IISW2013

Fundamental Ion Implantation Technologies for Image Sensor Devices

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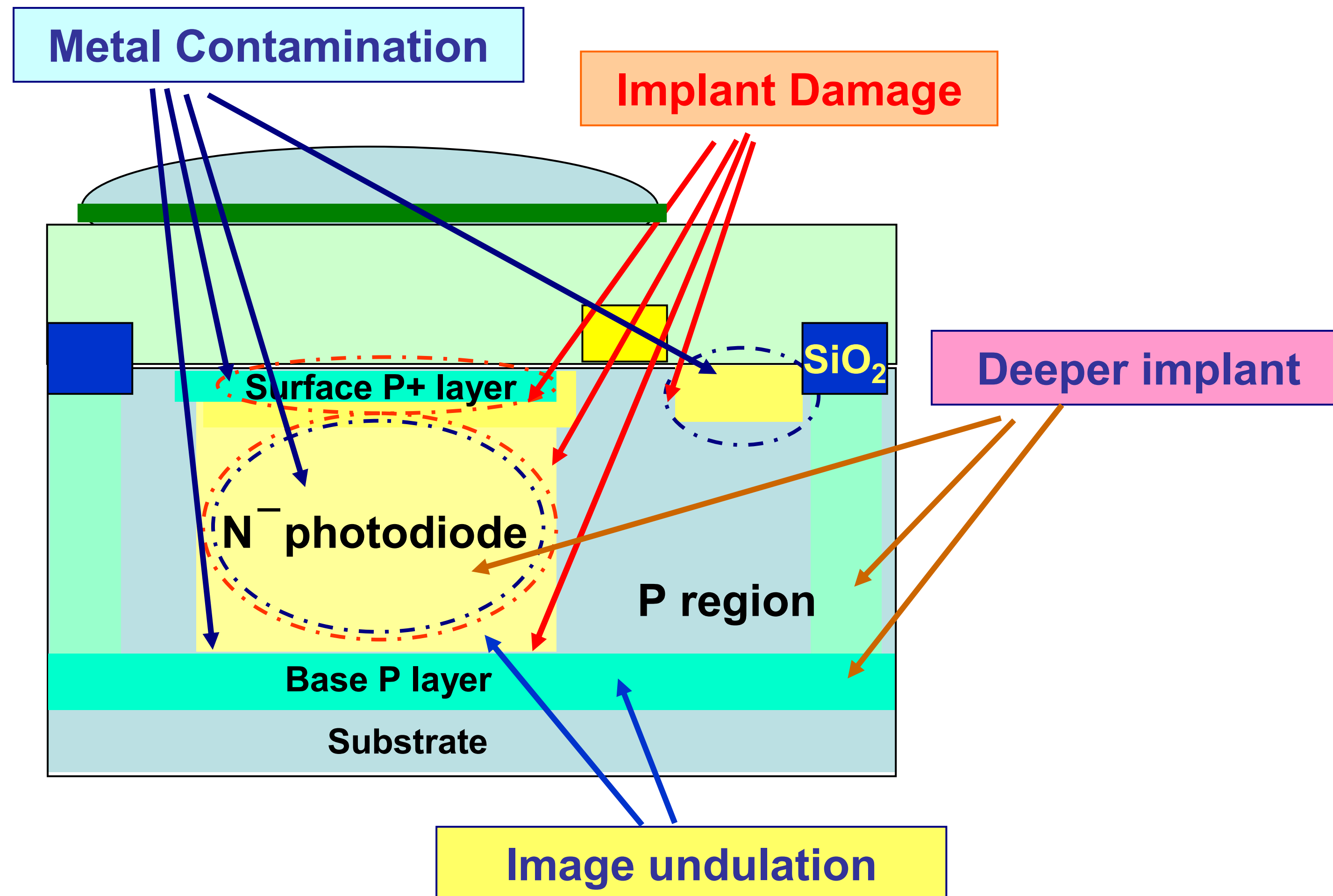
SEN corporation

Genshu Fuse and Michiro Sugitani

Outline

1. Typical CIS structure and Implantation
2. Metal contamination
3. Implant damage
4. Image undulation issue from beam scan
5. Deeper implant with Ultra high energy implanter
6. Ultra low energy/medium dose implant
7. Implant angle accuracy
8. Summary

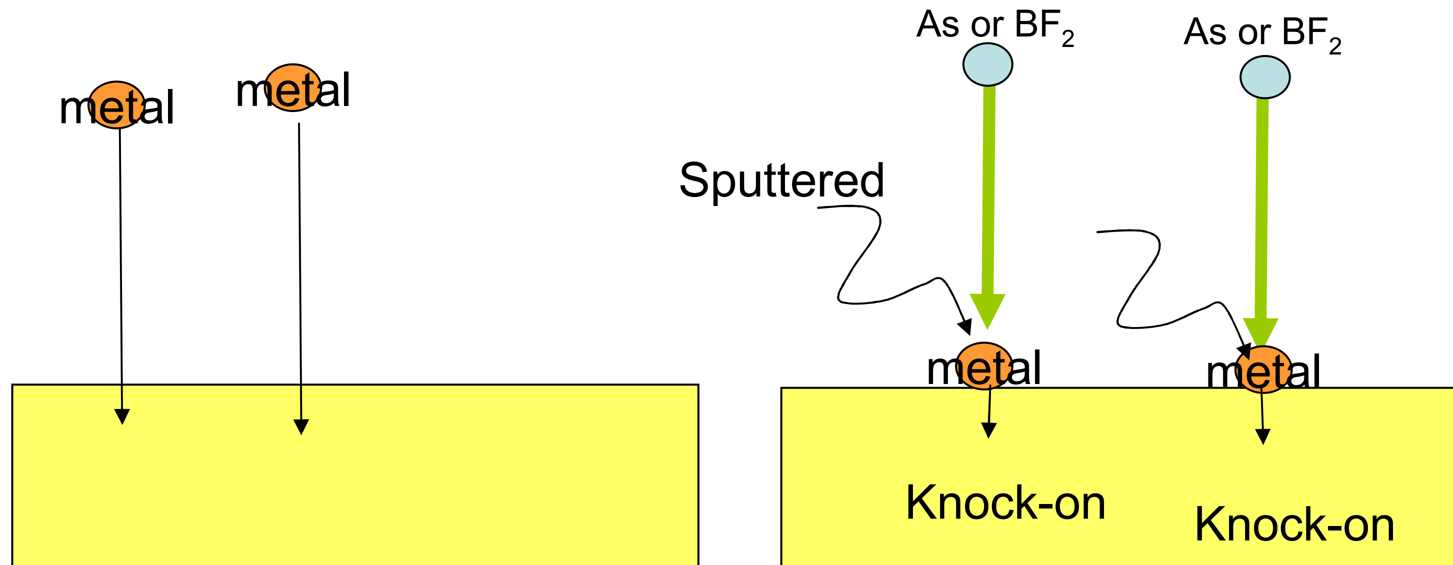
1. Typical CIS structure and Key Implantations
[Image about CIS implant issues]



