NISSIN ION EQUIPMENT CO.,LTD.

Nissin's Boron and Carbon Cluster Ion Implanter: CLARIS G2

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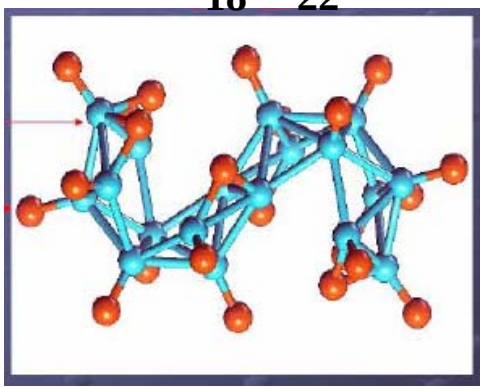
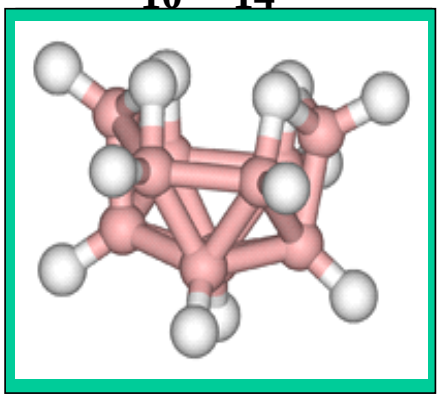
1. Feature of the cluster ions

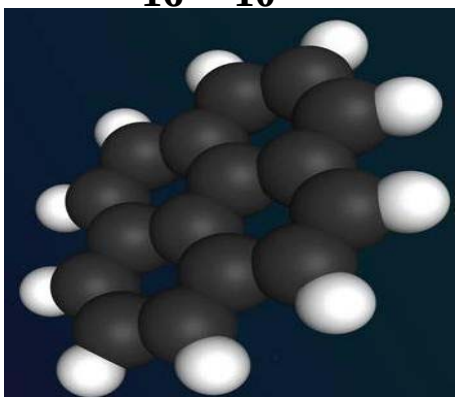
Octadecaborane
$B_{18}H_{22}$



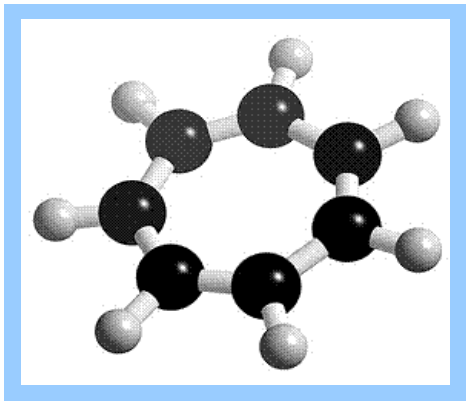
Decaborane
$B_{10}H_{14}$



Pyrene
$C_{16}H_{10}$



Dibenzyl➔ Benzyl
$C_7H_7^+$



Cluster Characteristics	$B_{18}H_{22}$	$B_{10}H_{14}$	$C_{16}H_{10}$	$C_{14}H_{14}$
Mol. Weight	216.77	122.24	202.25	182.26
Typical Usage Temperature	90-100 ℃	30-40 ℃	90-100 ℃	40-50 ℃

