Специализированные электронно-лучевые системы для микроэлектроники

В.В. Казьмирук

ИПТМ РАН

Специализированные электронно-лучевые системы

1. Системы поиска дефектов

2. Системы для верификации дефектов

3. РЭМ для измерения критических размеров
   - 1D (CD), 2D, 2,5D, 3D

4. Электронные литографы

- KLA-Tencor eS35
  - Die-to-die
  - Image contrast inspection
  - Pixel size: 15, 20, 25nm
  - Landing energy 1750V
  - Data rate 50mpps

- Hermes Microvision eScan 315
  - Die-to-die
  - Image contrast inspection
  - Pixel size: 10, 15nm
  - Landing energy: 2000V
  - Data rate 100mpps

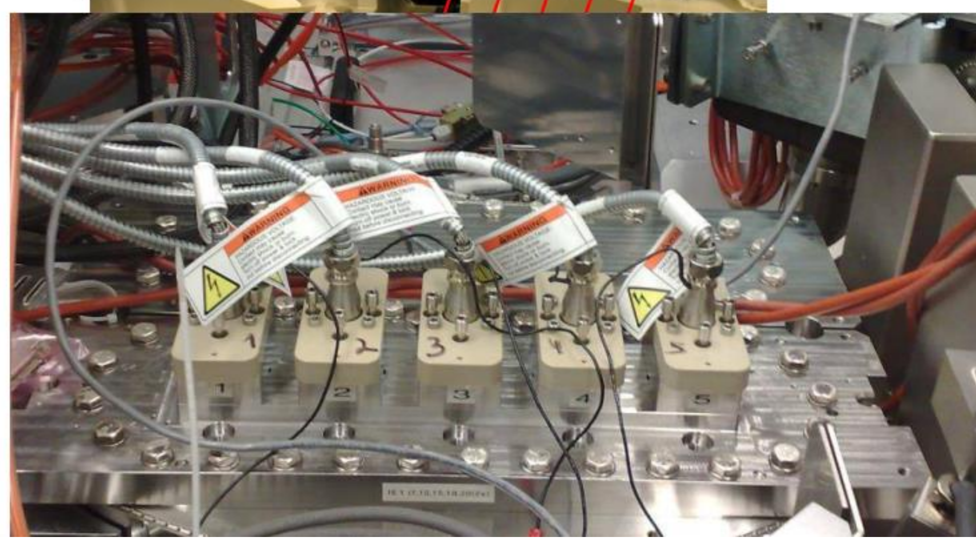
- NGR 2100
  - Die-to-database
  - Fast CD inspection
  - Pixel size: 3nm
  - Landing energy 2600V
  - Data rate 50mpps

Molecular Imprints

EBI – Multi-Column E-Beam Wafer Inspection

- **Core technology**
  - E-beam resolution
  - Revolutionary multi-column technology
  - High data rate columns

- **Benefits**
  - High TPT
  - Leap jump in resolution



AutoFlow

EDA Tool Set

Design Rule

OP
C

Design Layout

Design of OPC applied

Simulation

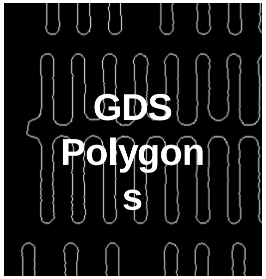
GDS Modification

Hot Spot & Auto Recipe

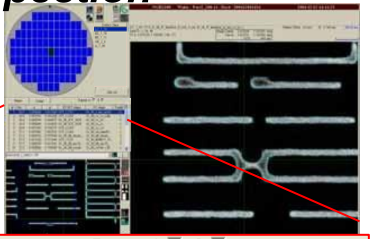
Process Recipe for Inspection Criteria & Manual Site Analysis

GDS or OASIS optional layer to define inspection locations for trouble-spot analysis

NGR2100C



2D SEM Inspection



Shape | Detail | Repeat ≥1 ☑ 0 ☑

#	Sev	x	y	PCOPC shape	PC shape	Total#
1	56.7	5.004886	8.413168	ICV_11371	01_00_c_inv_m345	12
2	56.8	5.007650	9.563260	ICV_11203	01_00_cs_c1_c2la	1
3	56.8	5.000790	9.588477	01_00_ICV_3454	01_00_cs_c2	4
4	56.8	5.006044	9.519676	01_00_ICV_3509	01_00_cs_c1	1
5	56.9	4.997250	9.526737	ICV_11203	01_00_cs_c2	1
6	57.1	4.997906	9.483521	ICV_11203	01_00_ch_nand3e...	1
7	57.2	4.998950	8.978996	01_00_ifti_btcalc_...	01_00_ifti_btcalc_...	3
8	57.5	5.001106	8.711049	ICV_11371	01_00_#1#ICV_14...	2
9	57.7	5.000599	9.013541	01_00_ifti_inc38_...	01_00_ifti_inc38_...	9
10	57.8	4.990696	8.794949	01_00_ifta_btcalc...	01_00_clcbw_c2b...	1

CD Data and Inspection Results

2100C Specification

Principal Performance	
Item	Specification
Resolution	Sub ｎｍ
Measurement Repeatability（３σ）	＜500 pico meter
Scan Rate	200 MHz
Accelerating Voltage	０．２～３ｋV
FOV	16μ-50μ （16000×16000 pixels）
Sampling Rate	20０M pixel／sec.
Scanning Linearity（３σ）	＜０．０１％
MAM（Move－Acquire－measure）	＜20 sec.
Stage Accuracy（３σ）	0.1 μm

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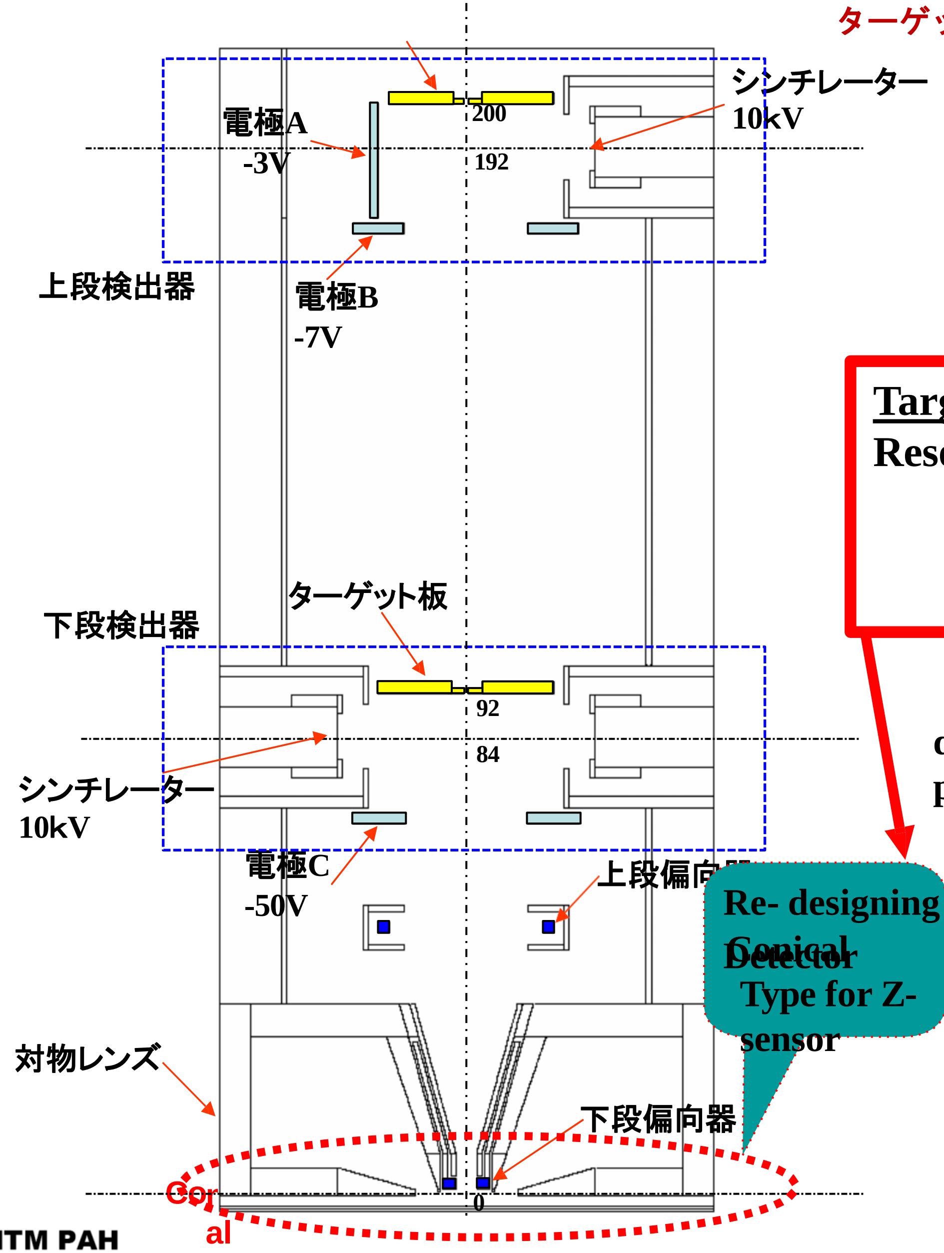
Throw the lens detector



Simulating condiyion

Resolution: １～２ nm

FOV : 50μm

distortion : <0.1%

Static Scan : +/- 60V

Target Specs.

Resolution WD 2mm

Static Plate length

2mm Detection ratio

Without mesh

Top detector	Bottom detector
Target plate Position 200mm	92mm
Diameter 0.5mmϕ	1.5mm ϕ
Position 192mm	84mm
Upper deflector	Lower deflector
Position 49mm	2.5mm
Diameter 30mmϕ	4mm ϕ
Length 2mm	2mm

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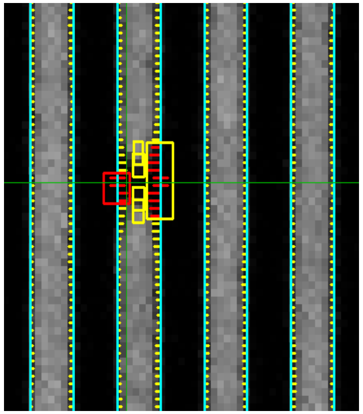
2D Application Model for Printability Management

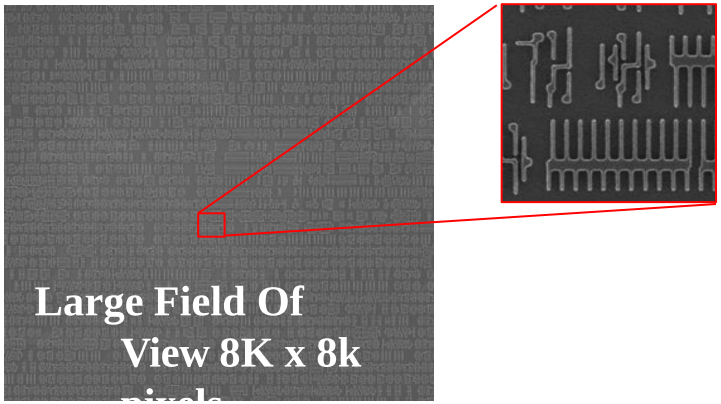
Philosophy:

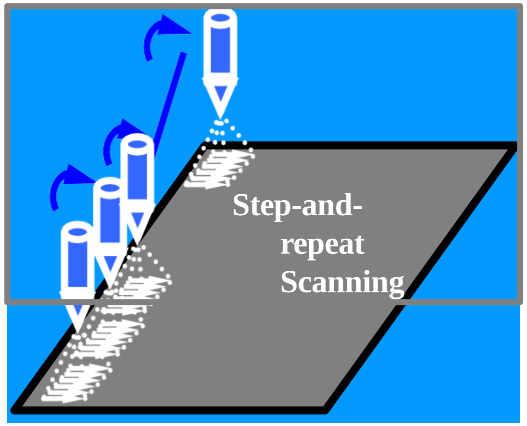
- As we enter the next phase of semiconductor evolution OPC and the ability to manage printability, has become the gating issue of both production and performance yield.
- 2D OPC and Feature Printability is required.
- Multiple process point correlation is required.
- An integrated EDA and 2D Metrology solution will be required.

Technology Overview

- **Electron Beam Based System**
- **Die-to-Database Inspection of Wafer Features**
- **Step and Repeat Image Acquisition**
- **High Pixel Count (8K-28K)**



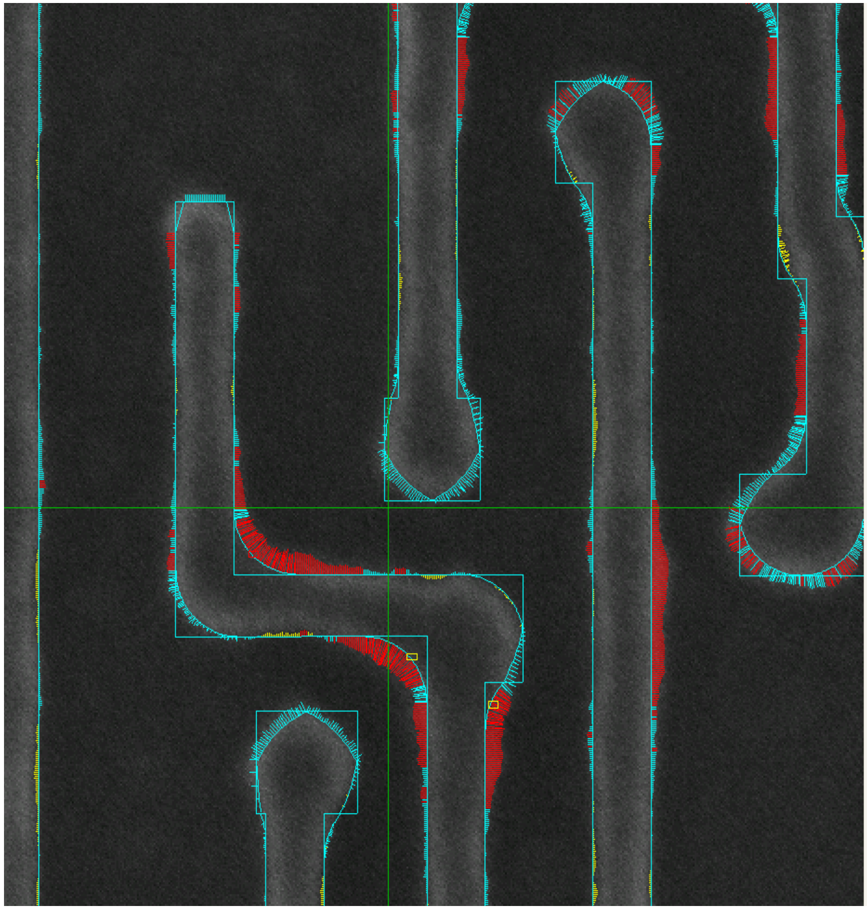




Technology Overview

- **High Scan Rates** **(100MHz - 200MHz)**
- **High beam Current** **(1nA – 5nA)**
- **Low Sample Damage** **(4X less than 1D SEM)**
- **High Speed Real-Time Algorithms**
  - **Verifiers, Classified, GDS Polygon Shapes**
- **Ultra high accuracy GDS overlay, for 2D Metrology**
  - **3 proprietary algorithms, every feature/every scan alignment**
  - **Every Overlay Alignment use 10's of thousands points – real- time**