2. Metal contamination

Two kinds of Metal contamination

1. Energetic contamination (from ion source)
2. Beam knock-on from metal put on surface



Molybdenum ion source arc chamber

Alfedo Cubina 1990 IIT P160

Analyzing Magnet strength

Mo^{+} ;98

Mo^{++} ;49

Same Analyzing Magnet strength

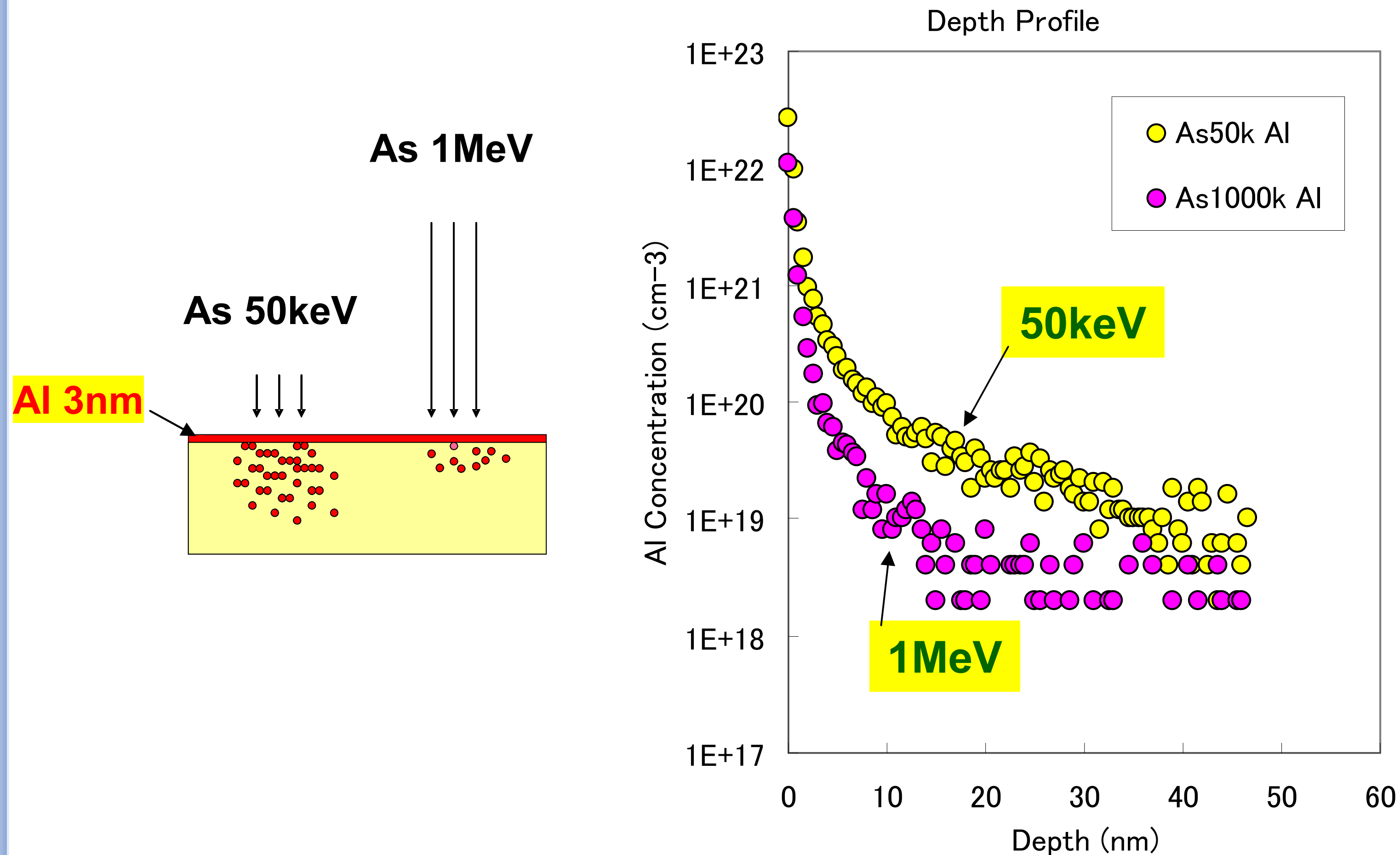
[BF_2=49]