2. Advantages of Cluster Ion Implantation (1)

1.Effective Transportation of Low Energy Ion Beam

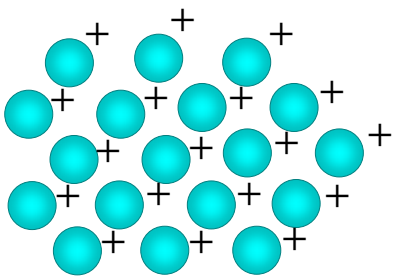
Low Space Charge Force

2.Equivalent High Beam Current

Molecular Beam Implantation

For Example: Boron 500eV

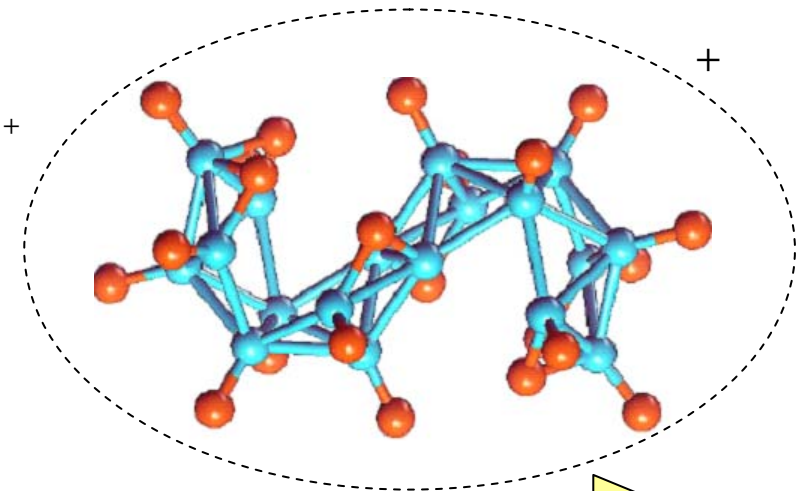
18 $[B]^+$



0.5kV extraction, +18 charge

Equivalent

$[B_{18}H_{22}]^+$



10kV extraction, +1 charge

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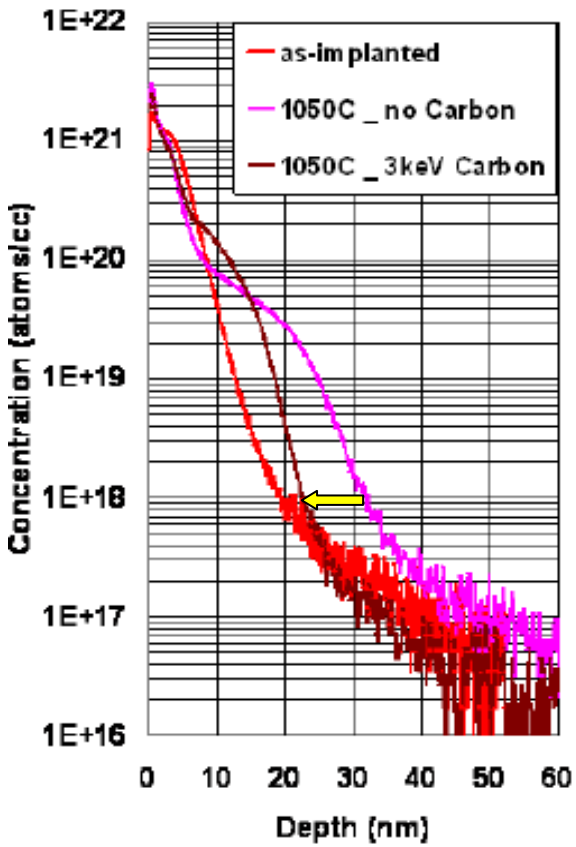
2. Advantages of Cluster Ion Implantation (2)

3. Various advantages for transistor formation process

(4) Cluster carbon co-implant for diffusion control



B_{18}(500eV 1E15/cm2)