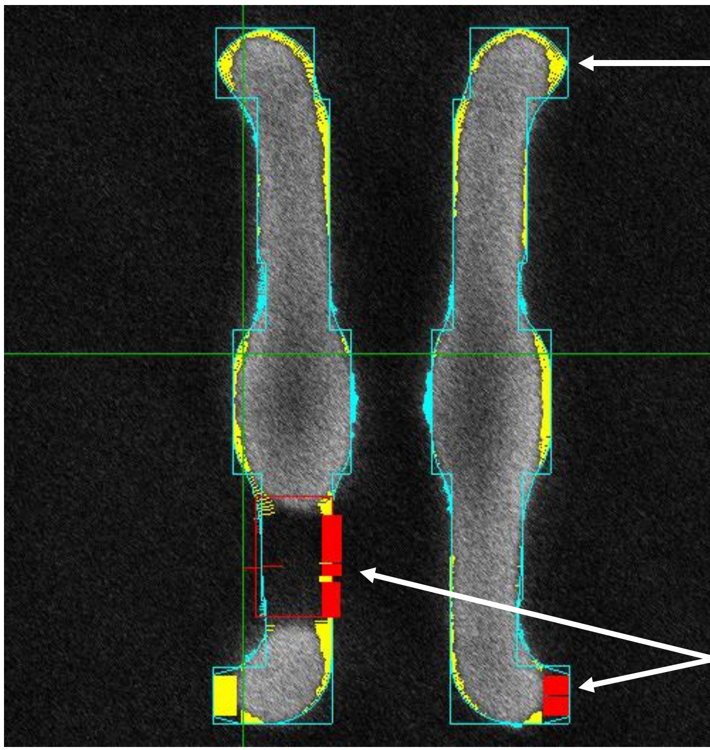
2D CD Measurements



Analysis Process Steps:

1) **The NGR software outlines the captured SEM image**
2) **The GDS is overlaid**
3) **With each raster of the beam a measurement is taken as a bias from the intended GDS shape**
4) **Target plus Bias results in CD measurements at every raster point on the shape**
5) **Individual site CD's are extracted**

Local Inspection



GDS Outline with OPC Shown

Sample Shown is Resist at Wafer Level. Feature size ~ 130nm Image is Cropped from the larger FOV

Individual “Out-of-Tolerance” sites are Identified in red as failed, and yellow as near failure. Void and Line End defects are shown.

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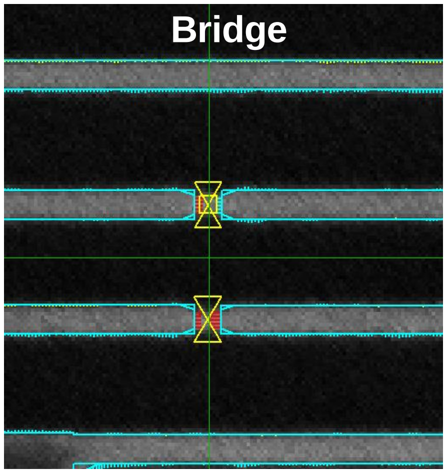
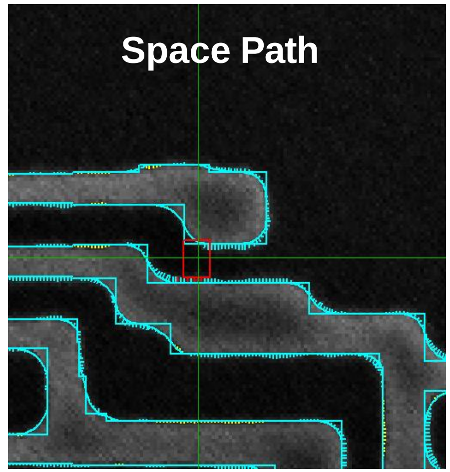
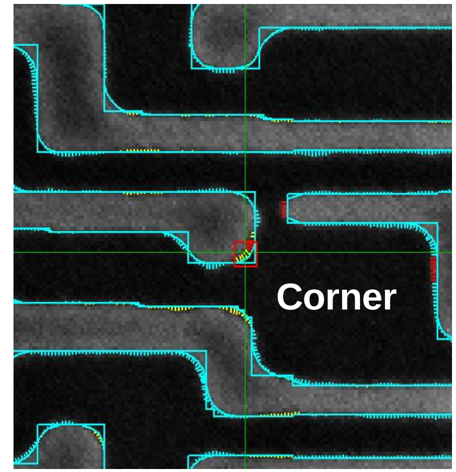
Defect Verifiers

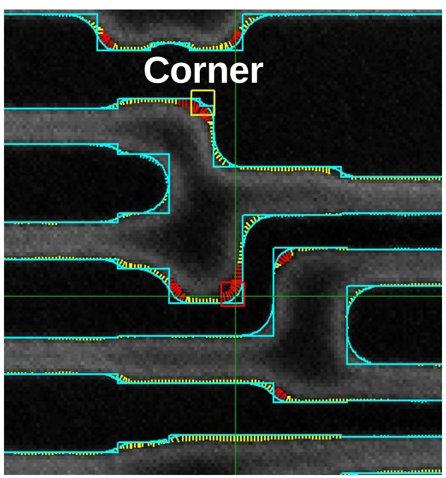
- **Line Width** **+ Line Path** **+ Bridge**
- **Space Width** **+ Space Path**
- **Gate &Active Width (worst)**
- **Gate &Active Width (average)**
- **Gate &Active Bias**
- **Ends (End-cap)**
- **Ends (Contact/via hole)**
- **SRAF**
- **Hole**
- **Random**

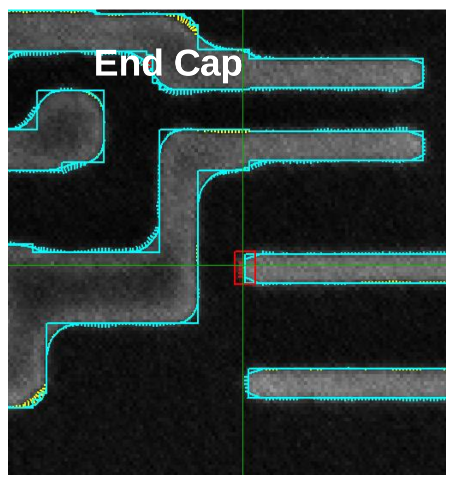
Verifier Examples

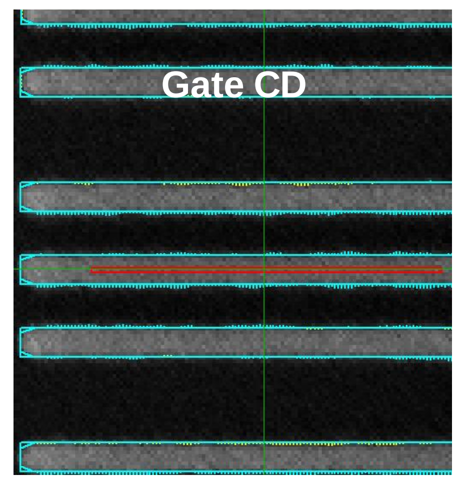




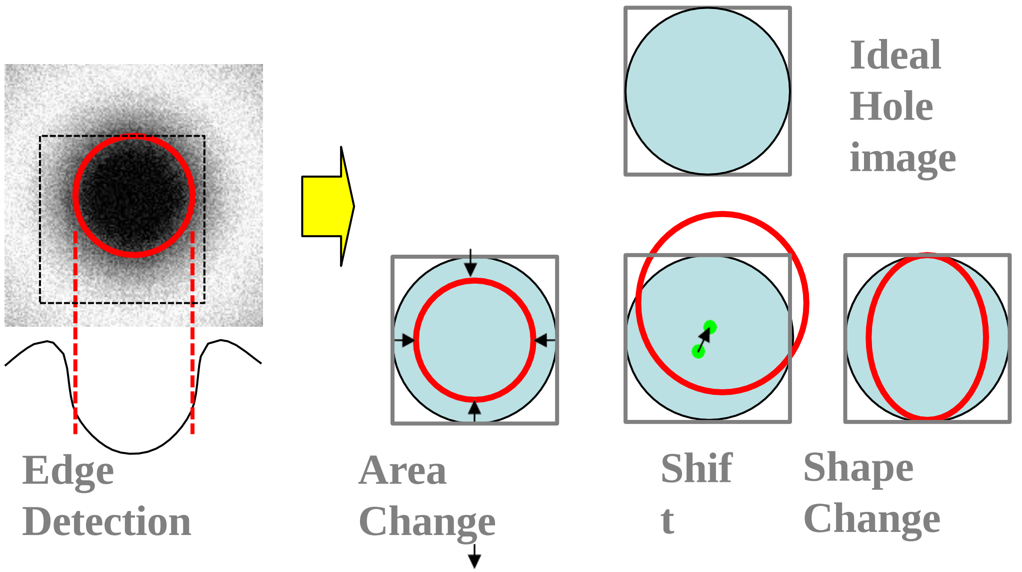




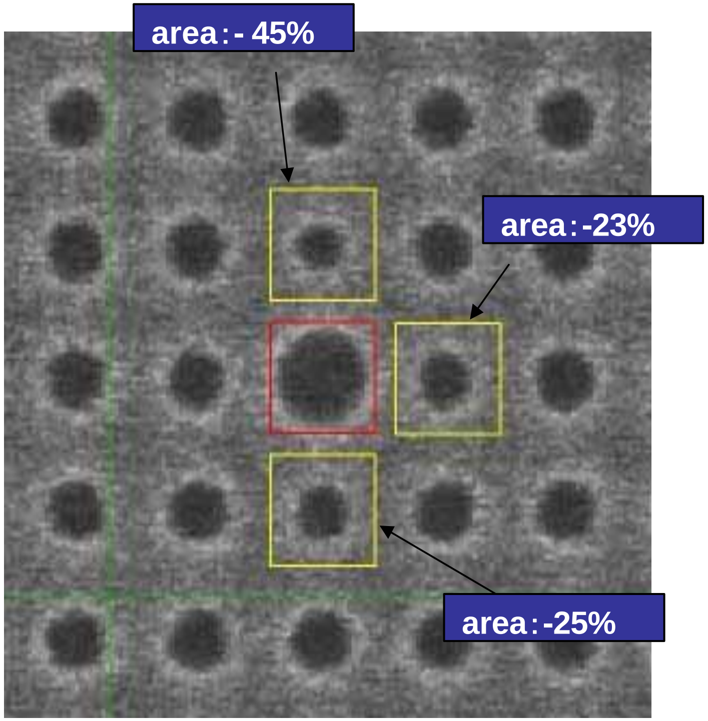




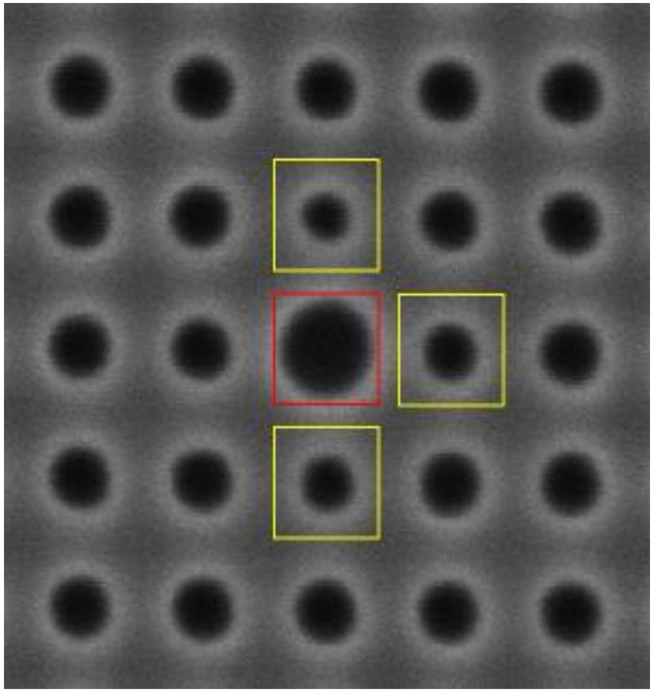
Contact Verifier



Contact Inspection



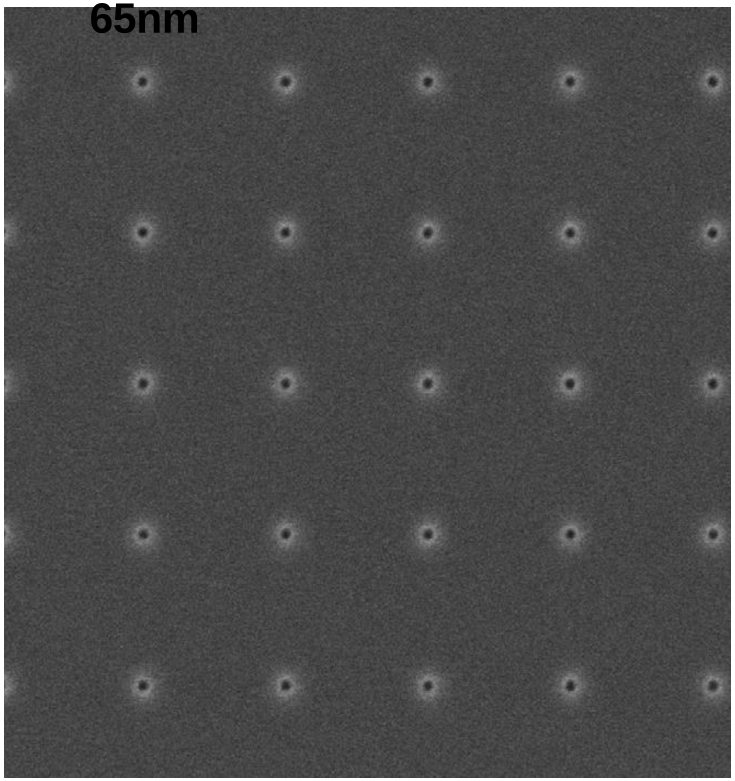
12nm pixel



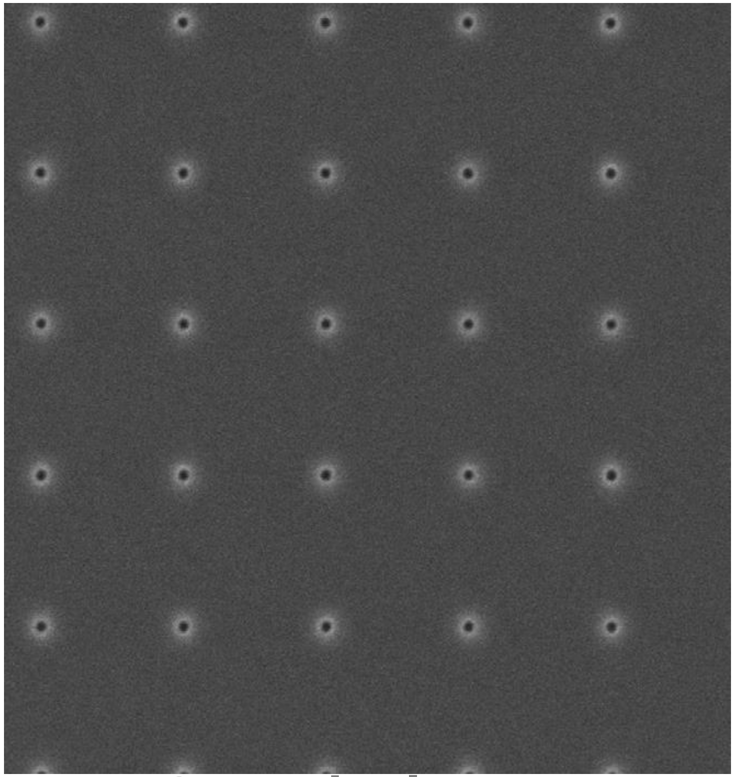
3nm pixel (Review

Via/Contact Inspection

Wafer Images at 65nm



3nm pixel 2 Ave.