Just for the record fluorine atoms have heavy chemical sputter strength

Molybdenum arc chamber source should not be used

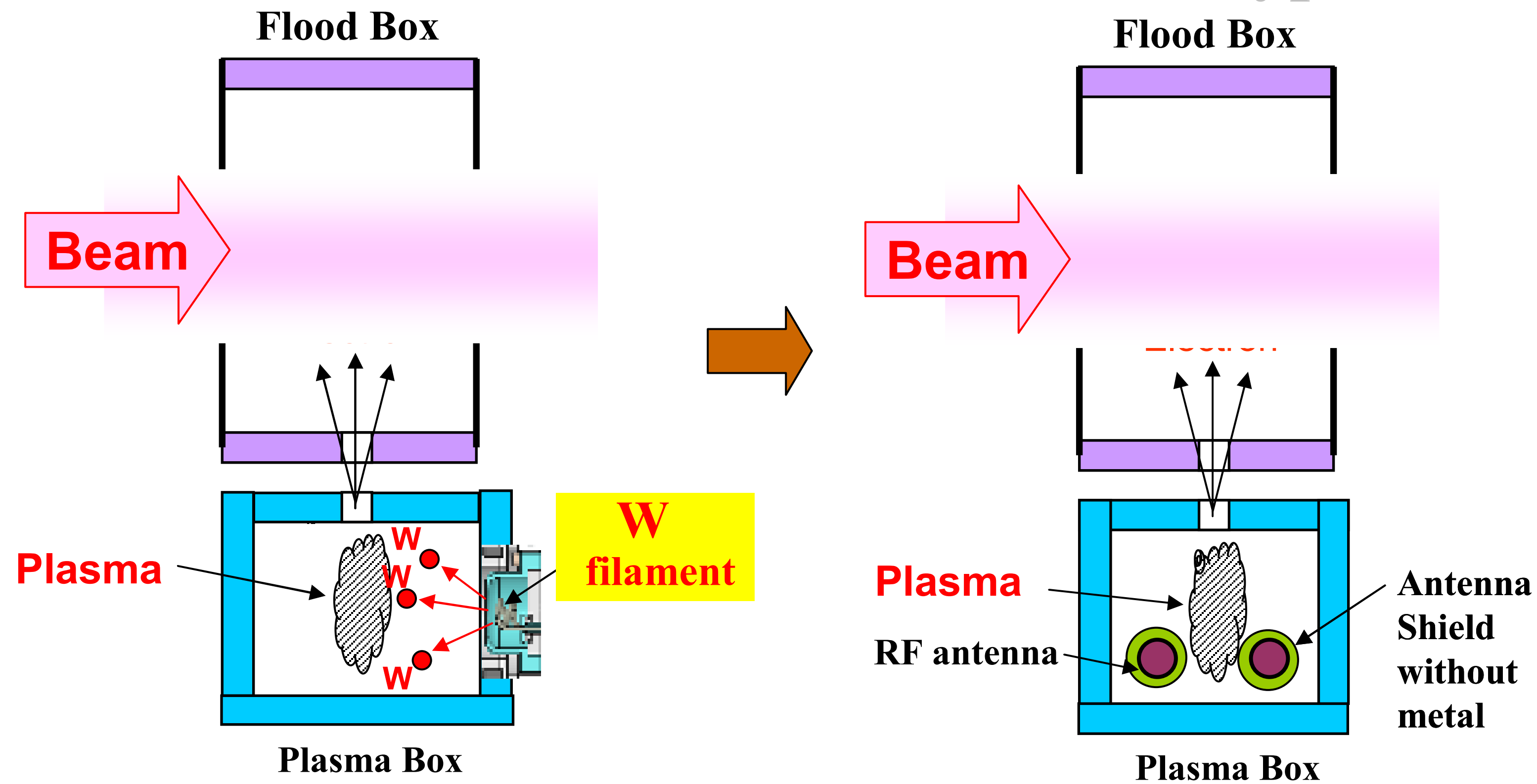
Metal contamination : Knock-on effect

Monte Carlo simulation [TRIM]