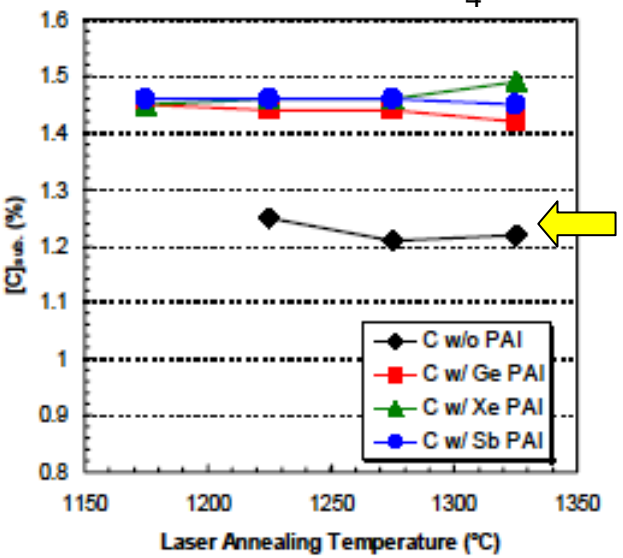
C_{16} suppresses the Boron diffusion

$Ge + C + B/BF_2 \rightarrow C_7/C_{16} + B_{10}/B_{18}$

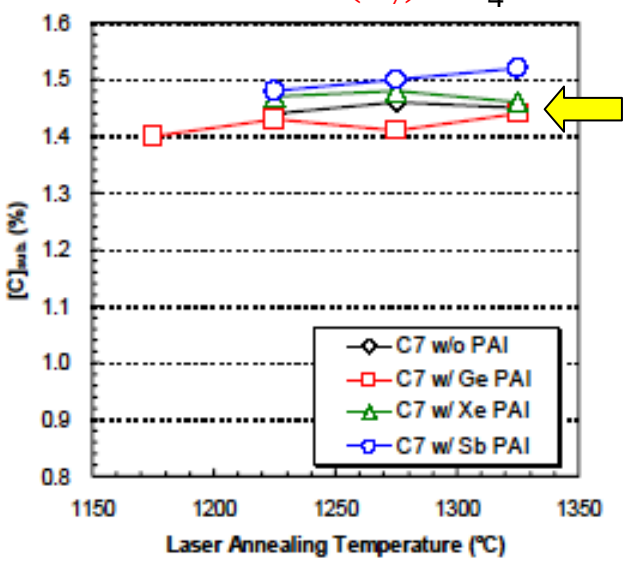
(5) N-MOS stress engineering

$Ge + C \rightarrow C_7/C_{16}$

Monomer C + P_4



Cluster C (C_7) + P_4



Enough high substitutional ratio with cluster carbon without PAI

From RTP2009 J.O. Borland

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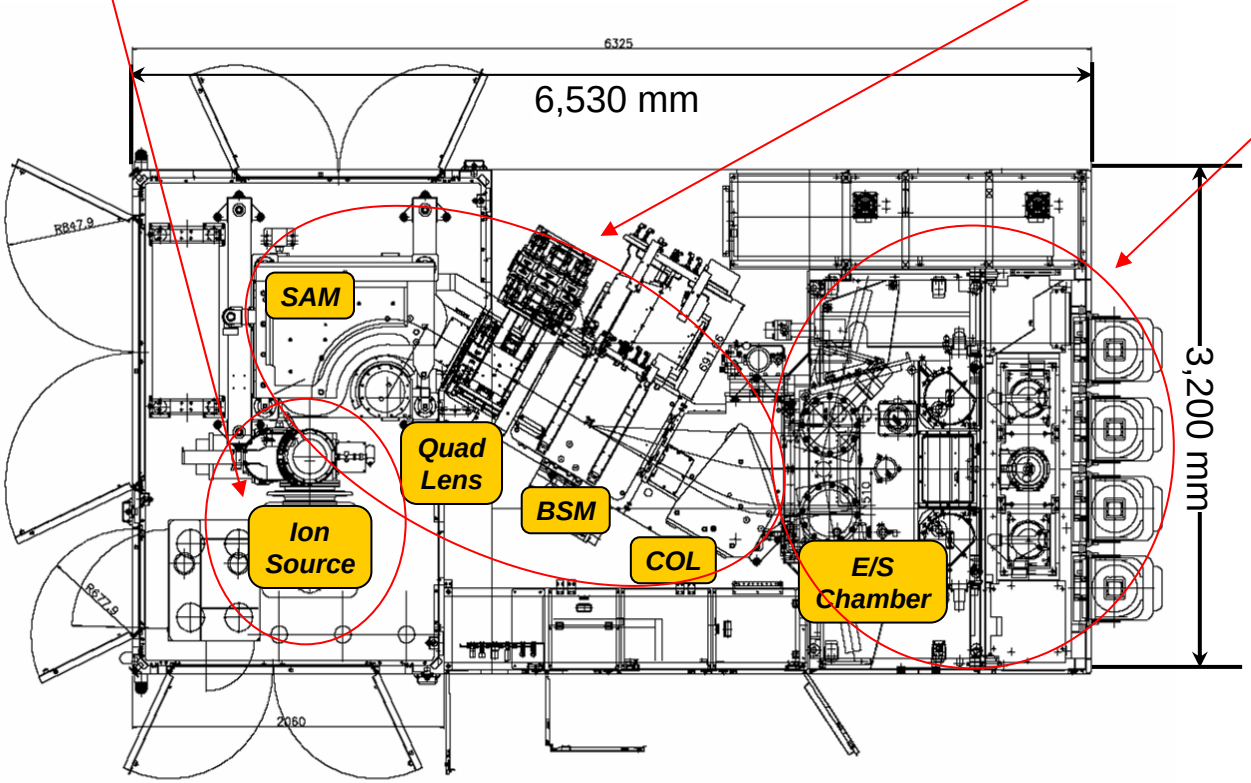
3. CLARIS System Configuration

Ion source : developed by SemEquip
- $B_{18}H_x^+$, $B_{10}H_x^+$, $C_{16}H_{10}^+$, $C_7H_7^+$
- As_4^+, As^+, P_4^+, P^+ (Developing)
- Auto Gas Cleaning System

Beam Line : based on EXCEED* series
- Up to 80kV extraction
- Movable MRS
- Wide gap magnet
- Fast magnetic beam scanner



End Station : common platform with EXCEED* series
- Sereal wafer handling
- 450 wph

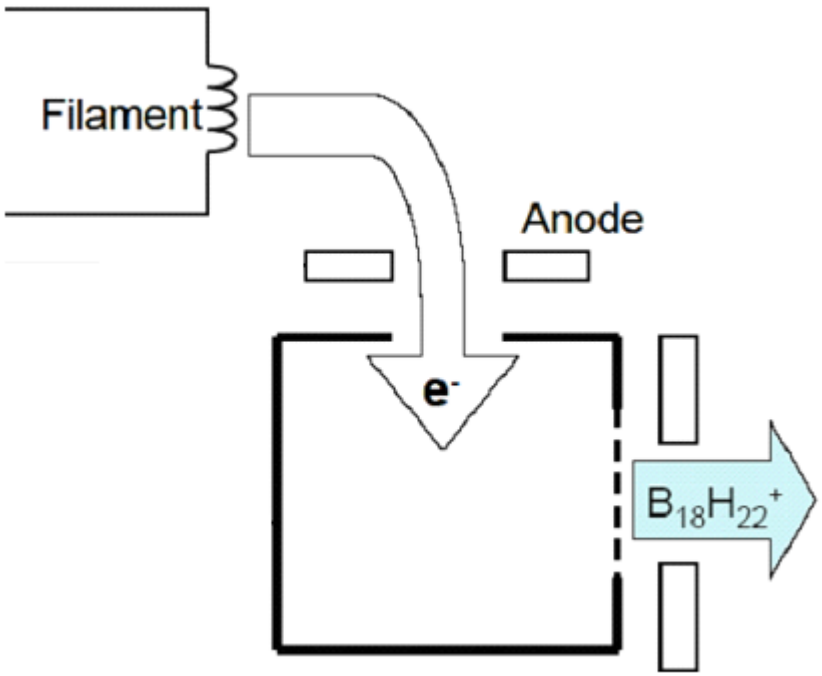
Beam measurement and control system : based on EXCEED* series

* EXCEED :
NISSIN's long selling successful medium current machine

3-1. CLARIS Ion Source

ClusterIon® Source **By SemEquip**

- electron impact mode
- soft ionization
- filament is located outside of arc chamber