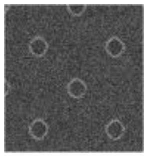


3nm pixel 4Ave.

(Review)

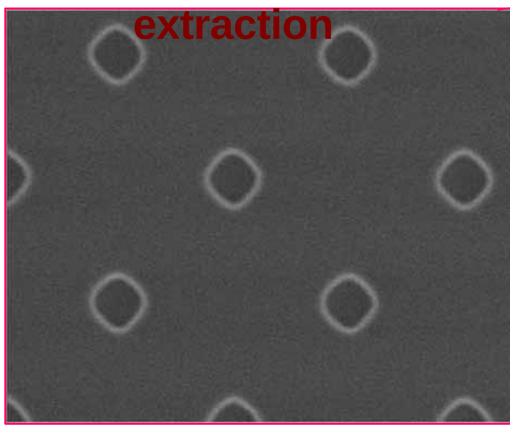
ИПТМ РАН

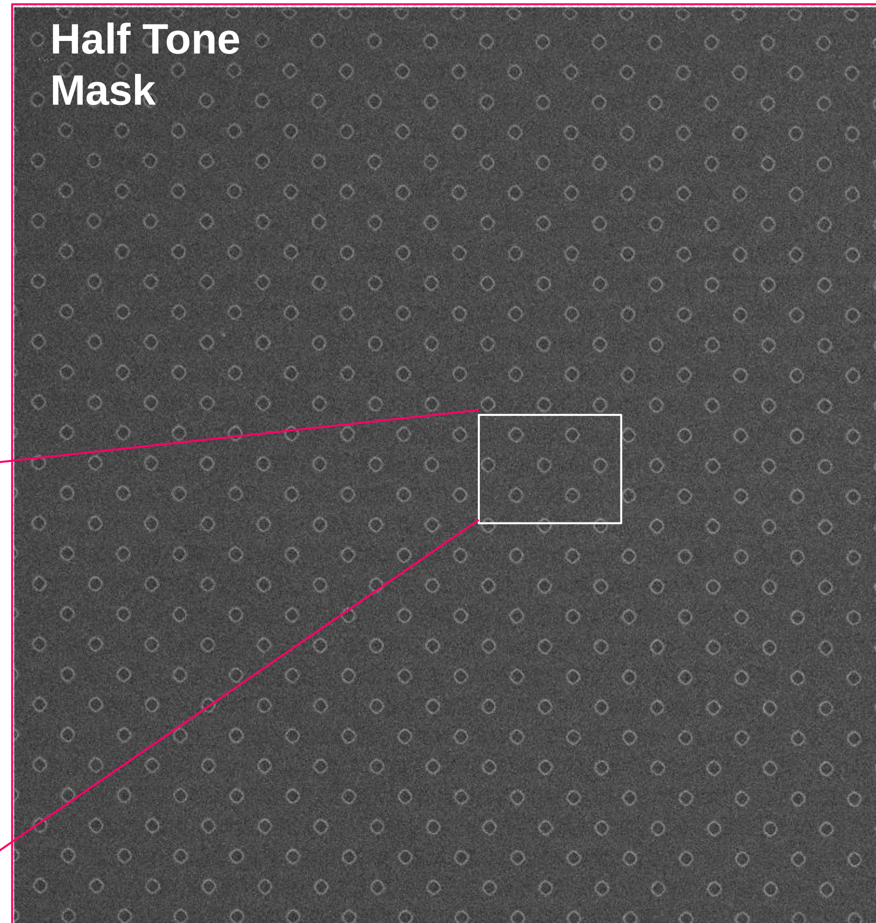
8000×8000 pixel SEM Image of 220nm Hole Pattern



Conventional CD-SEM Image: 512×512pixel

NGR's Large FOV contributes to statistical significance, and whole feature extraction





FOV: 16μm

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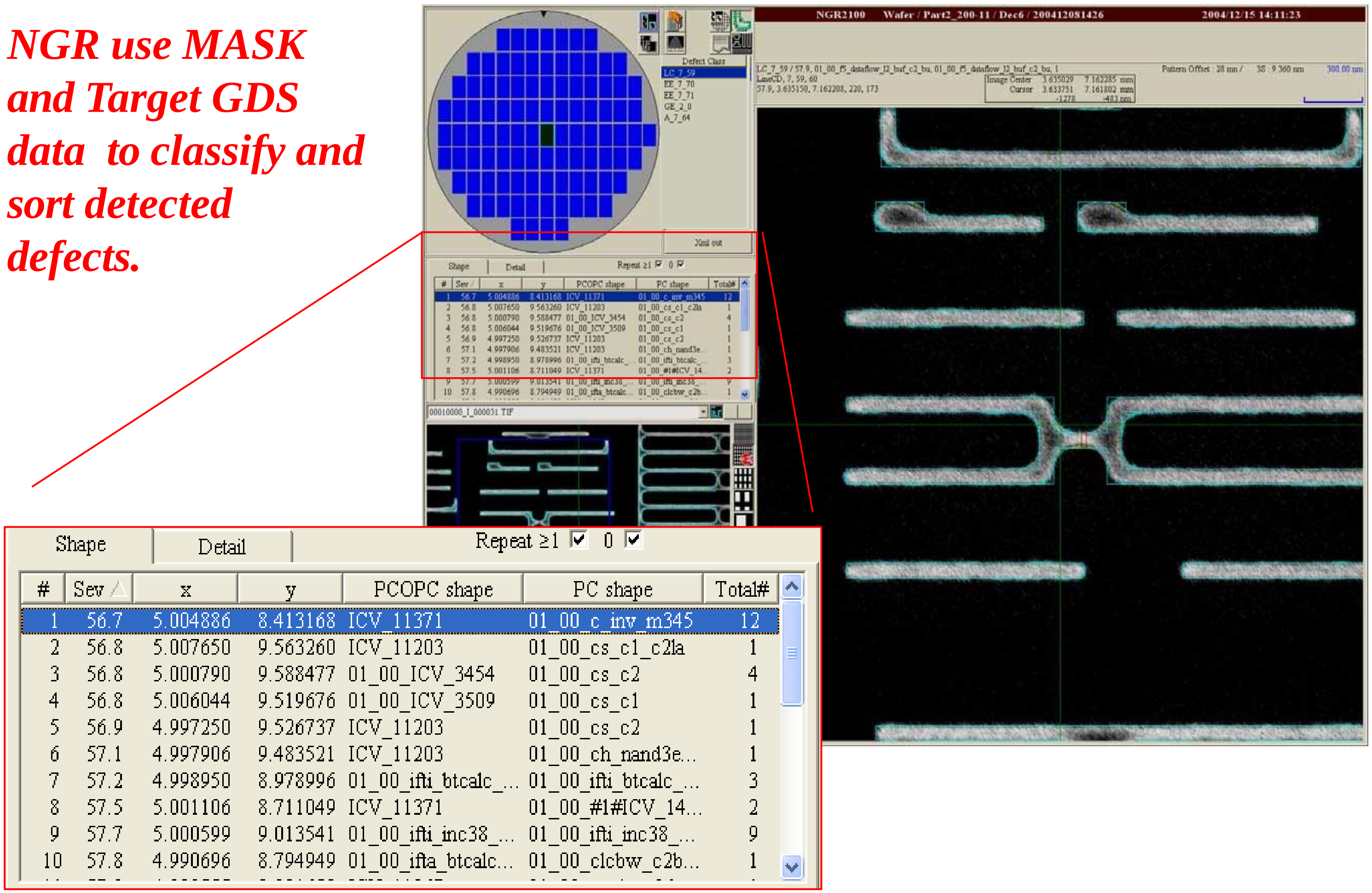
Example of Defect Classification

NGR use MASK and Target GDS data to classify and sort detected defects.



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4	56.8	5.006044	9.519676	01_00_ICV_3509	01_00_cs_c1	1
5	56.9	4.997250	9.526737	ICV_11203	01_00_cs_c2	1
6	57.1	4.997906	9.483521	ICV_11203	01_00_ch_nand3e...	1
7	57.2	4.998950	8.978996	01_00_ifti_btcalc_...	01_00_ifti_btcalc_...	3
8	57.5	5.001106	8.711049	ICV_11371	01_00_#1#ICV_14...	2
9	57.7	5.000599	9.013541	01_00_ifti_inc38_...	01_00_ifti_inc38_...	9
10	57.8	4.990696	8.794949	01_00_ifta_btcalc...	01_00_clcbw_c2b...	1

Scribe Line Test Chip

(CMOS)

Topics

- Scribe line TC structure
- Scribe line TC in products
- Devices in the scribe line TC
  - Transistors
  - Isolation
  - Capacitors
  - Sheet resistance
  - BE structures

Scribe Line TC structure

- Two independent test chips:
  - TS110A

    Contains FE and contact structures only

    One row of 82 pads
  - TS112A

    Contains BE structures mainly

    One row of 57 pads
  - 23 pin probe card
- Revision versions:
  - TS110B, TS112B

Scribe Line TC in products

- Same set of layers for all cases of top metal
- TS110A/TS112A appear in
  - Python
  - Shuttle 1, 2, 3
- TS110B/TS112B appear in
  - Shuttle 3

ИПТМ РАН

Scribe Line devices

- Front end
  - Transistors
  - Isolation (GC and M1 field transistors)
  - Gate oxide capacitors (LV HV N+ P+ GC square cap, LV N+ comb)
  - Sheet resistance
  - Open / Short (P+AA, N+GC)
- Back end
  - Sheet resistance (M1–ML)
  - Open / Short (M1–ML)
  - Chains (CS, V2-V5, VL/M3, VL/M4, VL/M5, CS N+AA–V5 stack)
  - CS and Via Kelvin resistance

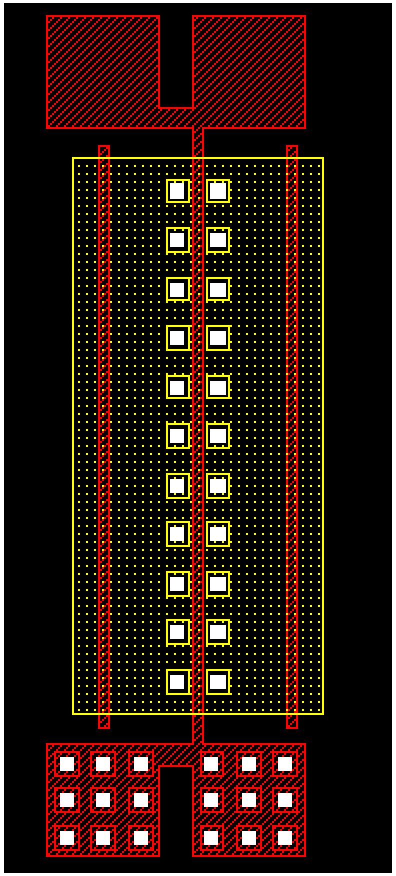
LV transistors

LV Transistors		W/L μm	Test Chip		Product
NMOS 1.8V	W = 10μm	10 / 0.16	TS110A	TS110B	Python, Shuttle 1 2 3
		10 / 0.18	TS110A	TS110B	Python, Shuttle 1 2 3
		10 / 0.20	TS110A	TS110B	Python, Shuttle 1 2 3
		10 / 0.25	TS110A	TS110B	Python, Shuttle 1 2 3
		10 / 1.0	TS110A	TS110B	Python, Shuttle 1 2 3
		10 / 10	TS110A	TS110B	Python, Shuttle 1 2 3
	minimal	0.22 / 0.18	TS110A	TS110B	Python, Shuttle 1 2 3
PMOS 1.8V	W = 10μm	10 / 0.16	TS110A	TS110B	Python, Shuttle 1 2 3
		10 / 0.18	TS110A	TS110B	Python, Shuttle 1 2 3
		10 / 0.20	TS110A	TS110B	Python, Shuttle 1 2 3
		10 / 0.25	TS110A	TS110B	Python, Shuttle 1 2 3
		10 / 1.0	TS110A	TS110B	Python, Shuttle 1 2 3
		10 / 10	TS110A	TS110B	Python, Shuttle 1 2 3
	minimal	0.22 / 0.18	TS110A	TS110B	Python, Shuttle 1 2 3

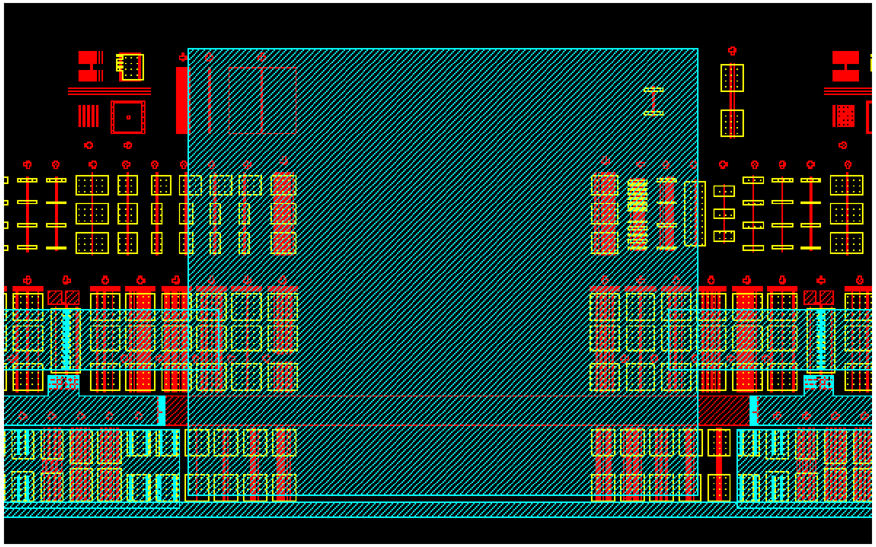
HV transistors

HV Transistors		W/L µm	Test Chip		Product
NMOS 3.3V	W = 10µm	10 / 0.27		TS110B	Shutttle 3
		10 / 0.33	TS110A	TS110B	Python, Shuttle 1 2 3
		10 / 0.35	TS110A	TS110B	Python, Shuttle 1 2 3
		10 / 0.50	TS110A		Python, Shuttle 1 2 3
		10 / 0.60		TS110B	Shutttle 3
		10 / 10	TS110A	TS110B	Python, Shuttle 1 2 3
	minimal	0.22 / 0.35	TS110A	TS110B	Python, Shuttle 1 2 3
	5V	0.6 / 0.5	TS110A		Python, Shuttle 1 2 3
PMOS 3.3V	W = 10µm	10 / 0.27		TS110B	Shutttle 3
		10 / 0.28	TS110A		Python, Shuttle 1 2 3
		10 / 0.30	TS110A	TS110B	Python, Shuttle 1 2 3
		10 / 0.50	TS110A	TS110B	Python, Shuttle 1 2 3
		10 / 10	TS110A	TS110B	Python, Shuttle 1 2 3
	minimal	0.22 / 0.30	TS110A	TS110B	Python, Shuttle 1 2 3
NMOS 3.3V Native		10 / 10	TS110A	TS110B	Python, Shuttle 3