Electron shower

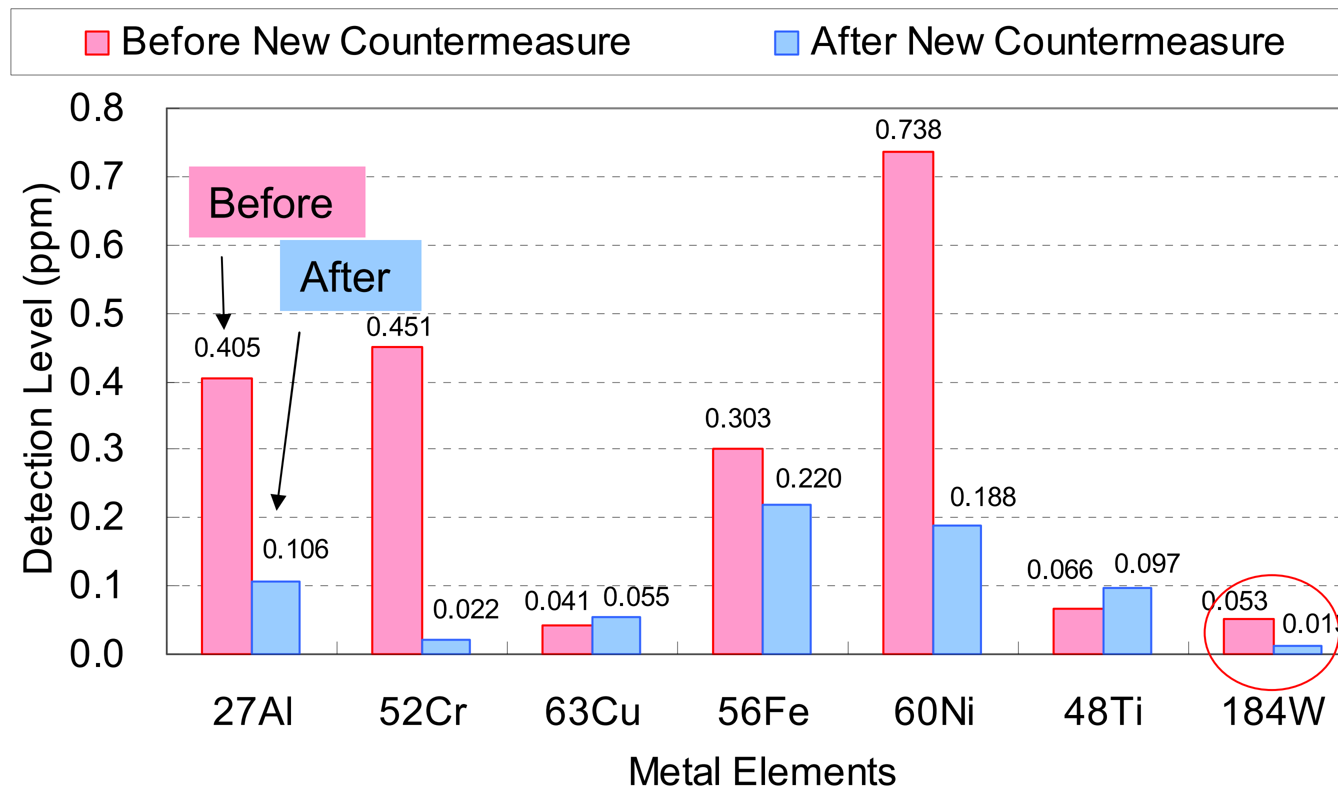
Filament type → Filament-less RF type



Metal contamination from W filament and arc chamber

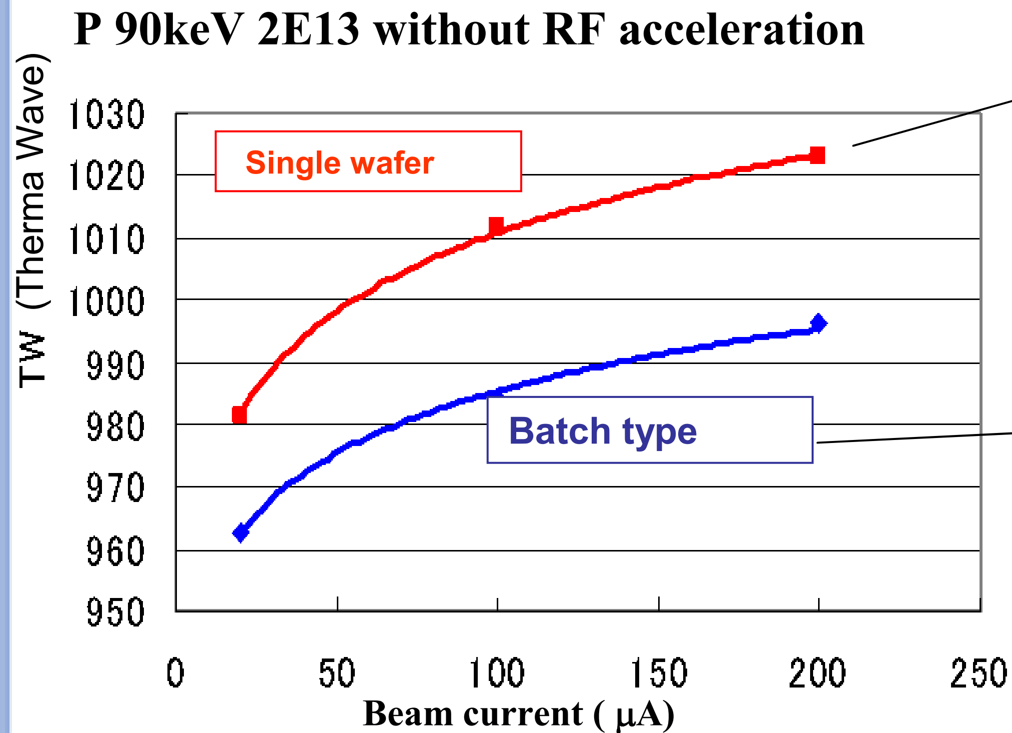
Metal contamination reduction

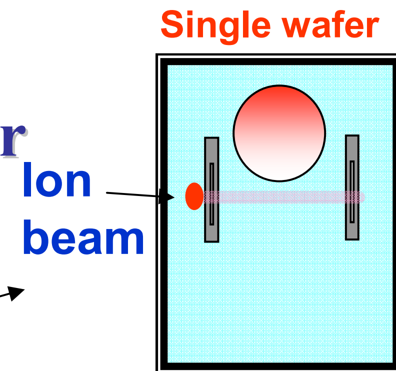
One example of Countermeasure for Metal Contamination on Medium current implanter