350 I/S

$B_{18}H_x$, $B_{10}H_x$

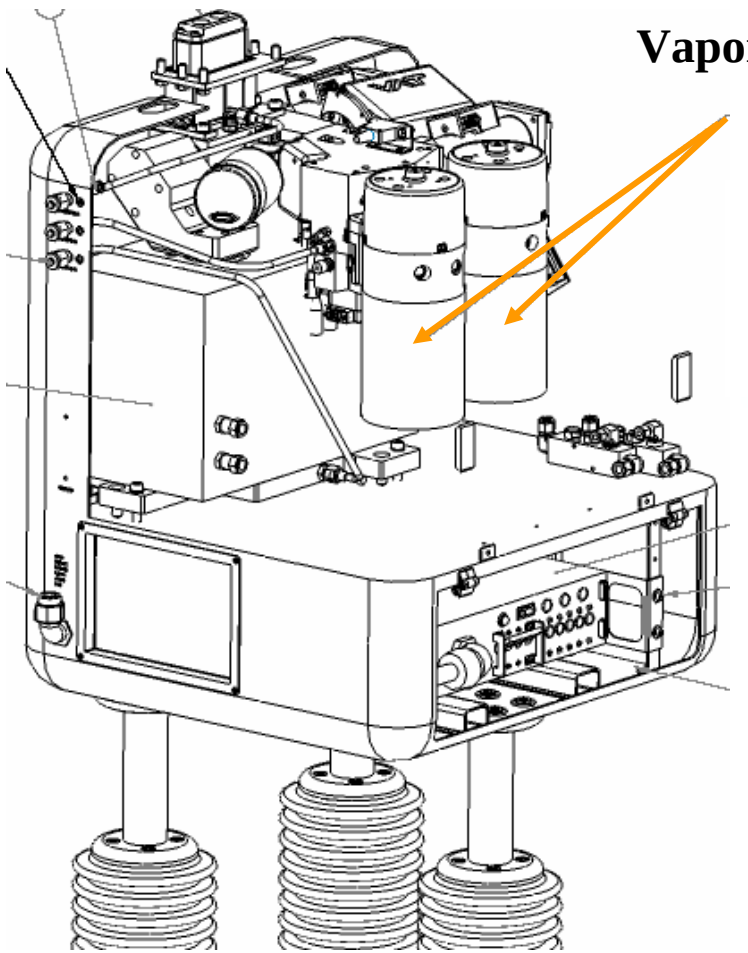
355 I/S

$B_{18}H_x$, $B_{10}H_x$, $C_{16}H_x$, C_7H_x

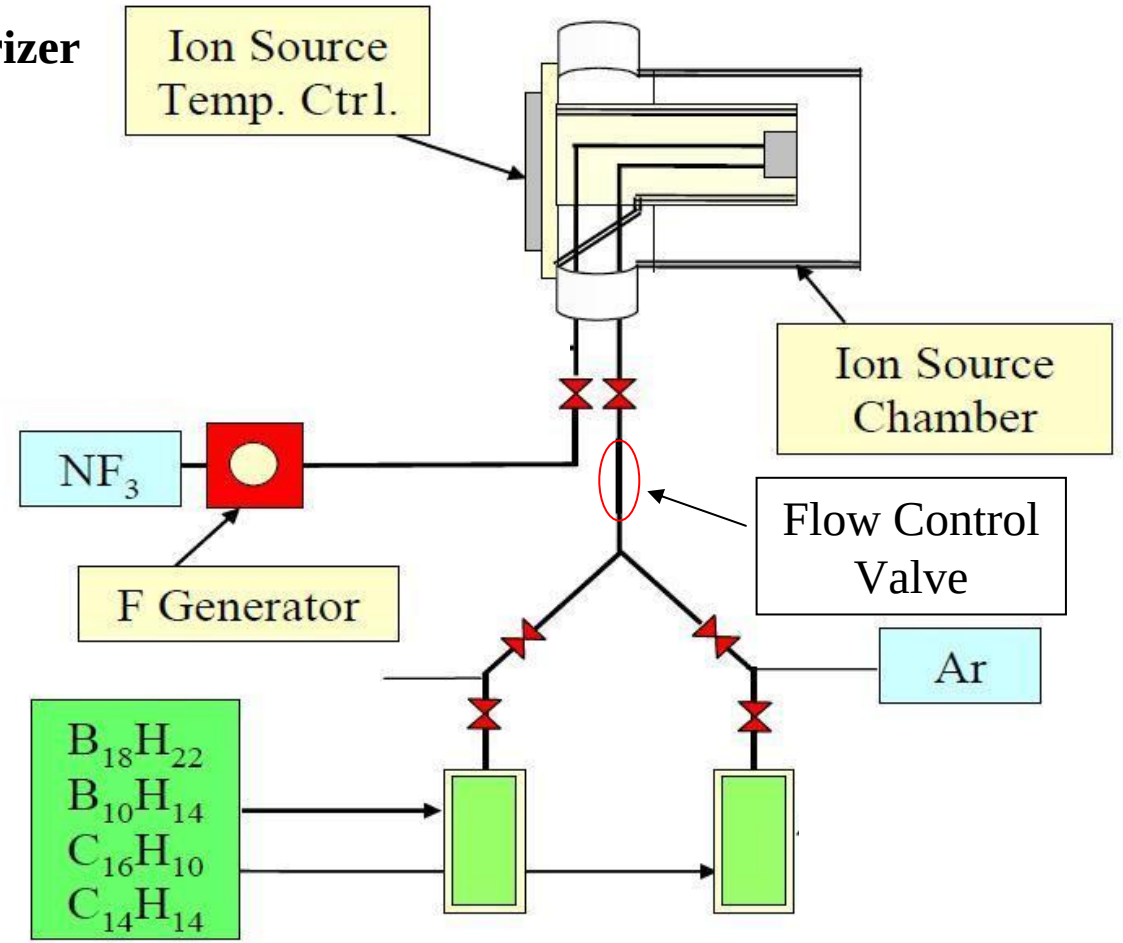
Optimized for carbon operation

(Glitch, Optics, Deposition, etc.)