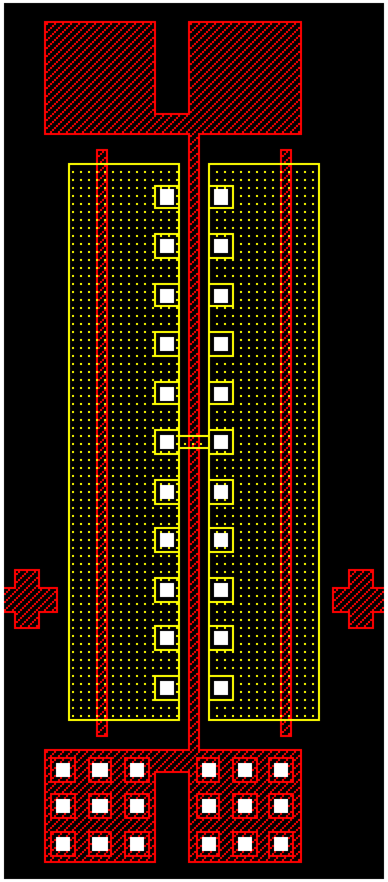
Transistor layout



W/L = 10μm / 0.18μm



Common diffusion pads, common gate



W/L = 0.22μm / 0.18μm

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Transistor measurements

Parameter	ET algorithm	Measurement conditions (NMOS)	
		1.8V	3.3V
Vth	VTcc	Vth=Vgs @ Id=0.1[μA]*(W/L), Vds=0.1V	Vth=Vgs @ Id=0.1[μA]*(W/L), Vds=0.1V
Vth	VTH4		max gm extrapolation - Vds/2, Vds=0.1V
Drive current	I4V	Vgs=1.8V, Vds=1.8V	Vgs=3.3V, Vds=3.3V
Isub max	Ismax	Vds=2V	Vds=3.6V
Off leakage	I4V	Vds=2V	Vds=3.6V
BVdss	Bvdss	Id=10nA/μm	Id=50nA/μm

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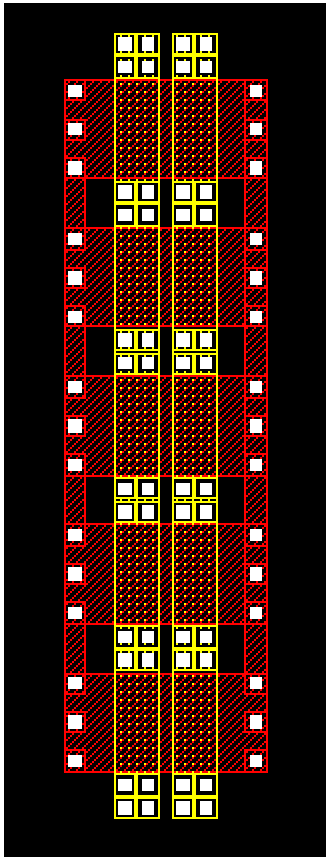
STI transistors



GC 3.3V field transistor

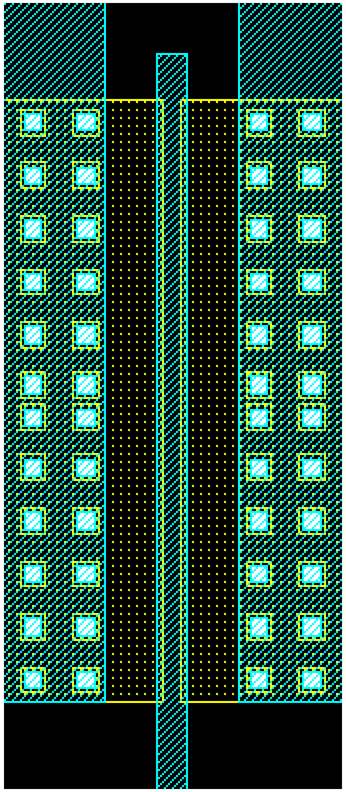
W/L = 5 x 2μm / 0.28μm

(TS112A,B)

Vth=Vgs@

Id=10nA, Vds=3.3V

(VTcc algorithm)



M1 LV field transistor

W/L = 10μm / 0.28μm

M1 width 0.5μm

(TS110A,B)

Vth=Vgs@

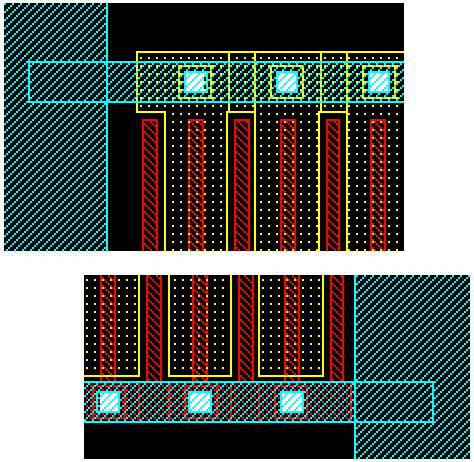
Id=10nA, Vds=1.8V

(VTF algorithm)

Gate oxide capacitors

Parameter	ET algorithm	Measurement conditions (N+GC square cap.)	
		1.8V, 6893μm^2	3.3V, 6893μm^2
Oxide thickness, accumulation	CV2	Vsg=2.5V	Vsg=4.0V
Oxide thickness, inversion (TS110B)	CV2	Vsg=-1.8V	Vsg=-3.3V
Oxide breakdown, accumulation	V2I	force Ig=-6.893μA	force Ig=-6.893μA

Parameter	ET algorithm	Measurement conditions (N+GCAA comb)
N+ Junction leakage	I2V	Vdb=1.8V, Vgb=0V
N+ Junction leakage	I4V	Vdb=1.8V, Vgb=1.8V
N+GCAA bridging	I2V	Vgb=1.8V, Vdb=0V
Gate leakage	I2V	Vgb=1.8V



N+GCAA comb structure

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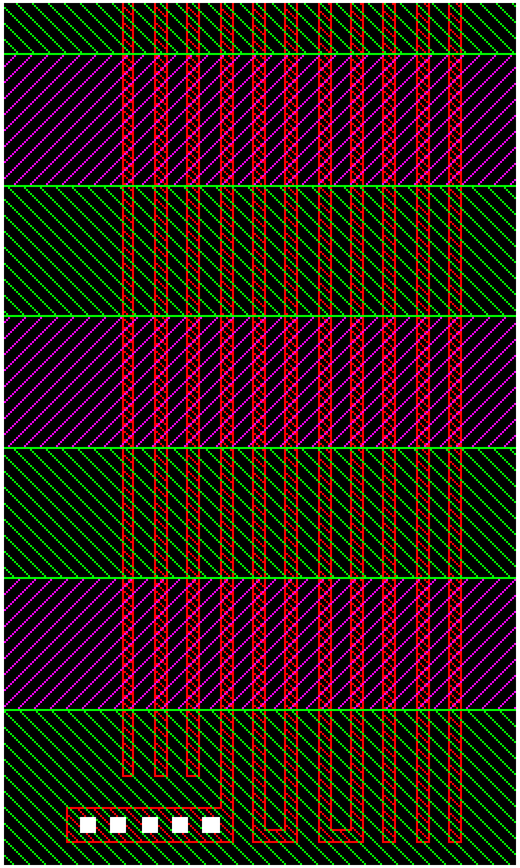
Sheet resistance

- AA, GC salicided
  - N+AA 0.22/50, 2.0/100, P+AA 0.22/50, 2.0/100
  - N+GC 0.18/50, 2.0/100, P+GC 0.18/50, 2.0/100
  - N+/P+GC 0.18/250, N+GC 0.18/250
- N Well
  - N Well under STI 20/100
  - N Well with P+AA 20/100
  - N Well under non-salicided AA 20/100
- Non-salicided resistors
  - P+GC 0.18, 0.25, 0.35, 0.50 /100
  - N+AA 0.22, 0.35, 0.60, 2.00 /100 (TS110B)



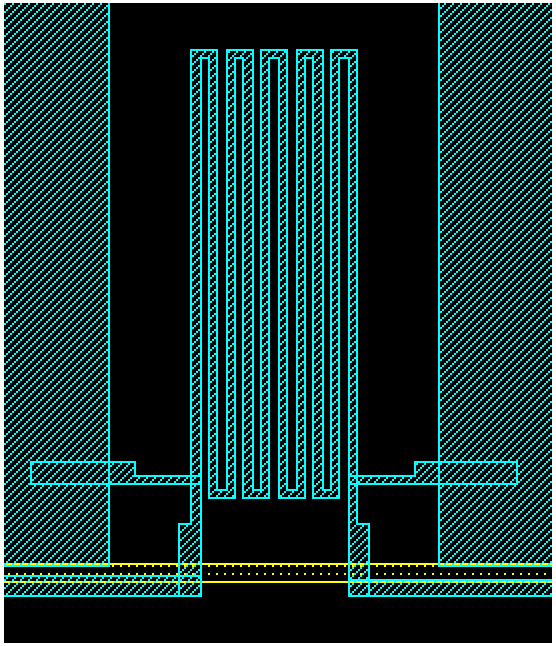
N+/P+GC 0.18/250

ИПТМ РАН

BE structures

- ML sheet resistance
  - TS110A for 6LM only
  - TS110B for all cases of ML
- VL chain repeated 3 times:
  - On M3 (4LM)
  - On M4 (5LM)
  - On M5 (6LM)
- 3-terminal Via structures:
  - Available in TS110 on Shuttle 1 and 2

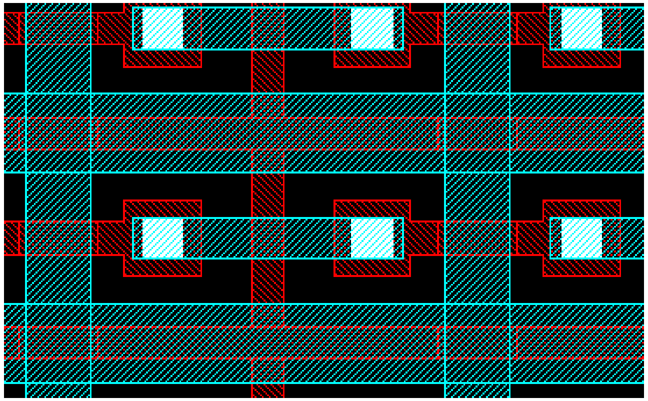
    (ET operation F2)



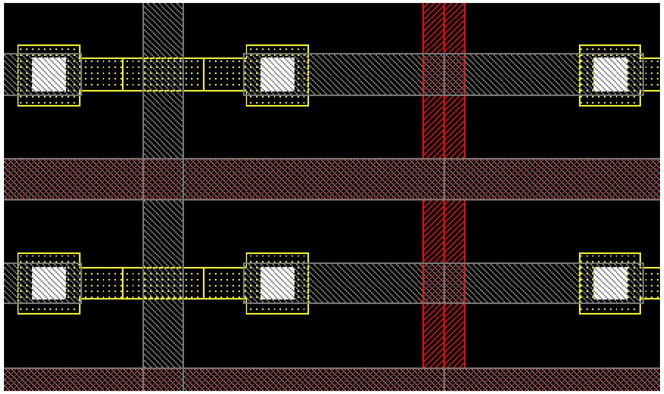
Metal sheet resistance

1/500µm

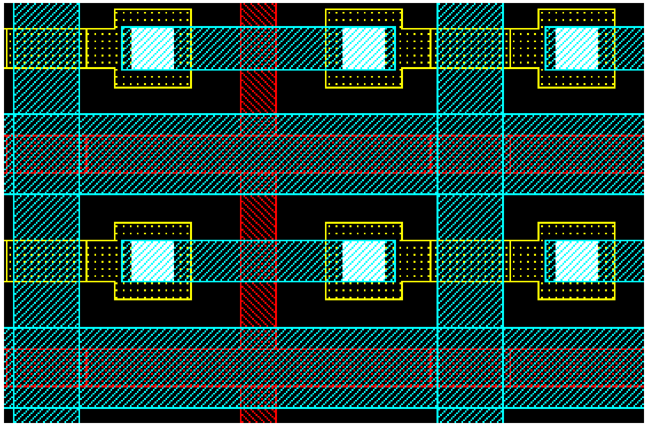
Chain structures



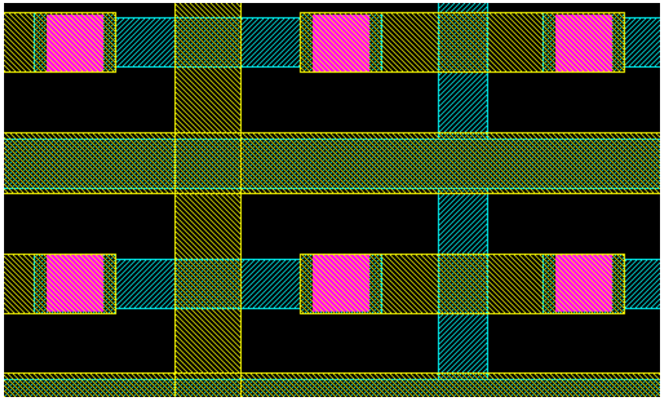
CS GC LE chain



N+AA CS-V5 LE stack chain (TS112B)



CS AA LE chain

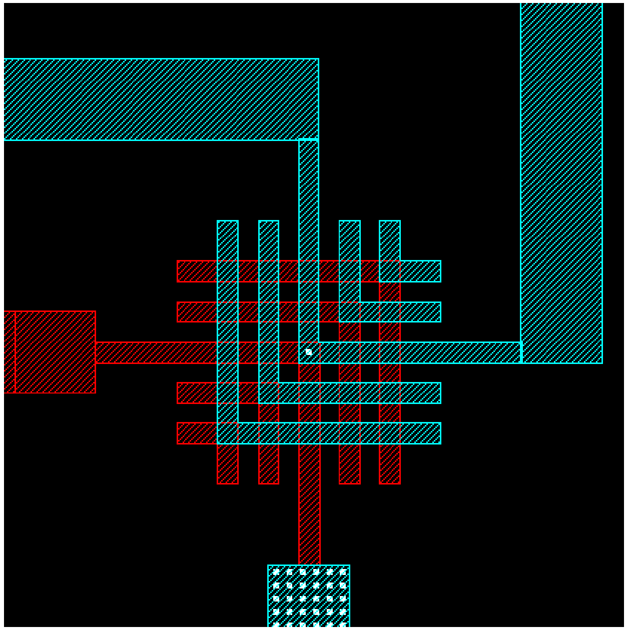


V2 LE chain

ИПТМ РАН

Contact / Via Kelvin structures

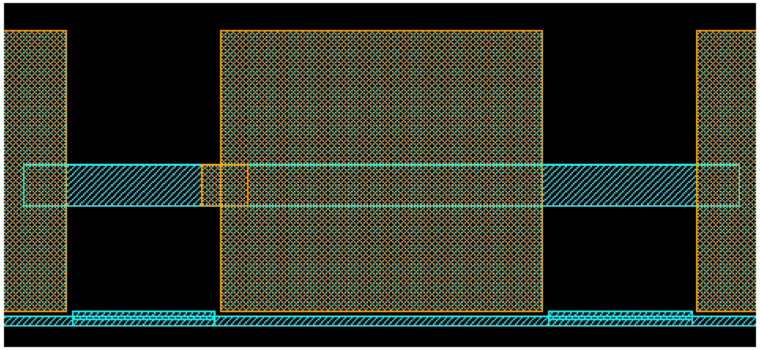
Parameter	Structure	Algorithm	Test Chip	
Rc CS N+AA 0.22	3 term.	R3V	TS110A	
	4 term.	R4V		TS112B
Rc CS P+AA 0.22	3 term.	R3V	TS112A	
	4 term.	R4V		TS112B
Rc CS N+GC 0.22	3 term.	R3V	TS110A	
	4 term.	R4V		TS112B
Rc CS P+GC 0.22	3 term.	R3V	TS112A	
	4 term.	R4V		TS112B
Rc V2 0.26	3 term.	R3V	TS112A	
Rc V3 0.26	3 term.	R3V	TS112A	
Rc V4 0.26	3 term.	R3V	TS112A	
Rc V5 0.26	3 term.	R3V	TS112A	



