EUVL Mask Carrier System

EUV Inner Pod (EIP)

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Introduction

- A comprehensive new approach to mask handling is needed to meet the requirements of EUV lithography. Particle free mask handling with vacuum compatible materials is critical enabling EUV technology.

- The objective was to determine the lowest particle/defect level that can be achieved during mask shipping and vacuum cycling.

Outline

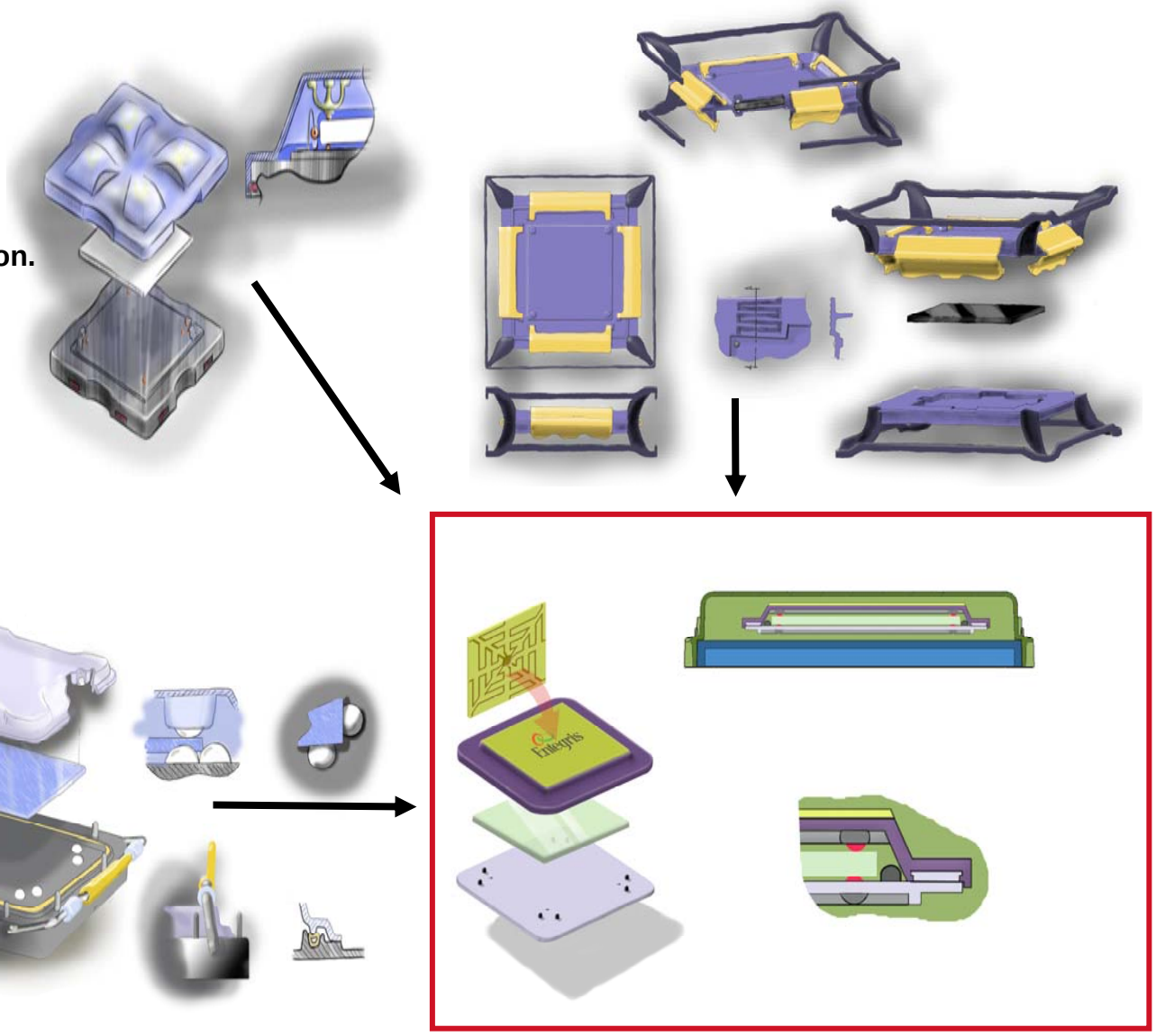
- Concepts
- Material of Contact Research
- Diffusion as a Feature
- Test Results
- Summary