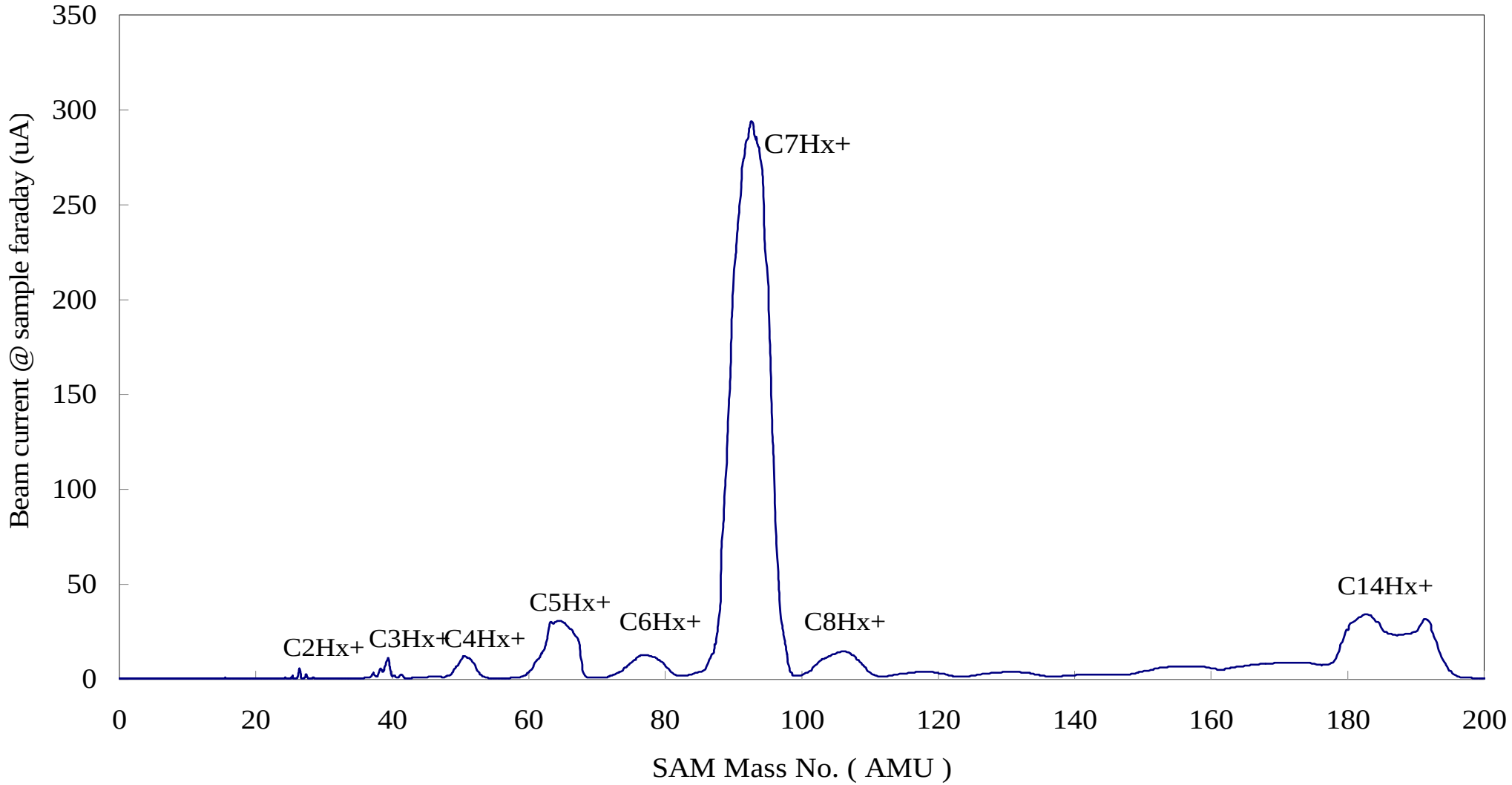
3-2. Vapor delivery system



Vaporizer



3-3. Mass spectrum of C_7H_x



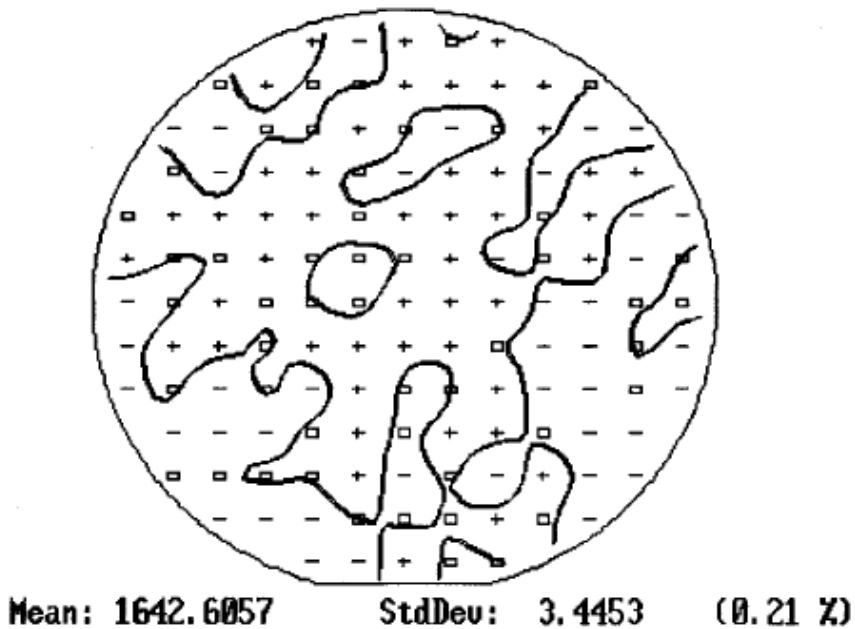
4. CLARIS Specification

Equivalent Energy & Beam Current	$B_{18}H_x$: B equivalent 200eV - 3keV 20.7mA $B_{10}H_x$: B equivalent 350eV - 7keV 15mA $C_{16}H_x$: C equivalent 240eV - 3.6keV 16mA C_7H_x : C equivalent 550eV - 10.5keV 10.5mA
Uniformity & Repeatability	< 1.5% (Depend on anneal condition)
Horizontal Beam Parallelism	< ±0.5 degree
Metal contamination	Al < 50ppm, others < 10ppm
Particle	< 30 adders (particle size > 0.12um)