4 terminal CS GC structure

M1 common, GC (AA) high

(TS112B)



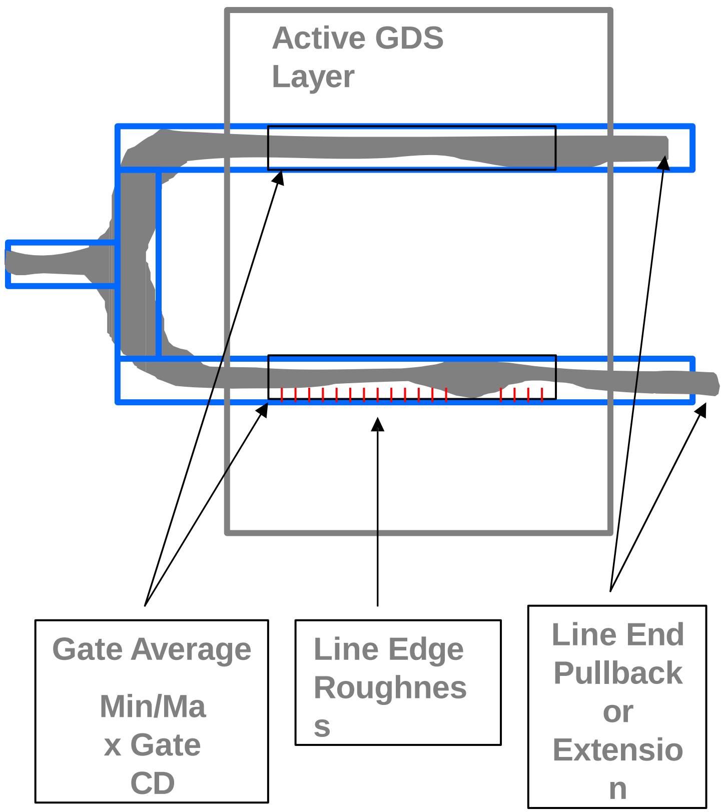
3 terminal V2 structure (TS112A)

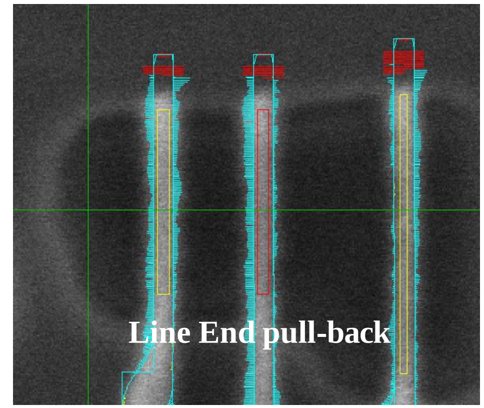
ИПТМ РАН

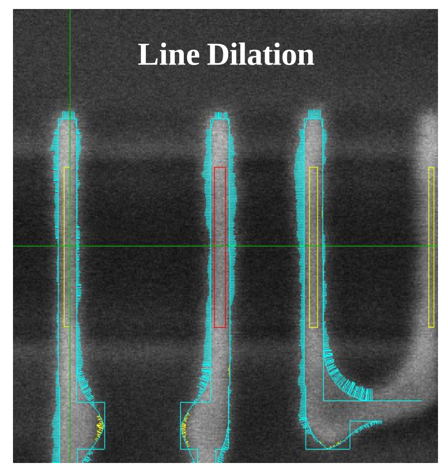
Измерительные РЭМ

Gate Verifier Concept

Измерения 1D (CD)





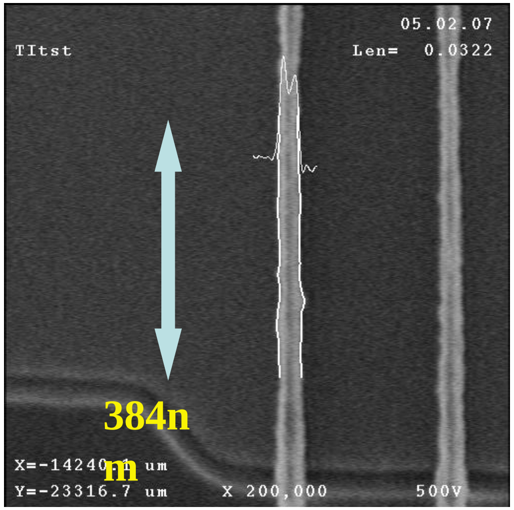


NGR2100 GDS SEM Mode

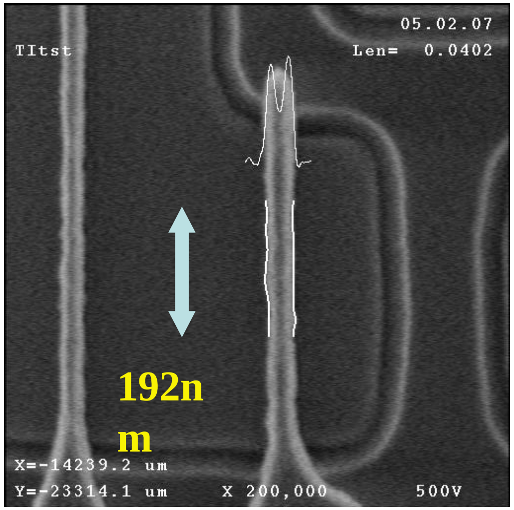
Freud1-3 (0.75un FOV) CD-SEM

Измерения 1D (CD)

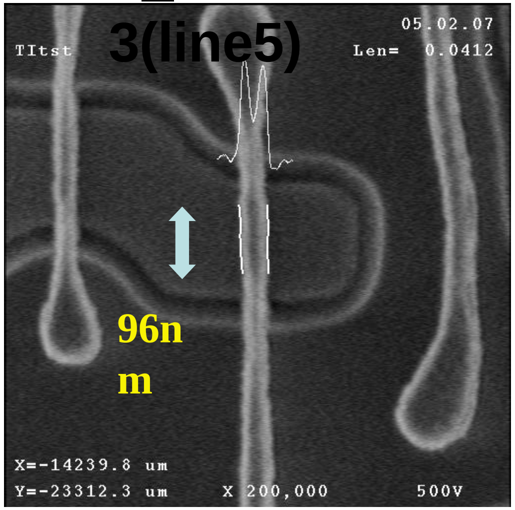
image F_1-3(line1)



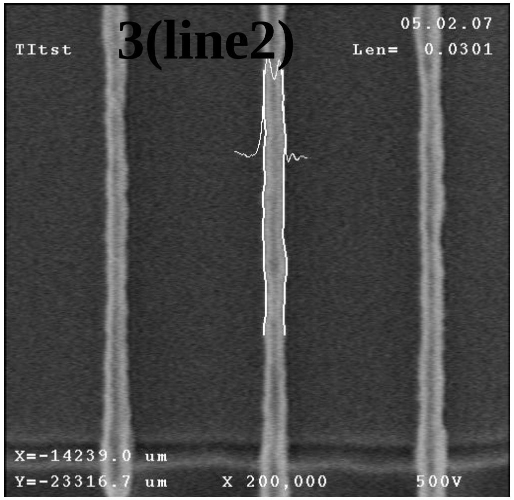
F_1-3(line3)



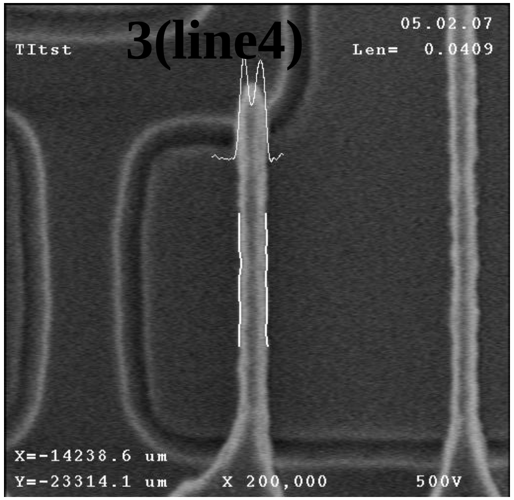
F_1-3(line5)



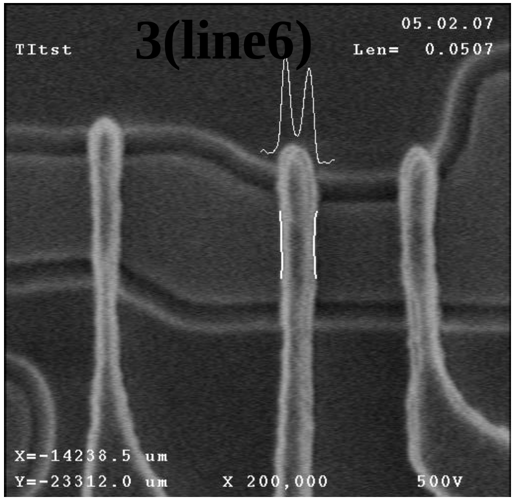
F_1-3(line2)



F_1-3(line4)



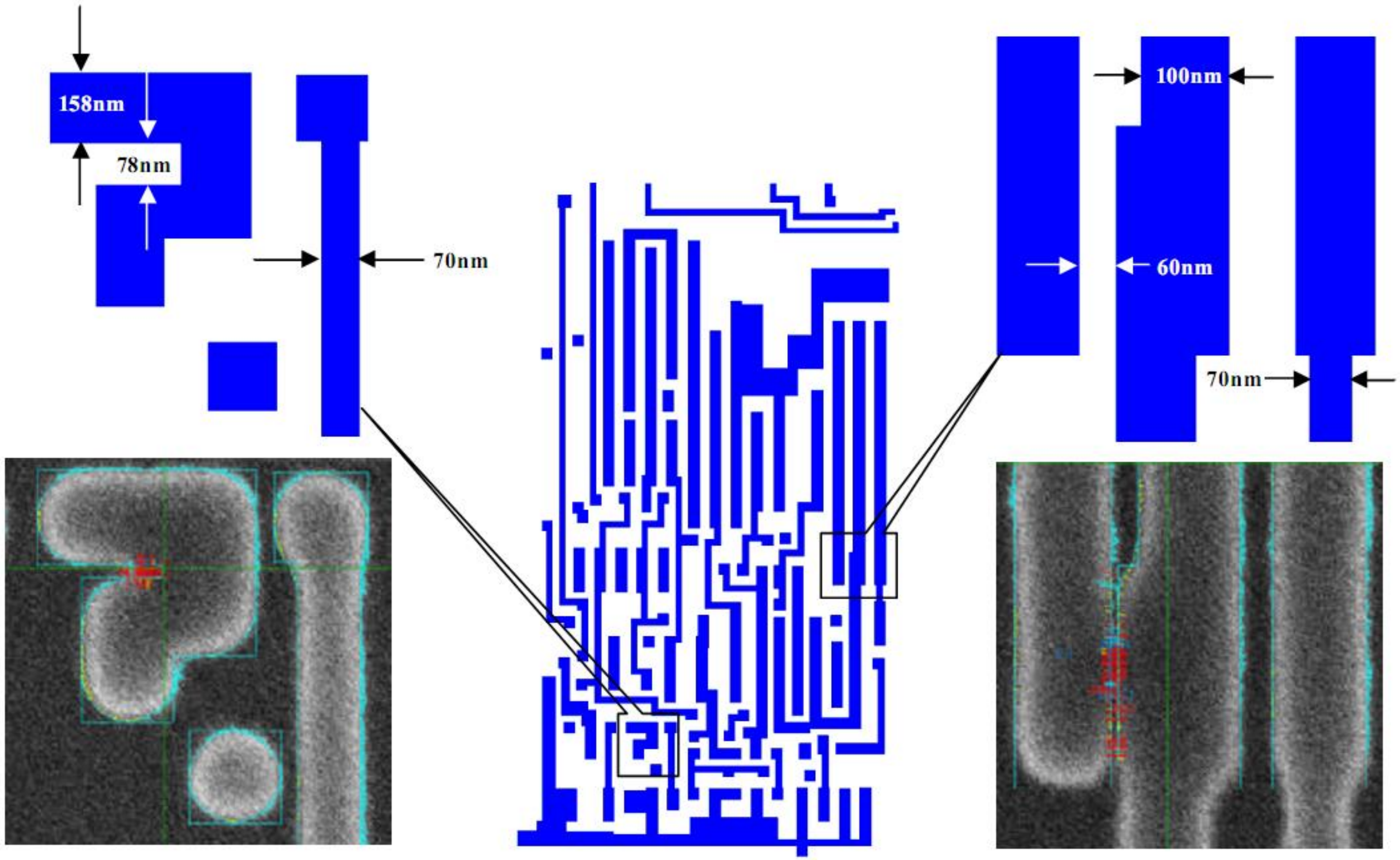
F_1-3(line6)



ИПТМ РАН

Electron Beam Die to Database Verification System (DDVS)

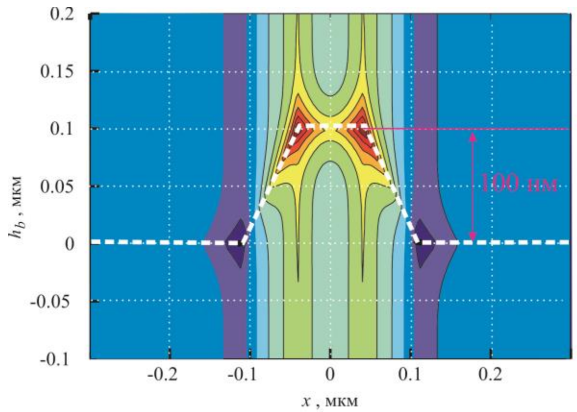
Измерения 2D

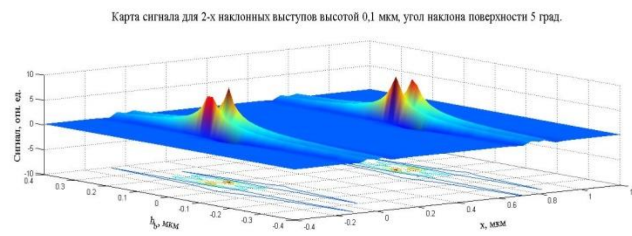


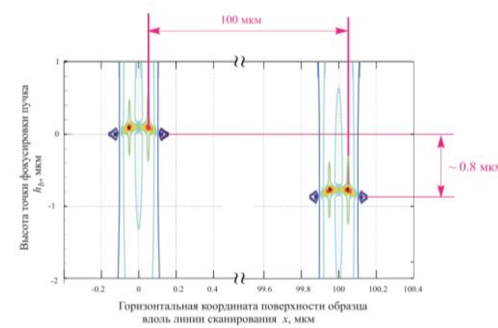
Imprinted 70 nm Logic CAD drawing (middle) and problem area magnifications on left (feature 1) and right (feature 2).