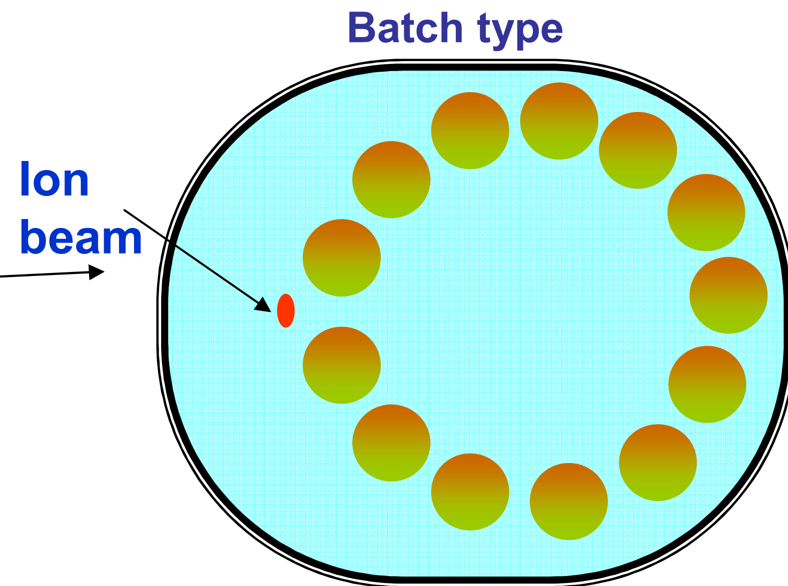


3. Implant Damage

Difference between batch and single-wafer





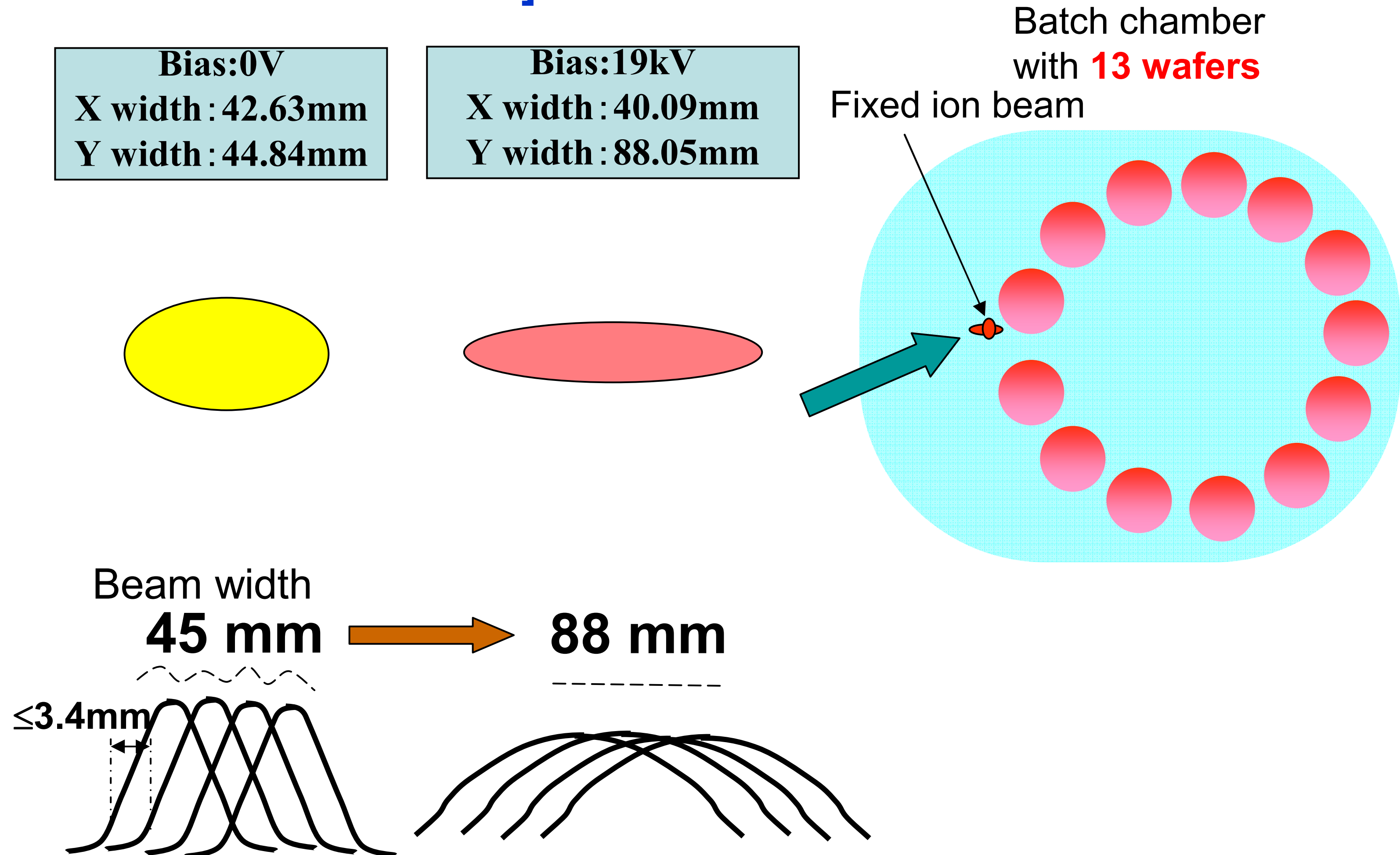


- Single-wafer type implanter produces more damage than batch type implanter under the same beam current.

4. Image undulation issue from beam scan

High energy batch type implanter case

[The effect of Bias Q Lens]