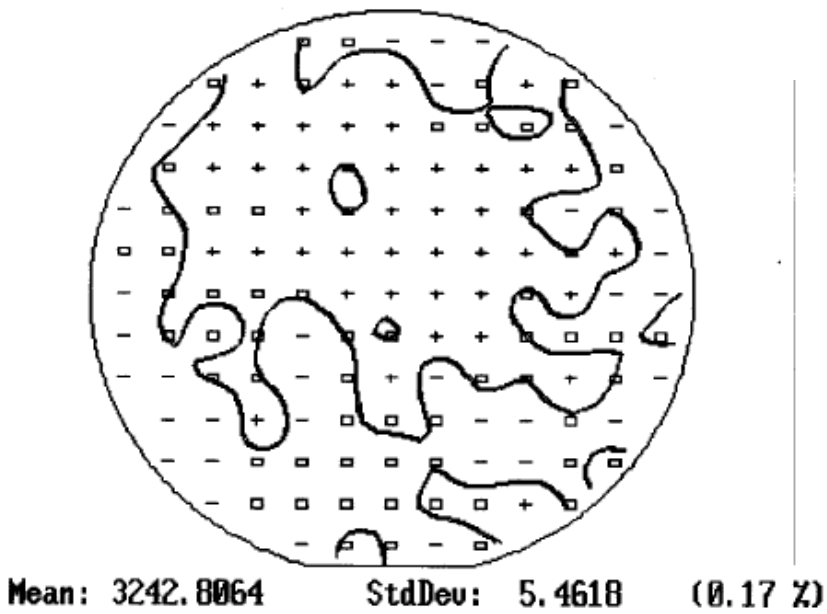
5-1. Cluster Carbon Uniformity

ion	Energy	Dose	TW	Uniformity
C7Hx	03.00 keV	3.00E+14 /cm2	1317.6704	0.24
	03.00 keV	6.00E+14 /cm2	1523.1078	0.22
	03.00 keV	1.00E+15 /cm2	1642.6057	0.21
	10.00 keV	3.00E+14 /cm2	1305.3359	0.58
	10.00 keV	6.00E+14 /cm2	2647.3069	0.34
	10.00 keV	1.00E+15 /cm2	3242.8064	0.17

C equivalent 3keV 1E15/cm2 0/0



C equivalent 10keV 1E15/cm2 0/0



5-2. Metal contamination and Particle

Metal contamination measurement with TXRF

C_7H_x 80keV 1mA 1E16

[ppm]

K	Ca	Ti	Cr	Mn	Fe	Co	Ni	Cu	Zn	Hf	In	Sb
0	0	0	0	0	0.13	0	0	0	0	0	0	0
Ga	Ge	As	Br	Y	Ta	W	Pt	Au	Pb			
0	0	0.76	2.43	0	0	0	0	0	0			