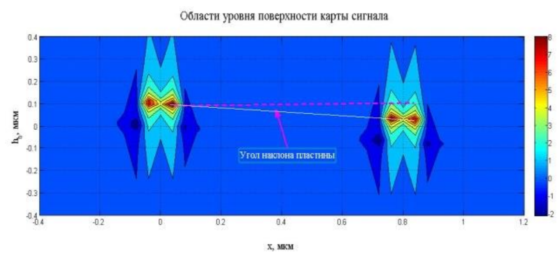
ИПТМ РАН

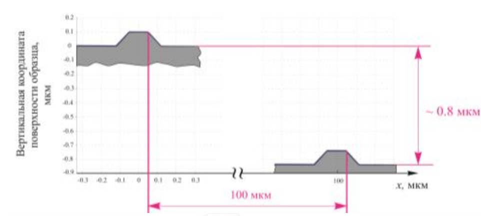
Измерения 2,5D

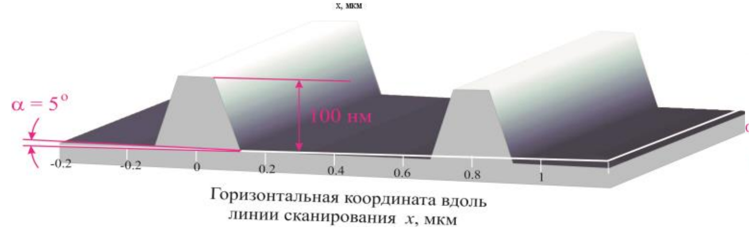


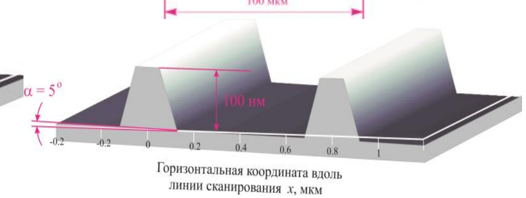












ИПТМ РАН

НАСТРОЙКА ФОКУСА ОПТИЧЕСКОГО ЛИТОГРАФА (СКАНЕРА)

•Использование РЭМ inline

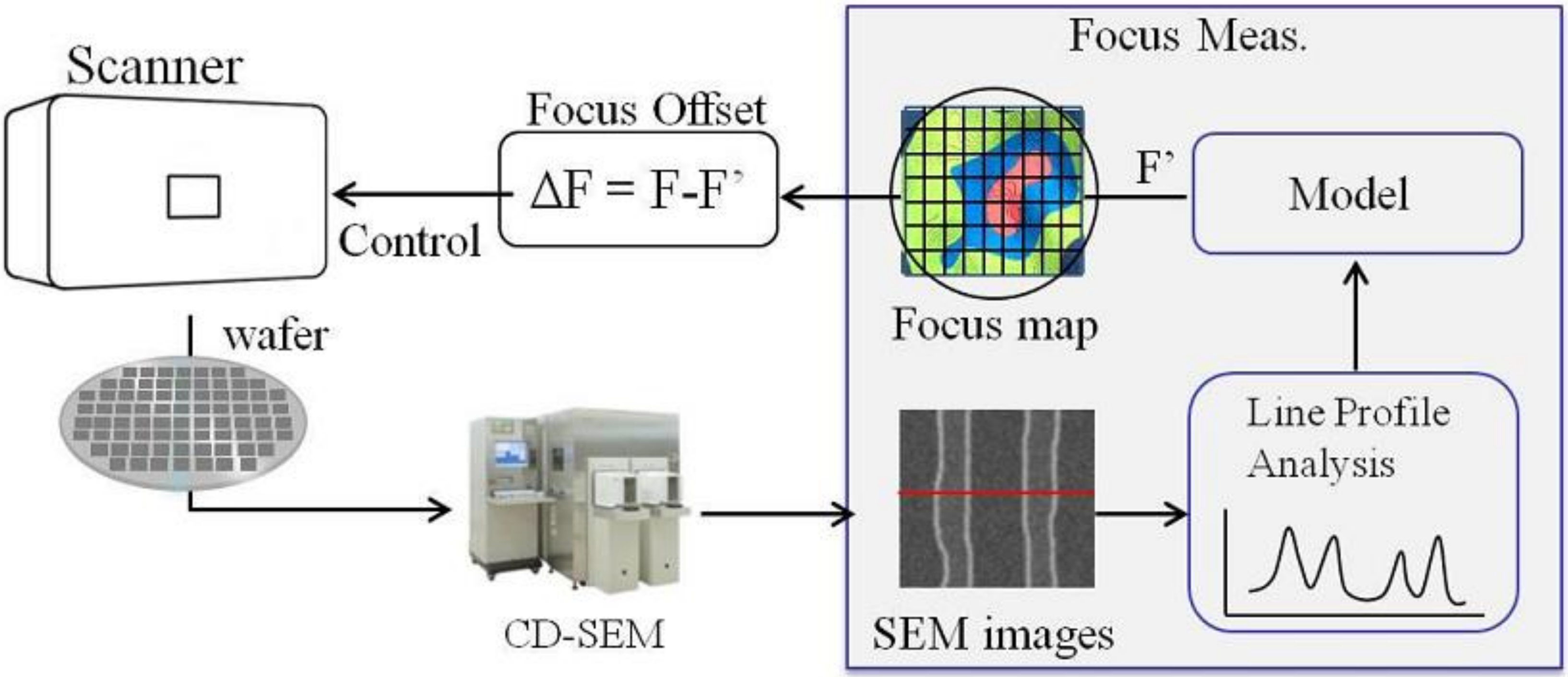
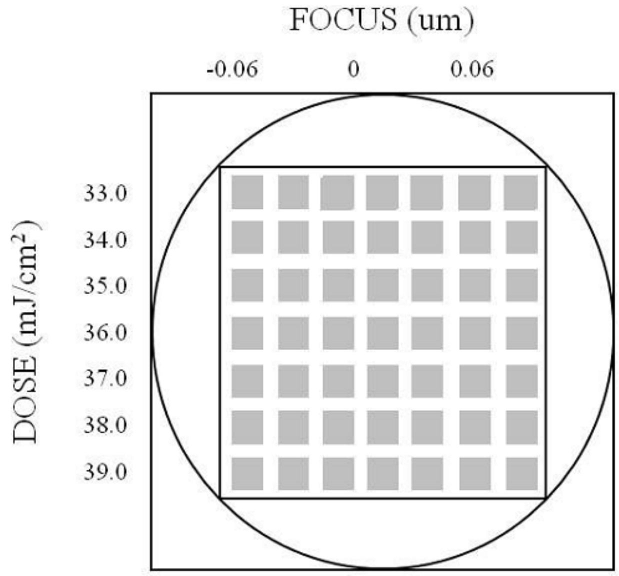


Figure1. Focus measurement for scanner control

ИПТМ РАН

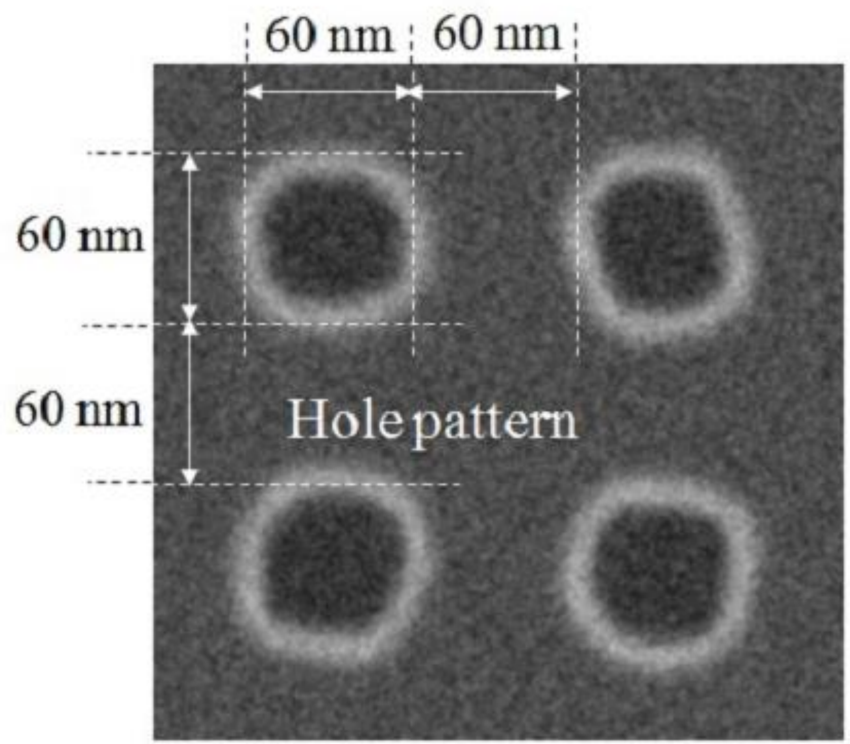
НАСТРОЙКА ФОКУСА И ДОЗЫ СКАНЕРА

•Использование РЭМ inline



Wafer	FEM Wafer
FEM conditions	Focus (Center: 0.00 um, Step: 0.02 um)
	Dose (Center: 36 mJ/cm^2, Step: 1 mJ/cm^2)

Figure8. FEM wafer for modeling



ПРОБЛЕМЫ:

1. Длительное время измерений
2. Подтравливание резиста электронным пучком

Сравнение производительности

COMPARISON

INSTRUMENT	EXPOSURING TIME VECTOR SCAN Min size 20 nm, field 200 x 200 mcm		MEASURING TIME RASTER SCAN field 200 x 200 mcm resolution 1nm (5 nm) accuracy 5%	
	1 structure	49 structures	1 structure	49 structures
STANDARD EBL	10 sec	1,22 hours	111 hours	136 work weeks More than 4 years
STANDARD SEM	10sec	1,22 hours	111 hours 4,5 hours	136 work weeks 223 hours
MS30.1	20 msec	55 sec	200 sec 8 sec	3,4 hours 7 min

•In measuring mode the throughput of the same device is "automatically" 4000 – 40000 times lower than for exposuring

ИПТМ РАН

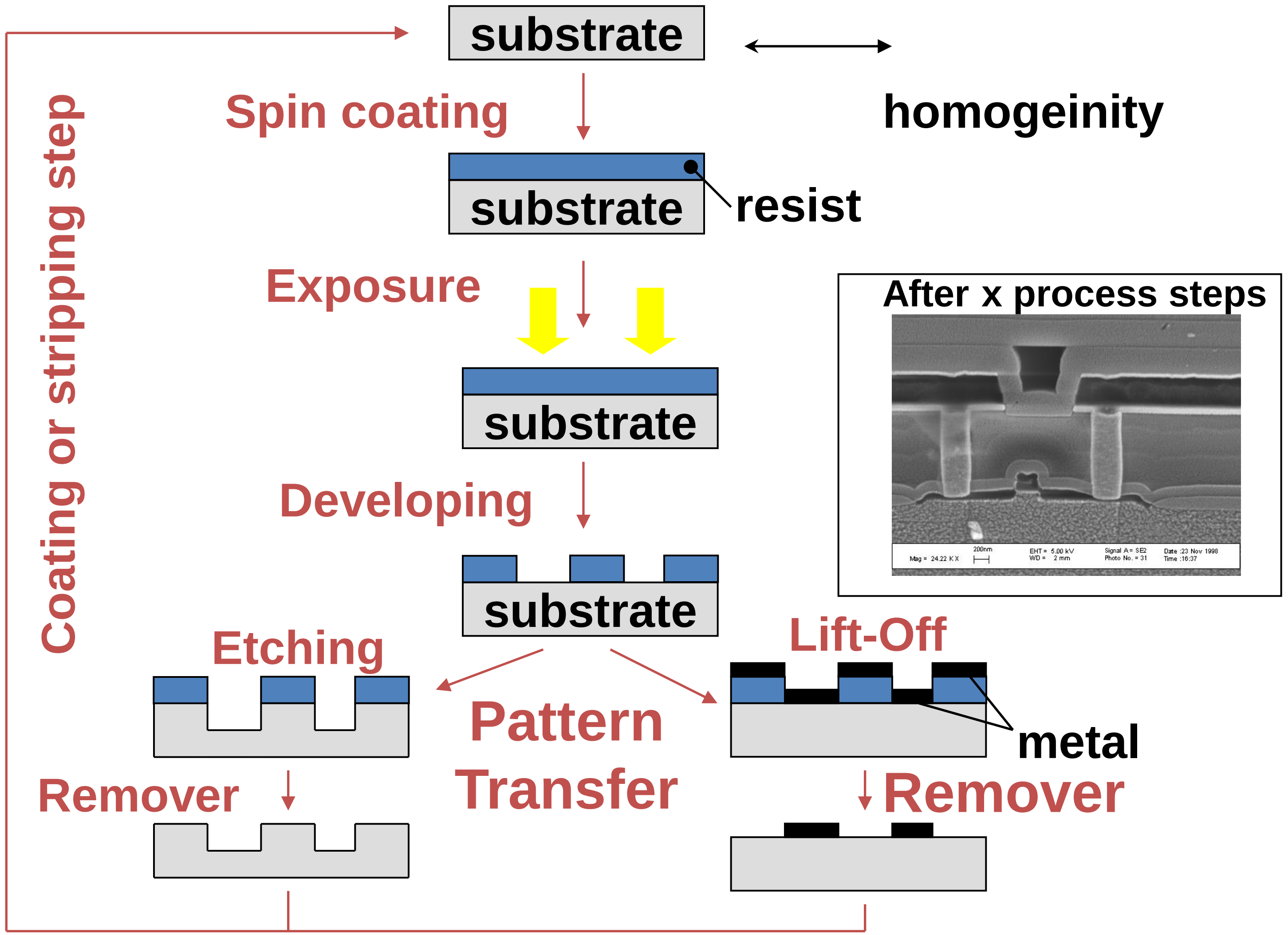
Заявленные производители полупроводников в РФ:

Предприятие	Адрес	Заявленный диаметр пластин (мм)	Заявленная топология	Требуемое разрешение, нм
Ангстрем-Т	г. Москва, Зеленоград,	200	90-130-180 (нм)	5-9
Ангстрем	г. Москва, Зеленоград,	100, 150	1,2-0,6 (мкр)	20 - 30
Микрон	Москва, Зеленоград,	200 ???	90-180 (нм) ???	5-9
Крокус	Москва,	200, 300	55-90 (нм)	3-5
НИИИС	Нижний Новгород,	150	???	
НПК ТЦ	г. Москва, Зеленоград,	100 ???	???	
Исток	г. Фрязино,	150 ???	???	
Микран	г. Томск	100 ???	???	
Группа Кремний ЭЛ	г. Брянск,	???	0,5(мкр)	25
ВЗПП-Микрон	г. Воронеж,	100, 150	???	
ВЗПП-С	г. Воронеж,	???	???	
Синтез-Микроэлектроника	г. Воронеж,	200	350 (нм)	20
НЗПП С ОКБ и НПП Восток	г.Новосибирск,	200	180, 250 (нм)	9-12
НИИ Системных исследований РАН	Москва,	???	250, 350,500 (нм)	10-20
Протон	г. Орел,	???	???	
НПП Пульсар	г. Москва,	???	???	
РКС	г. Москва,	76,2, 100, 150	1 (мкр)	20
Светлана-Рост	Санкт-Петербург	50,8 76,2, 100, 150	0,2 0,5 0,8 1 (мкр)	10 -20
Светлана-Электронприбор	Санкт-Петербург,	???	???	
НИИ полупроводниковых приборов	г. Томск,	???	???	
ЦКБА	г. Омск-27,	???	900 (нм)	10 -20
ADGEX		12,5	500 (нм)	10 -20
ОКБ-Планета	Великий Новгород,	100	150 (нм)	5-7

Электронные литографы

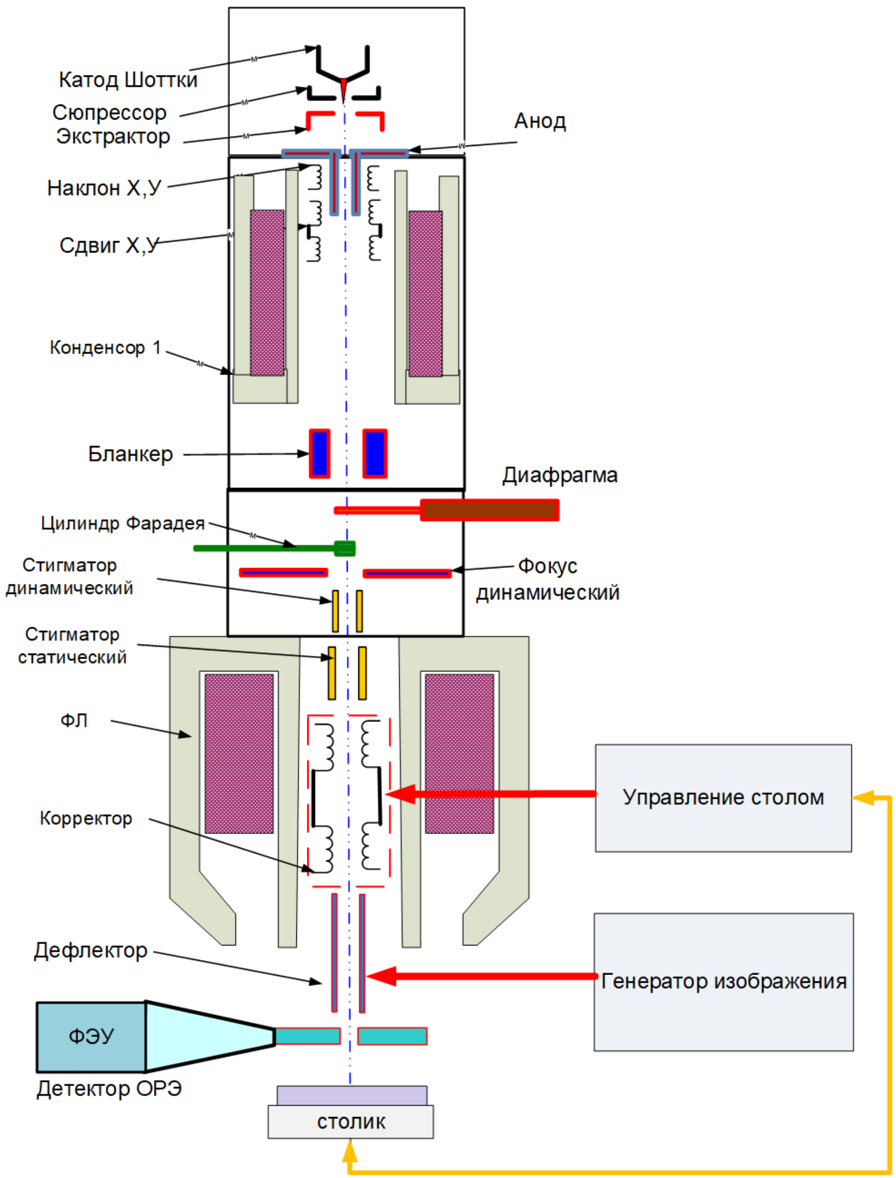
Process Cpecification

E-beam lithography and fabrication process



ИПТМ РАН

ЭОС ЭЛ с катодом Шоттки



ИПТМ РАН

Динамический фокус

Возможность динамического изменения диаметра пучка во время экспонирования

- Динамическая коррекция сферичности поля фокусировки

Дефокусировка на поле 200 мкм составляет 1,7 мкм уширение пучка – 17 нм.

- **Возможность поддерживать заданное значение диаметра пучка в плоскости экспонирования**
- **Возможность менять диаметр пучка: широкие линии рисовать широким пучком, мелкие детали – узким.**
- **Измерения можно проводить при минимальном диаметре пучка.**

Цилиндр Фарадея

Возможность осуществлять измерение и коррекцию параметров пучка без переезда стола

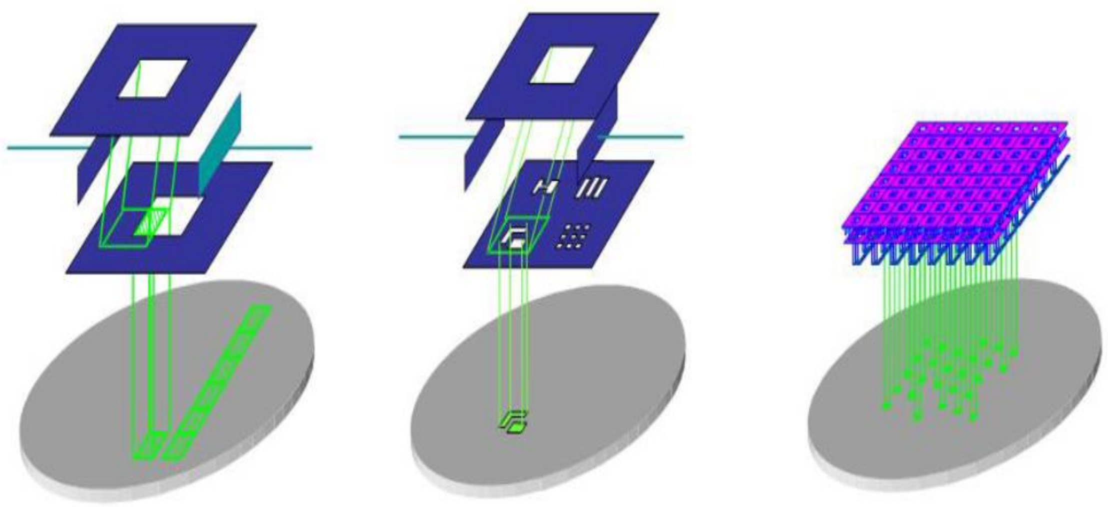


Fig. 1: The evolution in the number of pixels exposing the substrate with VSB principle. Left: conventional VSB, Middle: Cell or character projection (CP), to be used in combination with VSB, Right: Multi Shaped Beam: an array of independently controllable variable shaped beams

Профилированный пучок

Плотность тока J остается постоянной и составляет для VSB и MSB 50 и 20 А/см длительность одной экспозиции (шота), определяемая как $\tau = D/J$ равна соответственно 200 и 500 нсек (резист CAR)

Время экспонирования $t = \tau n$, где n - число шотов в 1 см^2.

Стратегия повышения производительности:

1. Повышение плотности тока

2.Увеличение площади экспонируемого элемента

Данные фирмы Vistec по времени экспонирования ½ шпблона

размер поля экспонирования 64 х 108 мм (пол шаблона 128 х 108 мм) резист 10 мкКл/см2

Tool Type	Layer	Beamlet Matrix Size	Maximum Beamlet Size [nm]	Shot / M-Shot Count [10^9]	Write Time [hh:mm]
VSB 50A/cm², 50kV	METAL	n.a.	n.a.	145	11:14 40 440
MSB 20A/cm², 50kV	METAL	64	200	22	05:23 19 380
		64	400	15	03:23 12180
		256	100	19	05:04
VSB 50A/cm², 50kV	VIA	n.a.	n.a.	31	04:24
MSB 20A/cm², 50kV	VIA	64	200	9	04:05
		64	400	5	02:16
		256	100	9	04:04
VSB 50A/cm², 50kV	ACTIVE	n.a.	n.a.	59	05:31
MSB 20A/cm², 50kV	ACTIVE	64	200	17	04:09
		64	400	12	02:41
		256	100	16	03:58
VSB 50A/cm², 50kV	POLY GATE	n.a.	n.a.	66	08:30
MSB 20A/cm², 50kV	POLY GATE	64	200	24	07:23
		64	400	19	05:06
		256	100	23	07:12

Тип	Шотов/см² * 10^9	Время 1 см², сек CAR	Время 1 см², сек PMMA
VSB (50)	4,77	1 328	1 3284
MSB1 (20)	0,724	637	6372
MSB2 (20)	0,493	396	3960
MSB3 (20)	0,625	601	6012

Гауссовский пучок

При экспонировании ток пучка I остается постоянным

Время экспонирования 1 см^2

$$t = D/I,$$

Экспонирование проводят по сетке с шагом Δ (нм) с частотой f (МГц)

Число узлов сетки (шотов) в 1 см^2

$$N = t*f$$

Взаимосвязь между параметрами описывается выражением

$$\Delta = (10^5 I/Df)^{1/2} \quad (1)$$

Время экспонирования и ток пучка в зависимости от частоты для шага сетки 30 нм

	F, МГц	D, мкКл/см^2	I, нА	D, мкКл/см^2	I, нА	t, сек
30	2	100	1,8	10	0,18	55555
	5		4,5		0,45	22222
	20		18		1,8	5555
	100		90		9	1111
	200		180		18	555
	400		360		36	277
	800		720		72	139

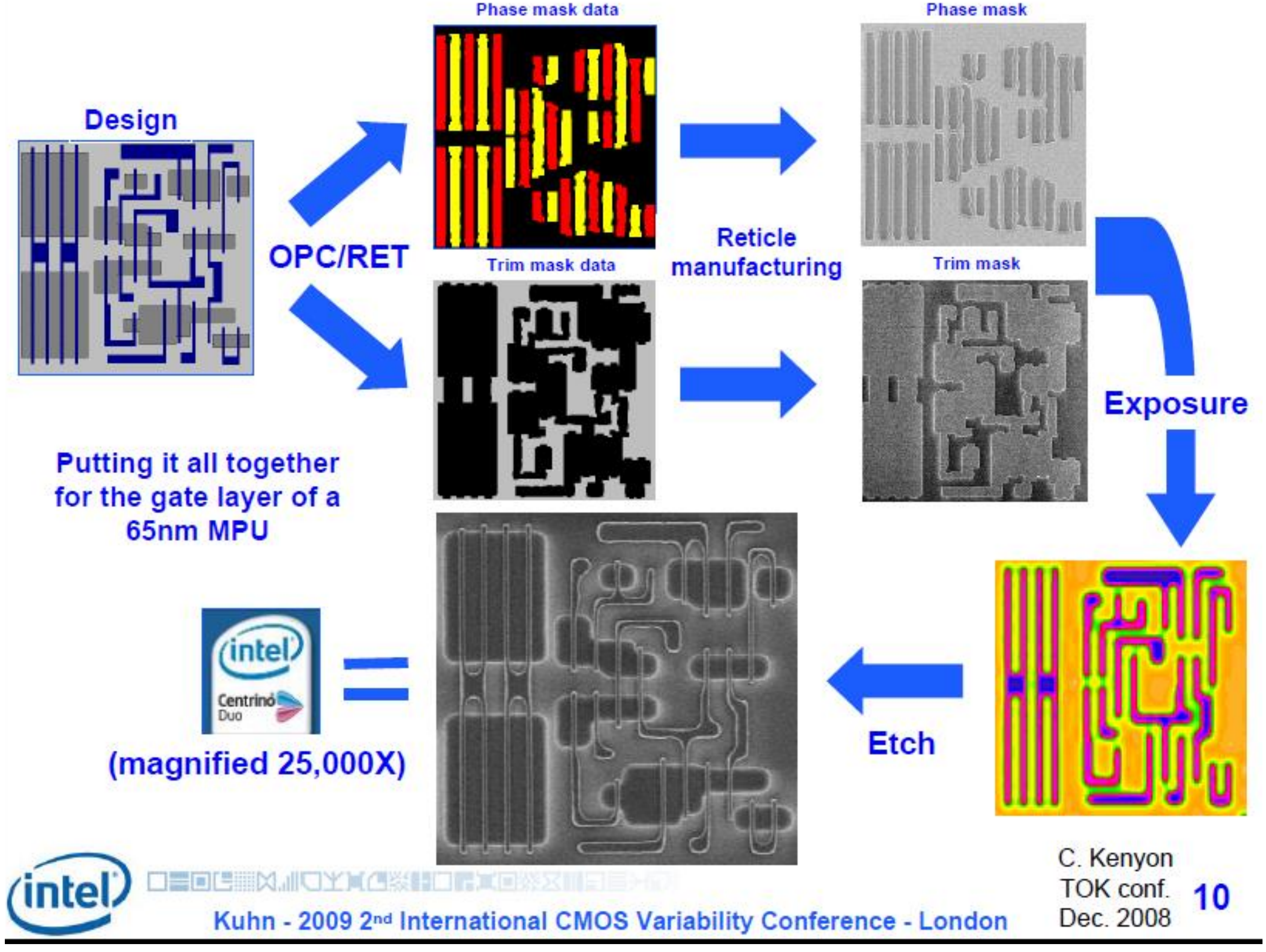
Тип	Шотов/см^2 * 10^9	Время 1 см^2, сек CAR	Время 1 см^2, сек PMMA
VSB (50)	4,77	1 328	1 3284
MSB1 (20)	0,724	637	6372
MSB2 (20)	0,493	396	3960
MSB3 (20)	0,625	601	6012

1. При низкой частоте развертки системы с GB (Nanomaker, J. Nabity, Elphy quantum) невозможно реализовать высокое значение тока

2. Время экспонирования систем с SB при снижении чувствительности резиста пропорционально увеличивается, тогда как в системах с GB это снижение производительности может быть скомпенсировано за счет соответствующего повышения тока пучка