♦ Result : The wafer map of dark current level

Difference of very low implant damage influences to the characteristics

Conventional beam

Broad beam

Dark current level
Worse

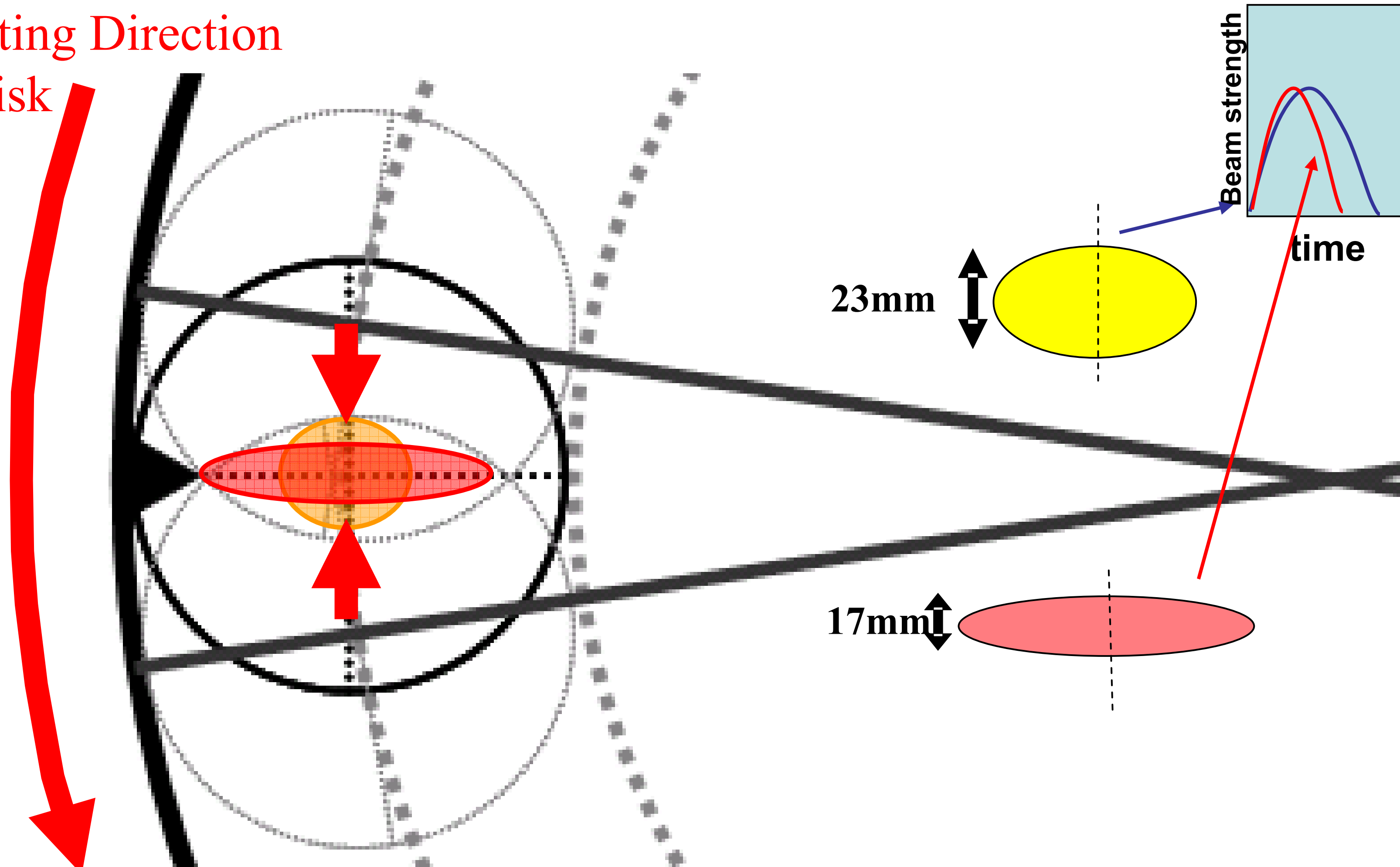
Dark current level
Better

Dark current level is lowered over the wafer overall

E. Kanasaki @IWJT2009

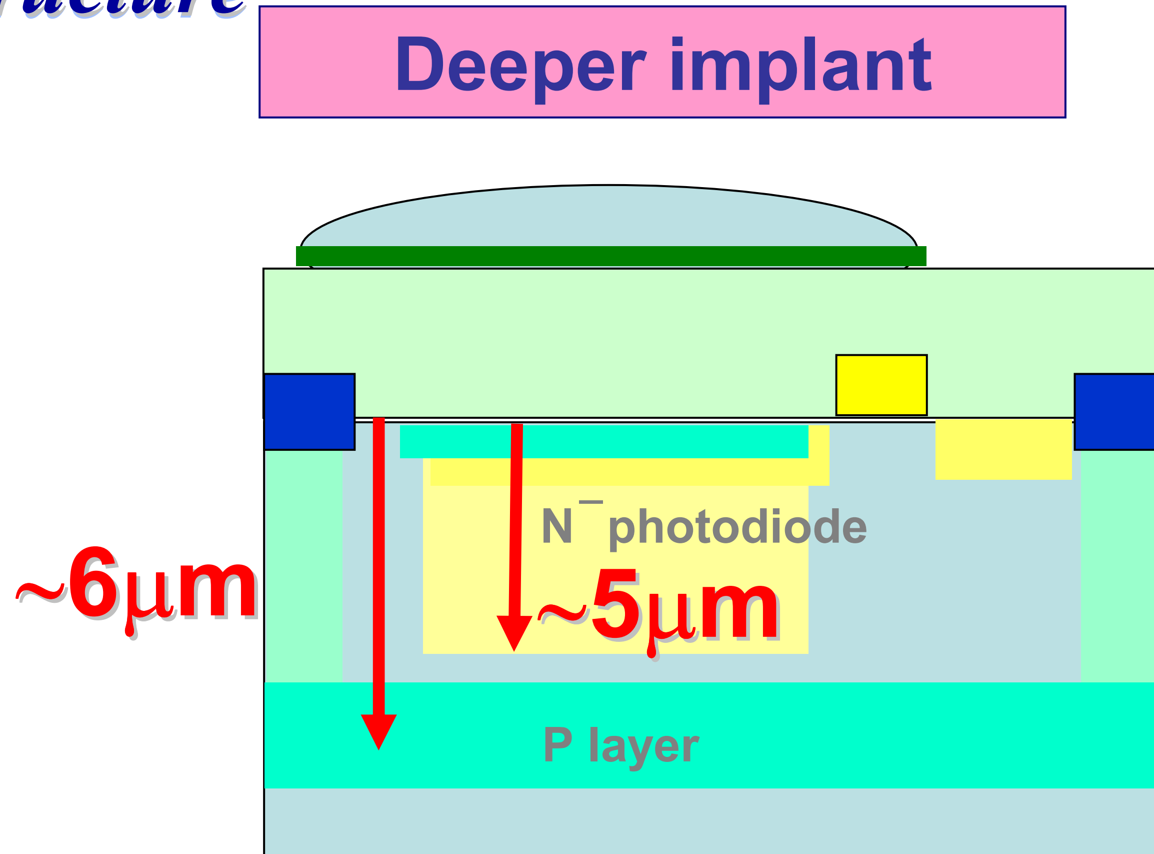
Lower implant damage on batch implanter and beam profile