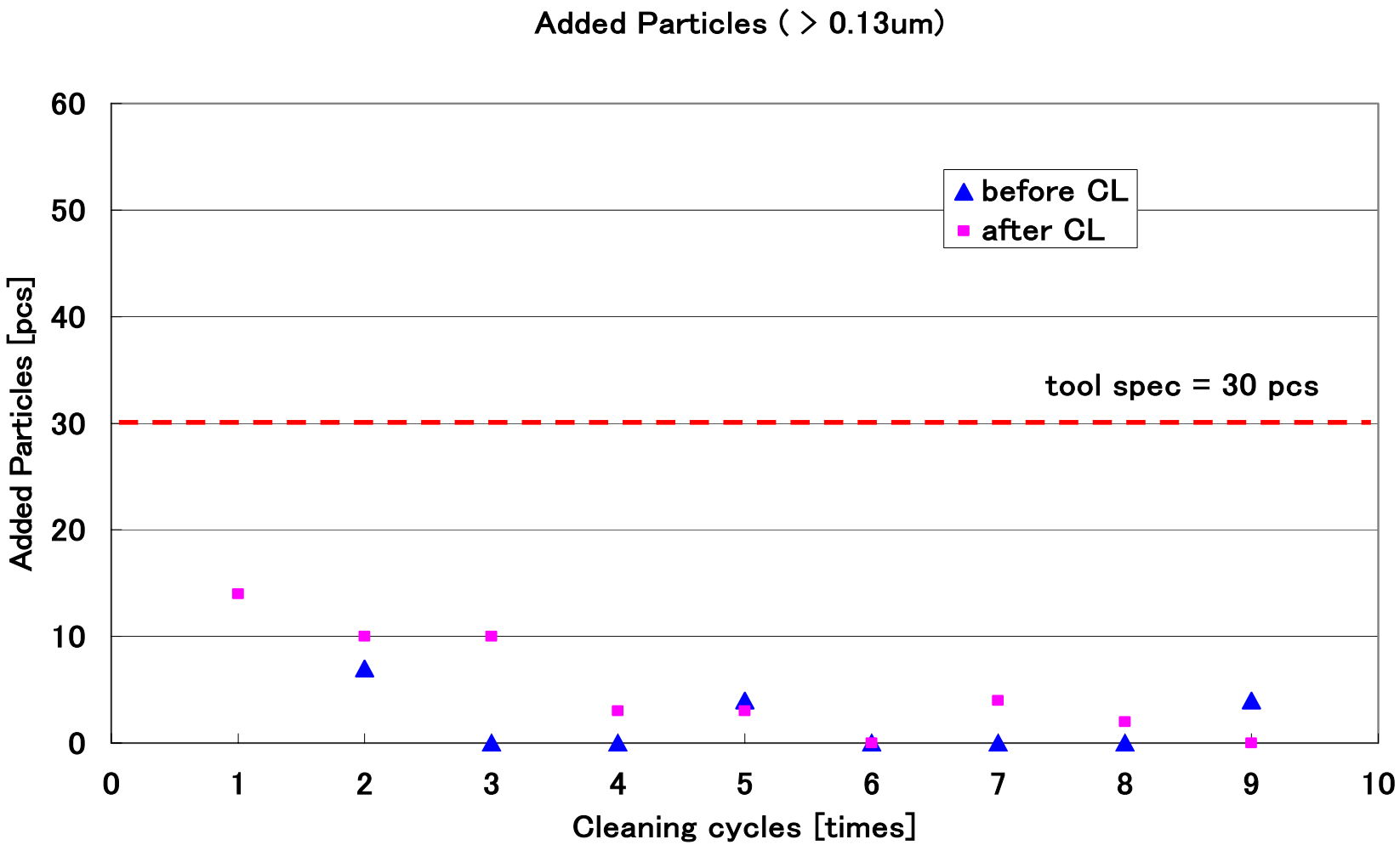
Every metal is less than 5ppm

Particle measurement

Beam Condition	Initial	After implant	Adder
C7 10keV 1E15	42	63	21

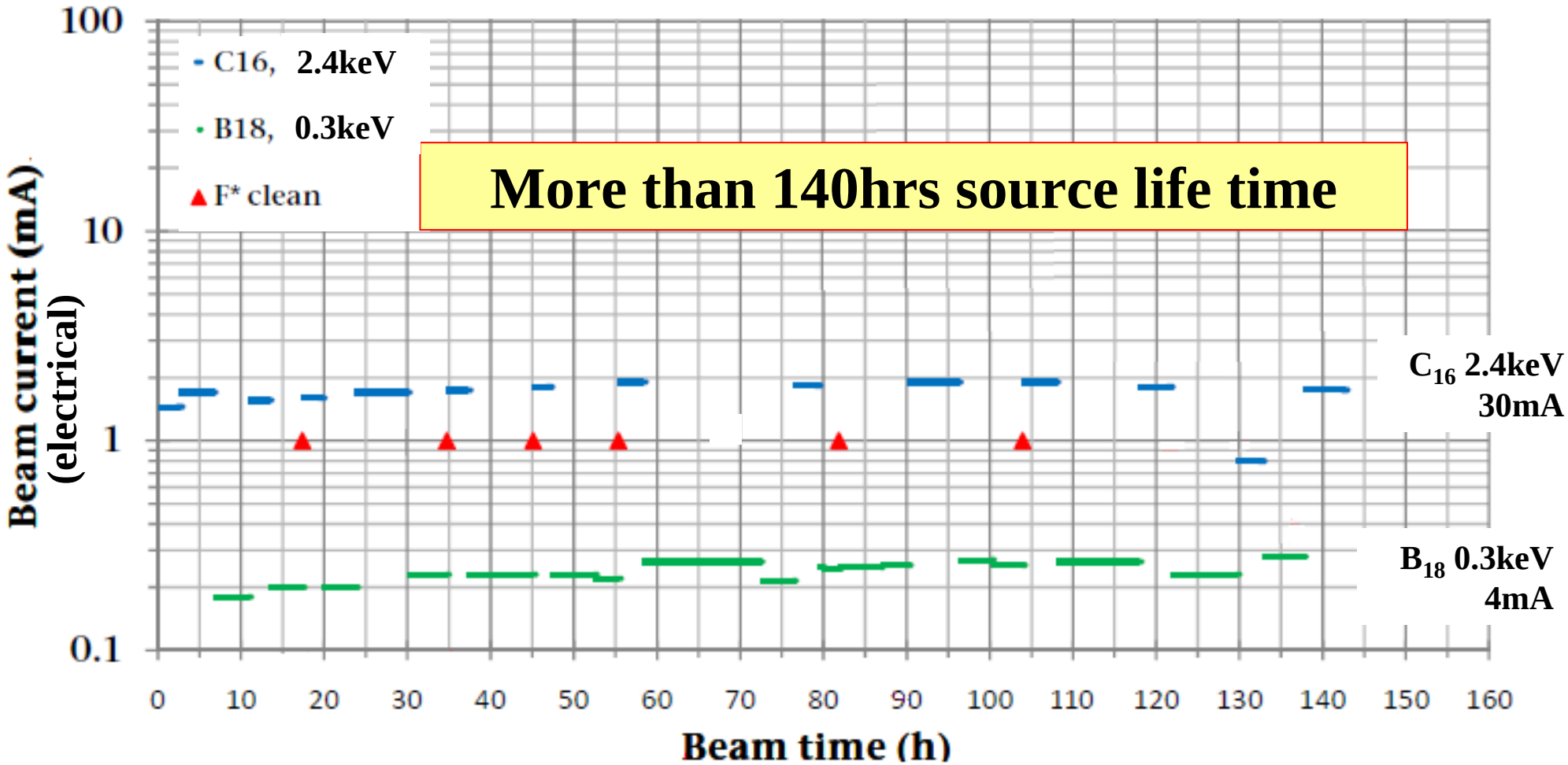
< 30pcs

5-3. Particle trends (Before and after NF3 clean)



- Measurement carried out at each cleaning cycle (~90H)
- Results are not affected by in-situ cleaning