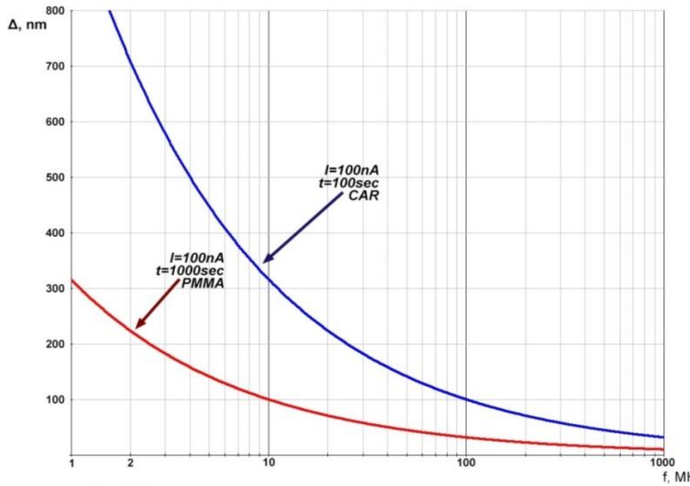
ИПТМ РАН

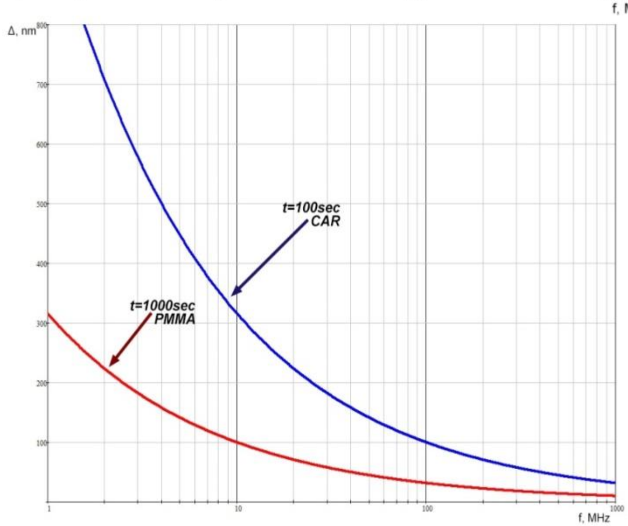
Контроль фотошаблонов с OPC

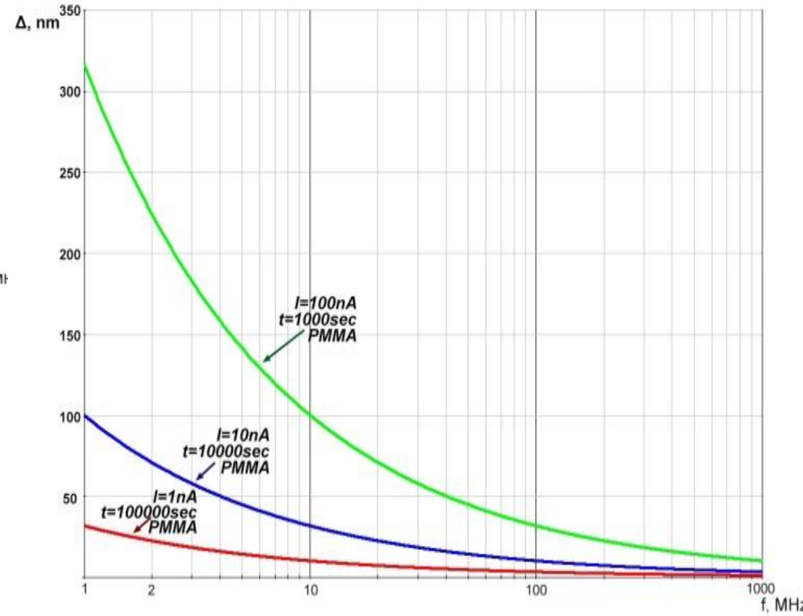


•Использование РЭМ МС30.1

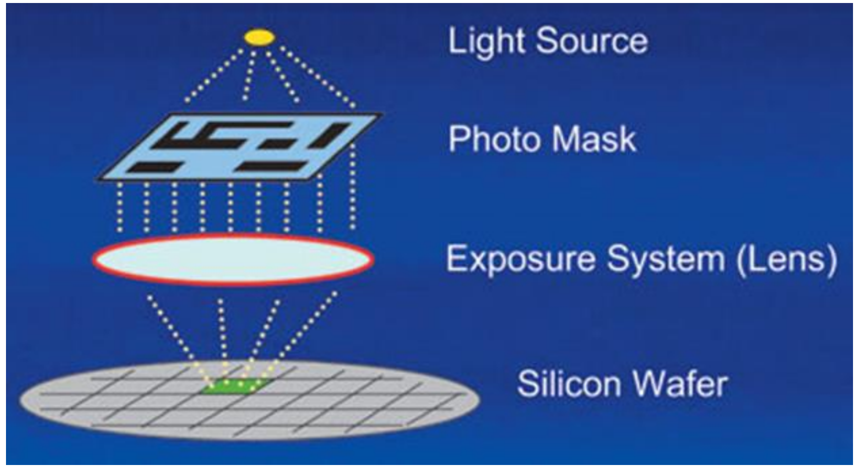
Зависимость шага сетки от тока пучка и тактовой частоты развертки

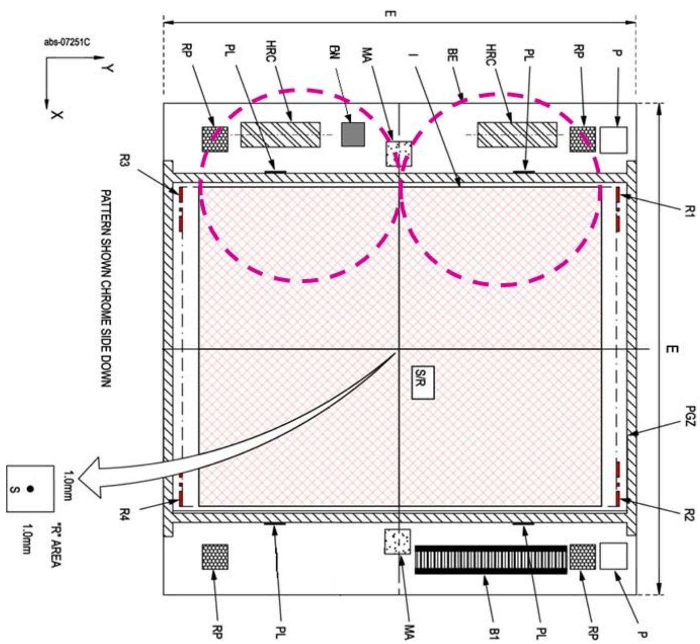


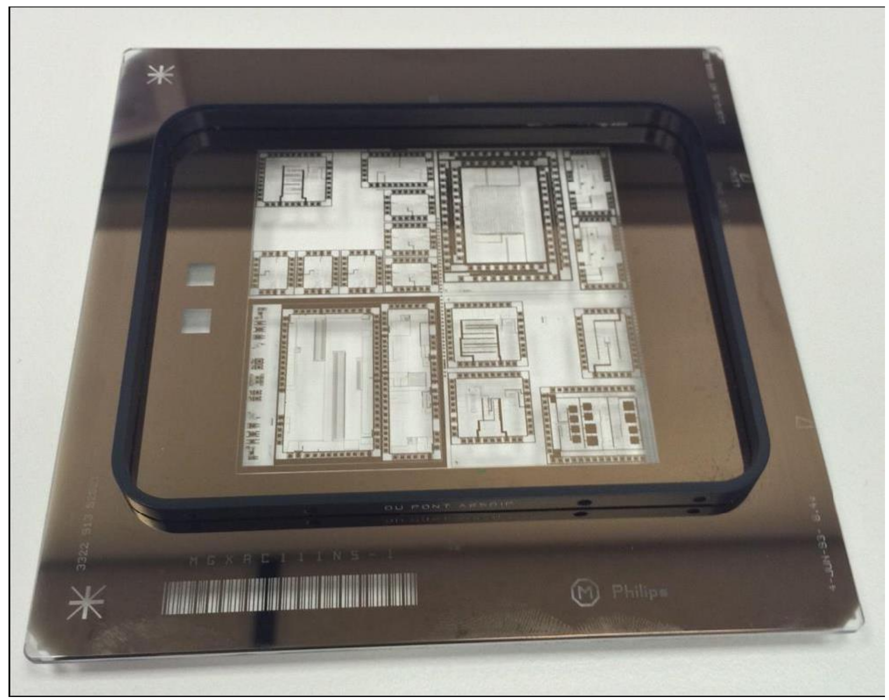




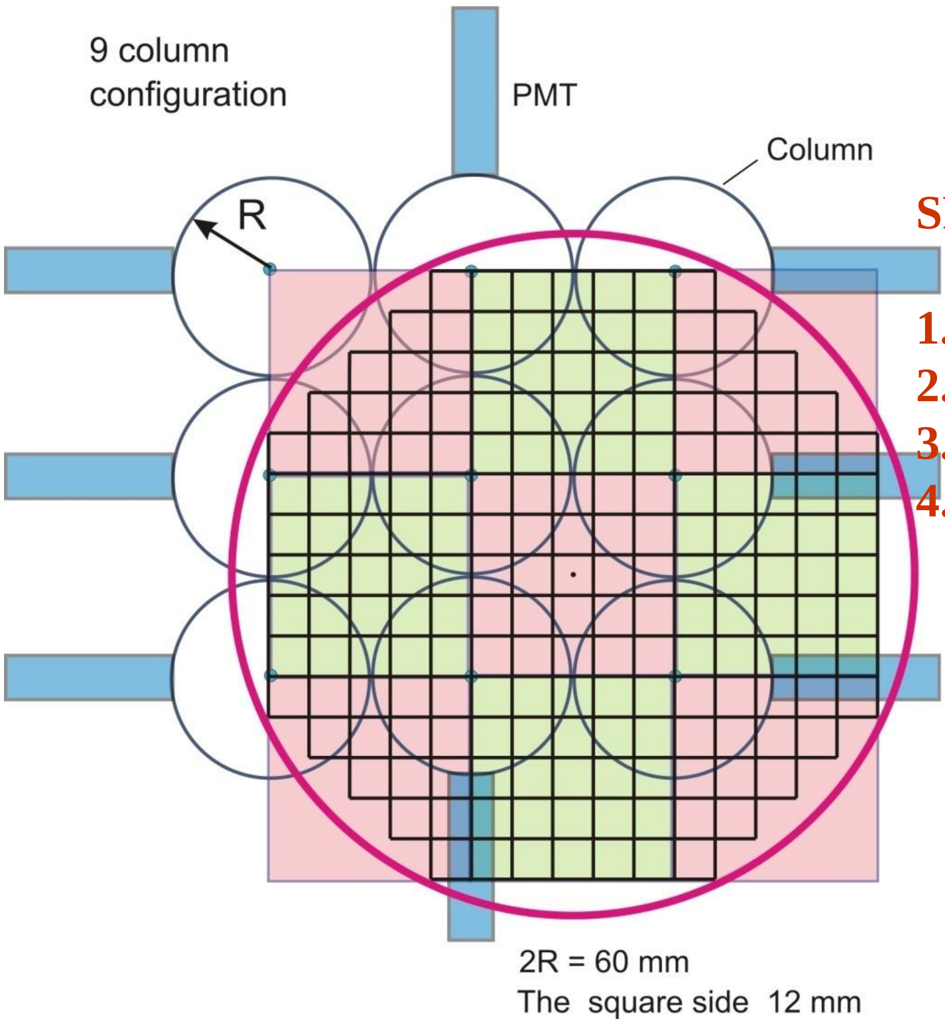
ПРИМЕНЕНИЕ ШАБЛОНА







9 (16) COLUMN LITHOGRAPHY SYSTEM



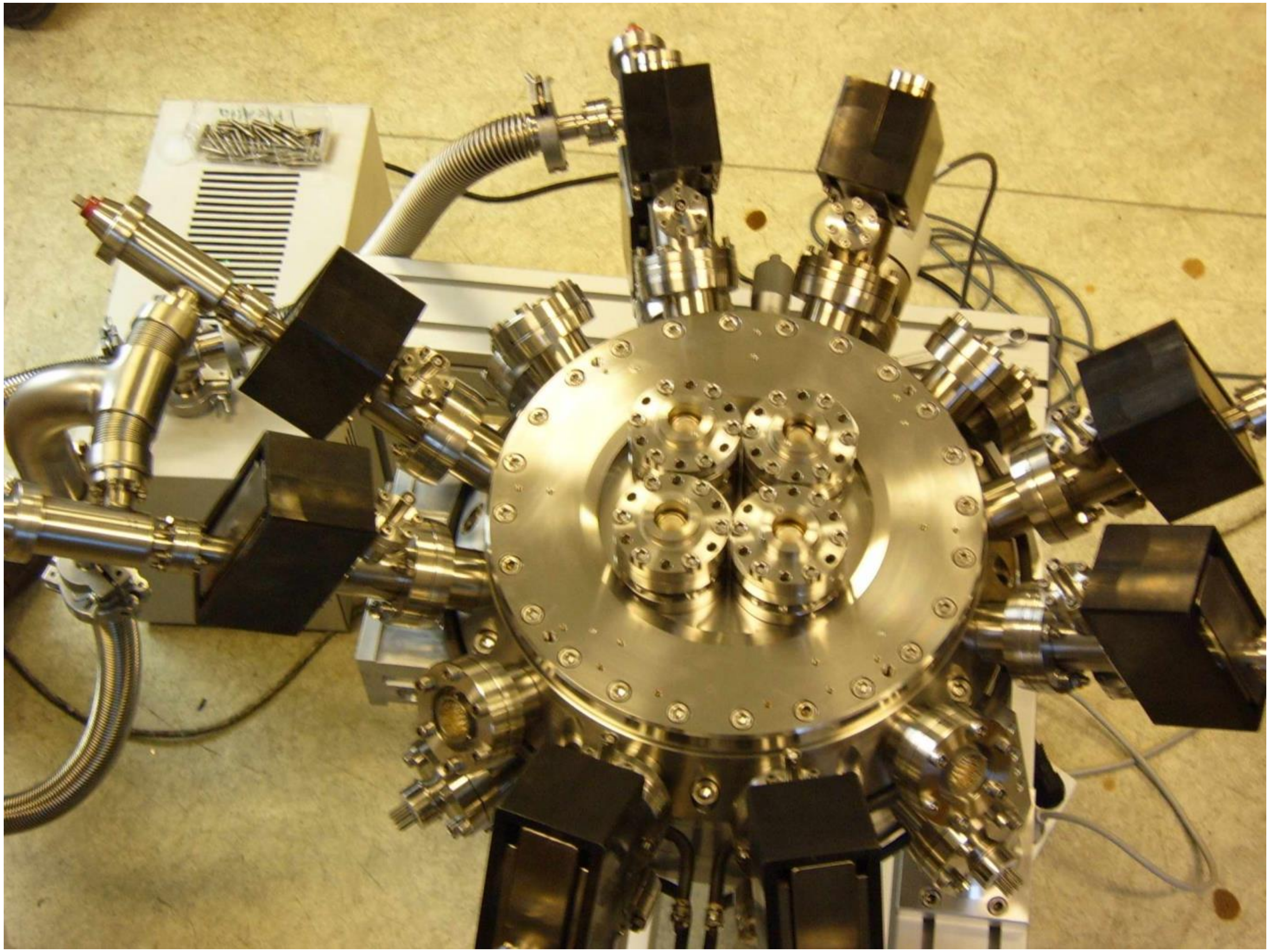
•Выбор числа колонн

SPECIFICATIONS

1. Accelerating voltage – 1-5 kV
2. Half Pitch size - 22 nm
3. Writing field - 400 x 400 µm
4. Throughput - 1 wafer/hour

ИПТМ РАН

КОМПОНОВКА МКЭЛ-4



•ЗАДЕЛ

Спасибо за внимание