♦ **Image drawing of experiment that shortens beam irradiation time**

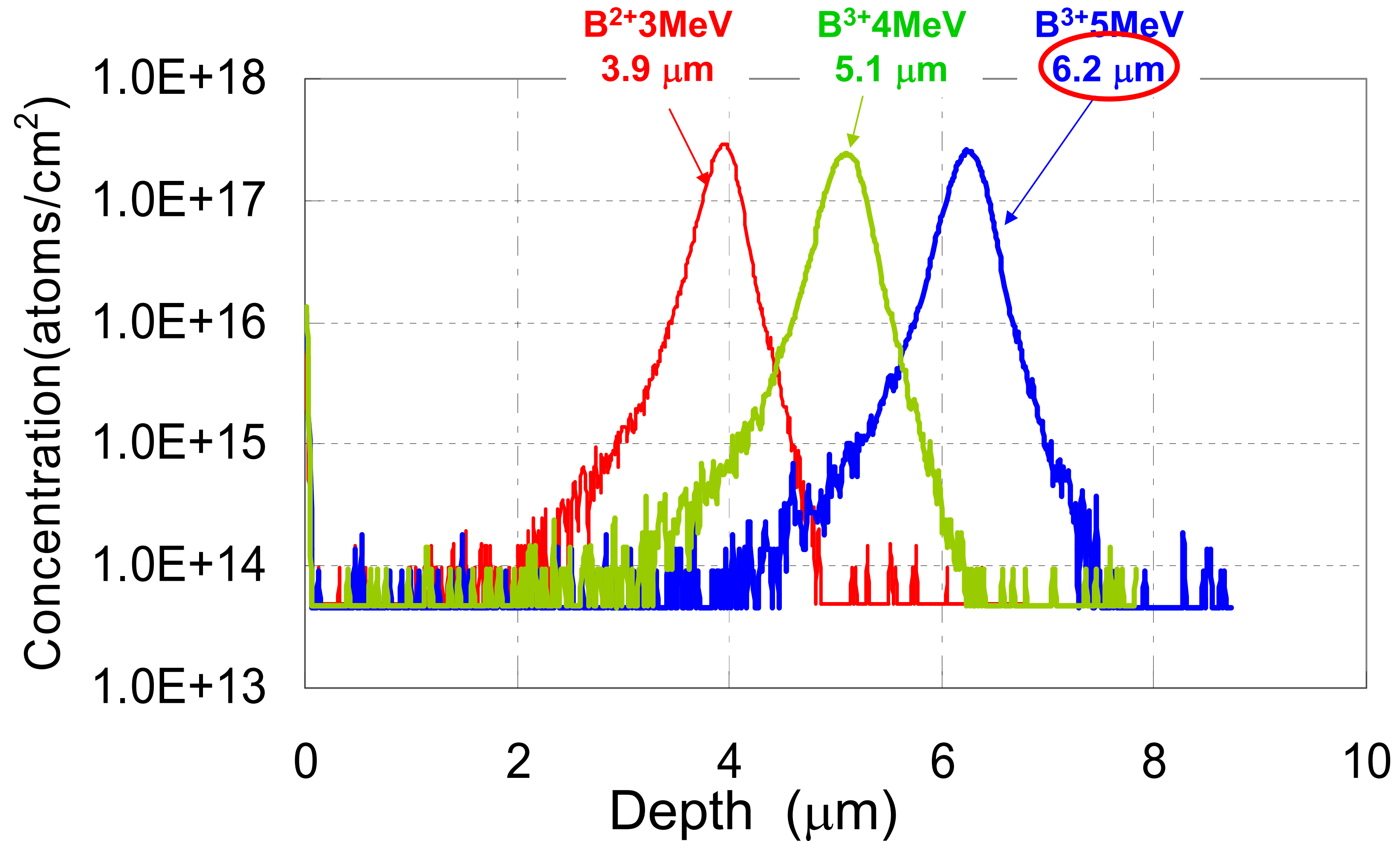


5. Deeper Implant with Ultra high Energy Implanter

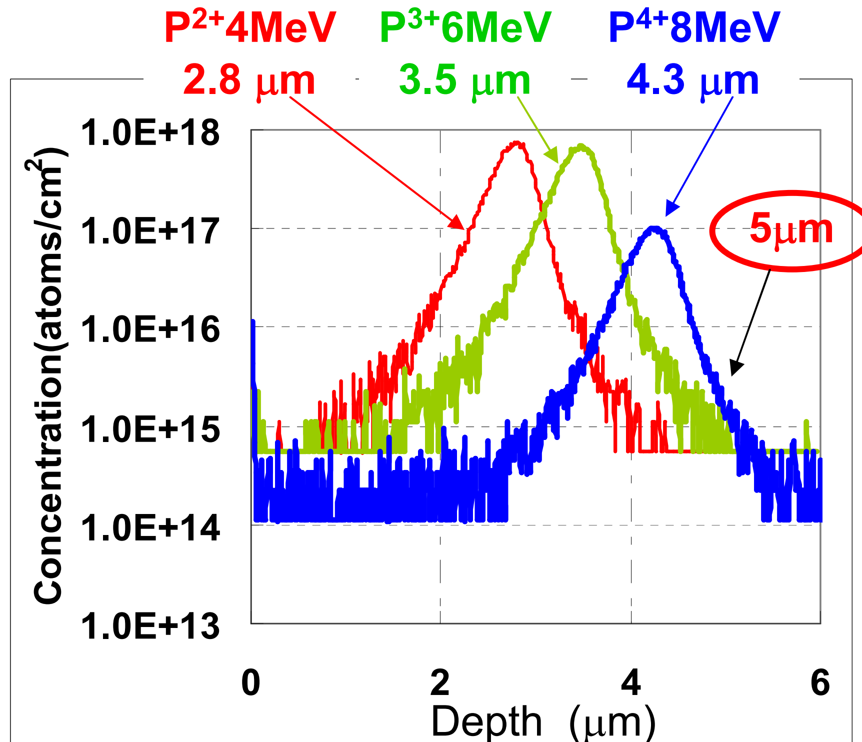
CIS structure

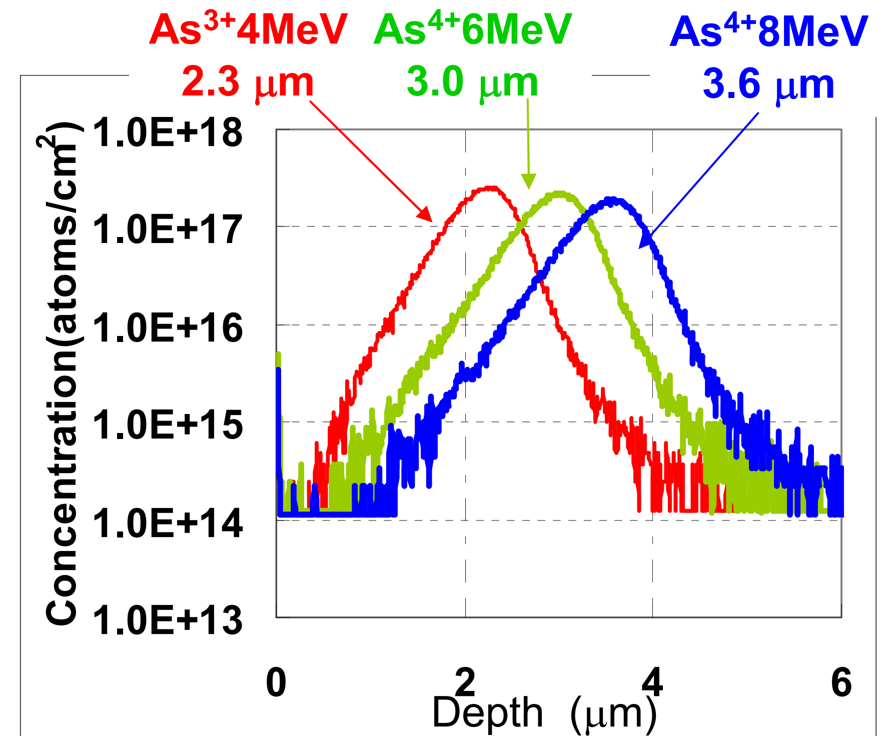


- UHE Boron Depth Profile -



- UHE P and As Depth Profile -





- UHE Beam Energy and Current -

unit: pμA

UHE	B			P				As			
	+	2+	3+	+	2+	3+	4+	+	2+	3+	4+
90keV	1000			1000				500			
0.3MeV	500			380				150	75		
～0.5MeV	750	75		450				150	75		
～0.9MeV	750	75		450	300				75	35	
～1.3MeV	750	75		450	300				75	35	
～1.5MeV	750	75	1		300				75	35	
～2.0MeV	750	75	1		350	50				35	
～2.5MeV		75	1		350	50				35	
～3.1MeV		75	1		350	50	1			35	5
～3.4MeV		75	1		350	50	1			35	5
～3.6MeV		75	1		350	50	1			35	5
～4.4MeV			1		350	50	1			35	5
～4.6MeV			1			50	1			35	5
～5.0MeV			1			50	1				5
～6.3MeV						50	1				5
～8.0MeV							1				5