5-4. Mixed Species operation of C_{16} and B_{18}



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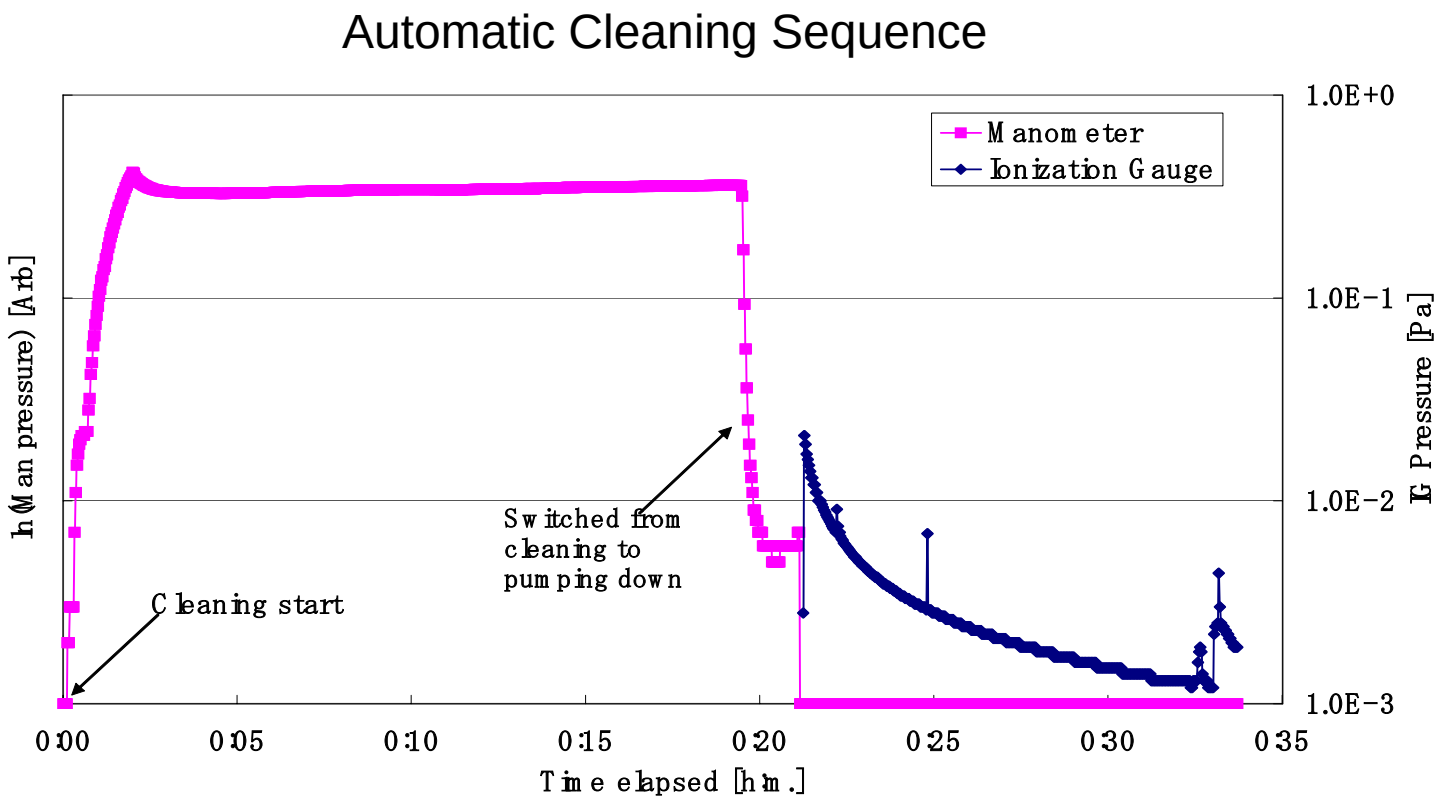
NF_3 Gas Auto-Cleaning System Optimization

NF_3 cleaning (Remote Plasma System)



NF_3 clean takes around 30min after 12 hours running B_{18}/B_{10}.

5-5. Auto beam set-up

Mixture operation with B_{18} & C_7 (Drift mode)

Ion	Equivalent Recipe	Tuning Time (m:s)	Tuned current (mA)	Status
B18	B 3keV 17mA	0:05:11	16.74	Cold start
B18	B 0.5keV 4.9mA	0:08:13	4.56	Recipe change
B18	B 0.45keV 4.3mA	0:07:54	4.21	Recipe change
B18	B 1keV 12.2mA	0:08:35	11.53	Recipe change
B18	B 0.33keV 2.5mA	0:08:45	2.43	Recipe change
B18	B 3keV 17mA	0:05:42	16.07	Recipe change
B18	B 0.23keV 0.9mA	0:09:55	0.85	Recipe change
C7	C 3keV 7.3mA	0:09:48	6.63	Species change
B18	B 0.45keV 4.3mA	0:08:28	4.50	Species change
C7	C 6keV 7.3mA	0:09:55	7.51	Species change
B18	B 0.33keV 2.5mA	0:07:09	2.39	Species change
C7	C 1.3keV 2.1mA	0:11:08	1.99	Species change

Average set-up time; 8m24s

6. Summary

- **Carbon cluster implant with CLARIS has been improved.**
  1. Competitive high beam current of carbon cluster
  2. Good uniformity, metal contamination and particle
  3. More than 140hrs source life time
  4. Stable mixed species operation

- **Carbon cluster implant has many process advantages**

The detail was presented in the poster session P1-30
(Cluster Ion Implantation for Process Application by Dr. Masayasu Tanjo)

And will be presented in the afternoon session today Th-14
(Optimization of Si:C stress retention and junction quality with ClusterCarbon implantation by Dr. Karuppanan Sekar)

Thank you for your attention