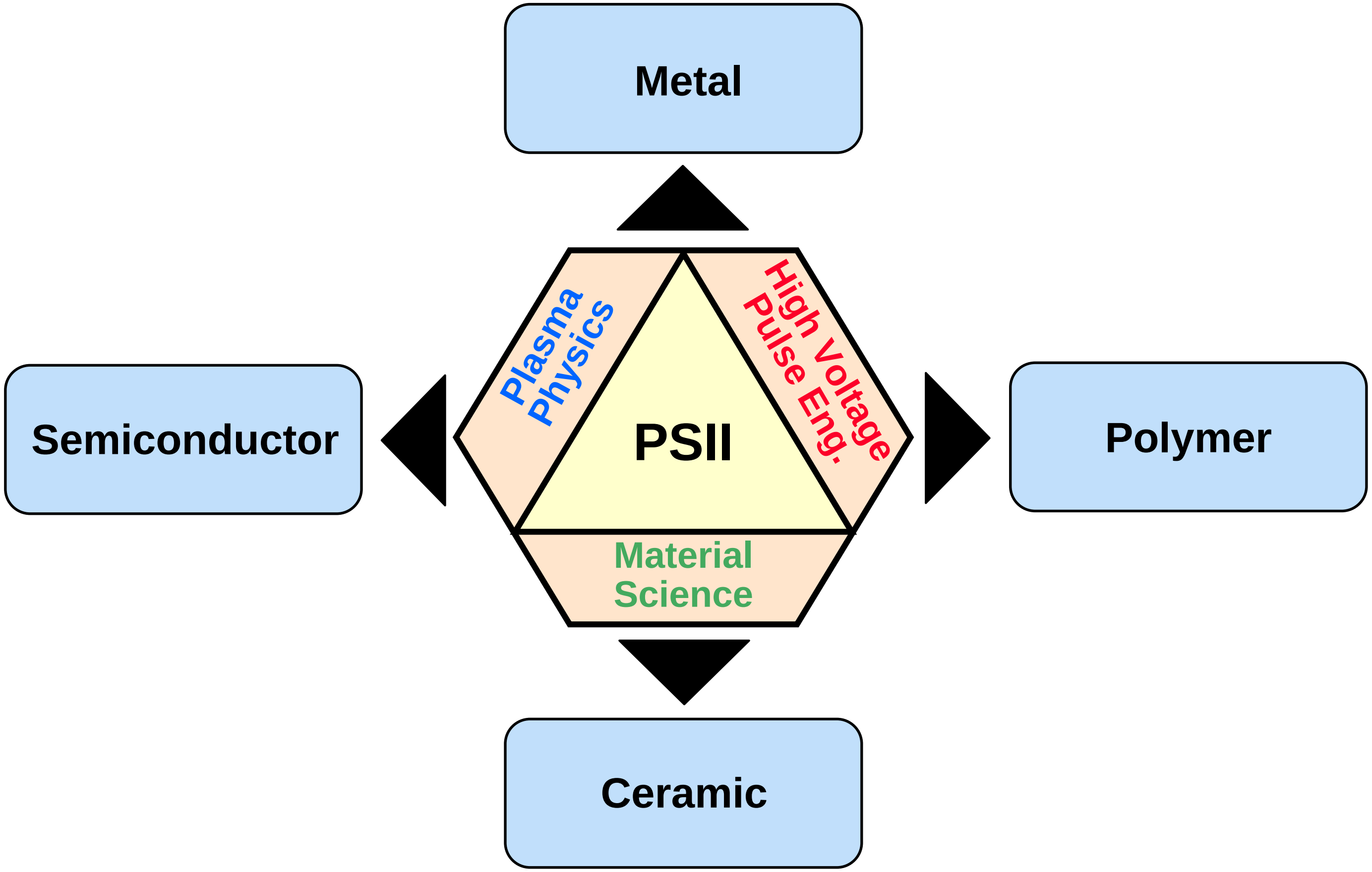
Polymer Surface Modification using PSII

Surface resistivity of MPPO as a function of ion energy



Epon's PSII chamber for IC-tray implantation

Conclusion



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PSII

Plasma Physics

High Voltage Pulse Eng.

Material Science

Plasma / PSII is a very promising tool for materials surface modification !!