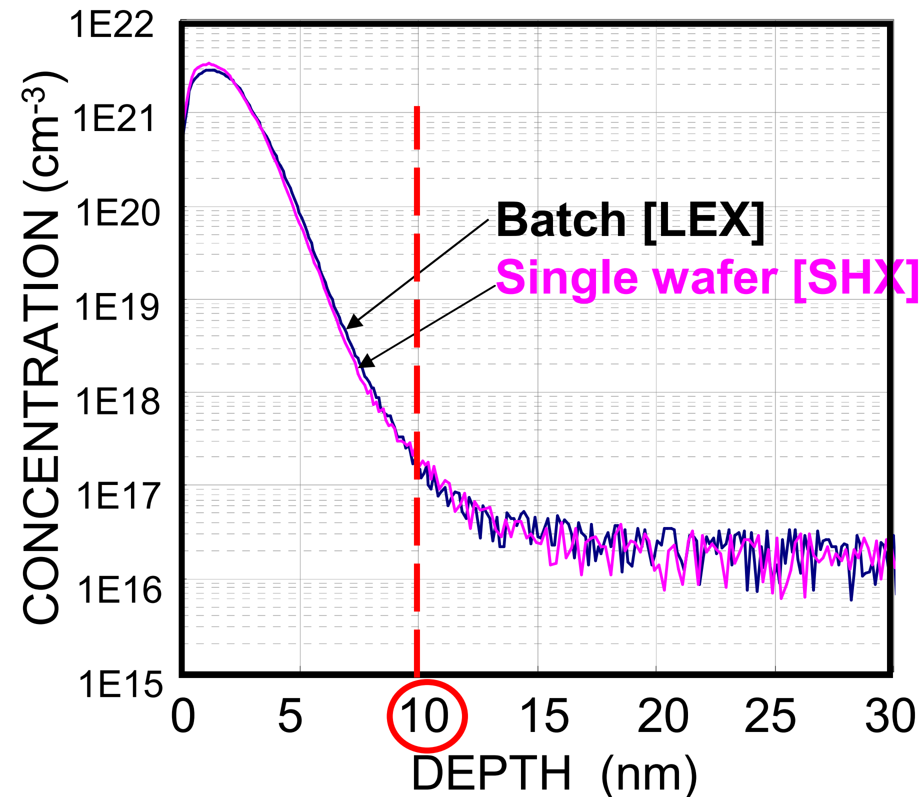
Available energy by UHE

6. Ultra low energy/medium dose implant

Backside Passivation for BSI

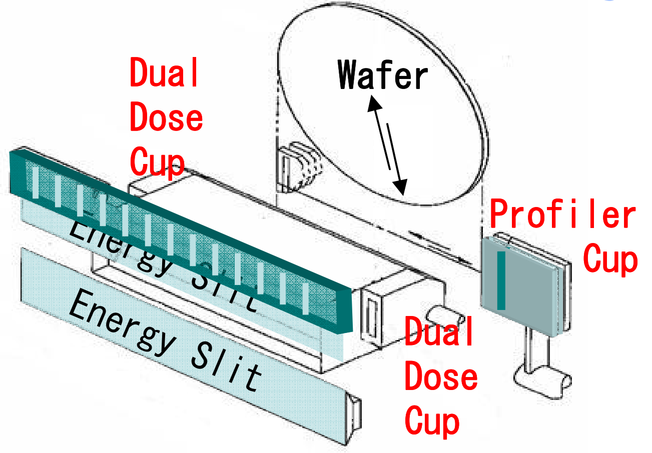
Low energy; 0.2keV and mid dose; 1E13cm^{-2} under sufficient uniformity and productivity

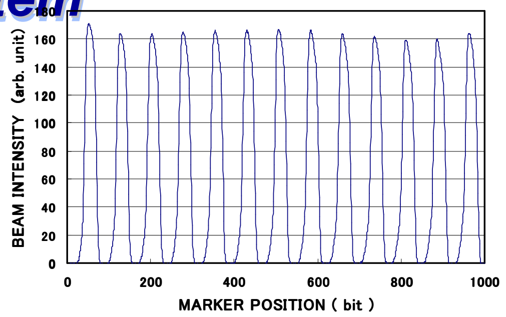
B$^+$ 0.2keV 1E15

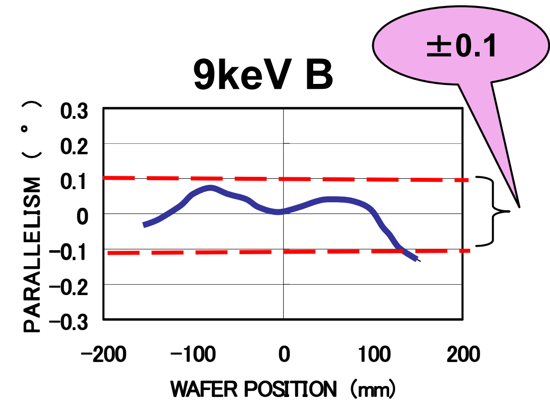


Single wafer implanter

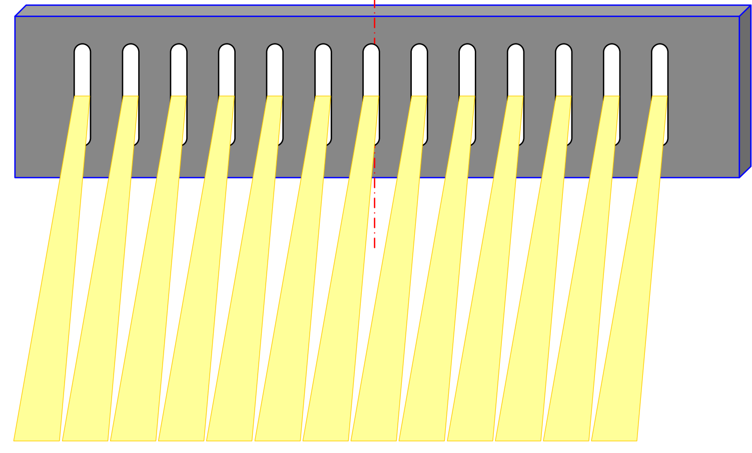
Beam Parallelism check system







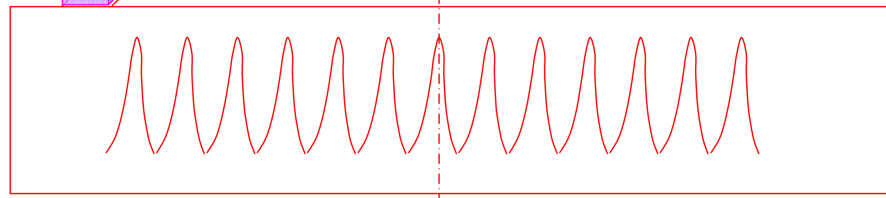
Divergence Measurement Mask



Real irradiation position

Profiler Cup

Profile of Parallelism



8. Summery

1. Metal reduction has been continued
2. RF shower is effective to reduction metal contamination
3. Low level of metal sputtering at MeV implant
4. Bias Q (beam modulation) is effective for image sensor to control damage and image undulation
5. Batch type implanter has still some merits for image sensor
6. UHE implanter can achieve up to 5 MeV boron and 8MeV phosphorous to form deep P and N layer
7. The reduced cone angle disk can decrease implant angle error to 0.34° even at batch implanter
8. Implant angle accuracies can reach under 0.2° as a practical ability
9. Ultra low energy/medium dose implant can be realized to form shallower surface P layer