- Concepts

Three Concepts to One

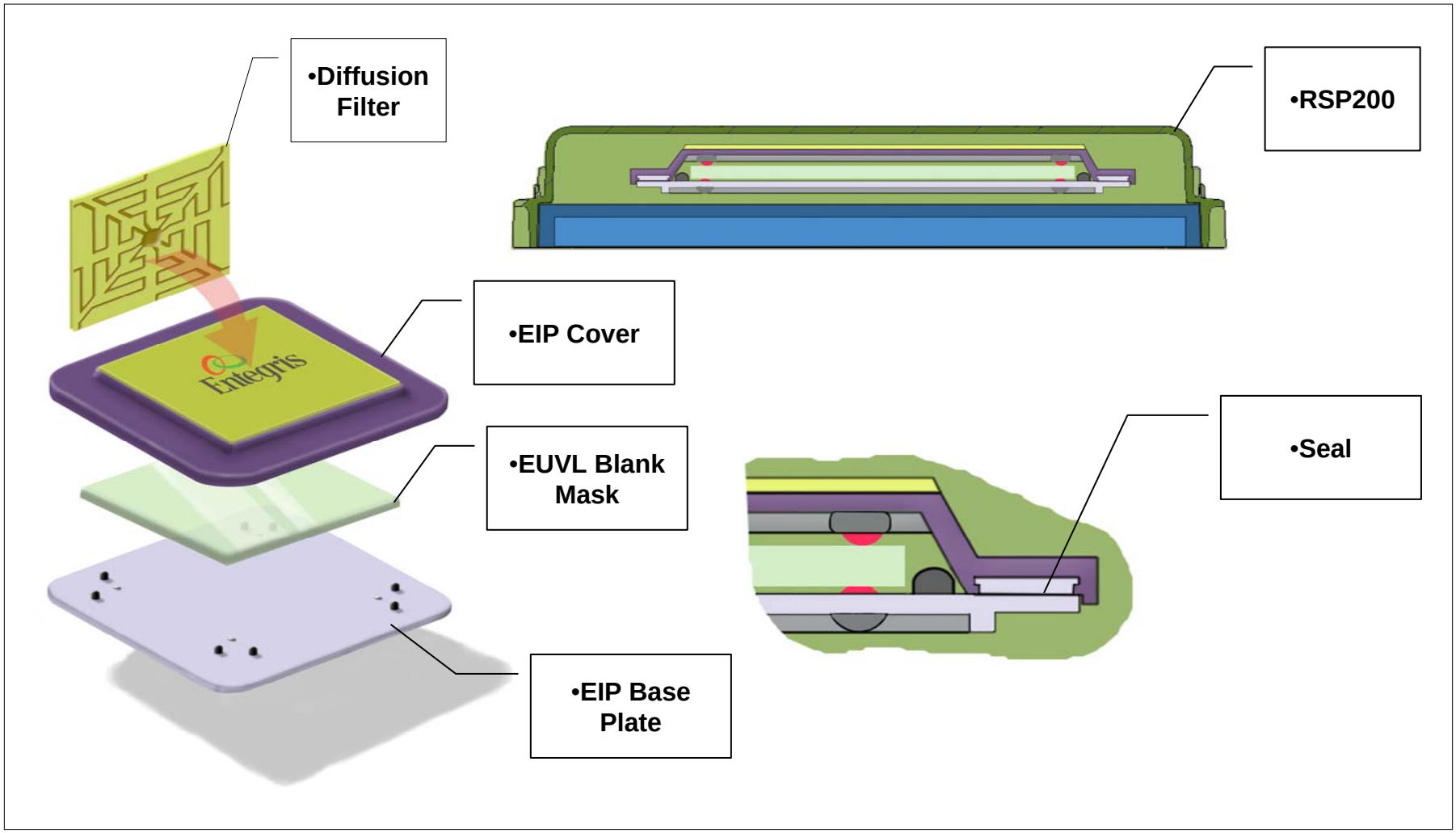
•Key Features:

- **Ball Contact**
- **Minimize Internal Volume**
- **Reduces amount of air needed to be transferred during pressure equalization.**
- **Provides mask retention with point contact.**
- **Diffusion Barrier**
- **Reduces particle migration to critical area of mask.**
- **Eliminates need for traditional elastomer seal.**
- **Easy to clean**



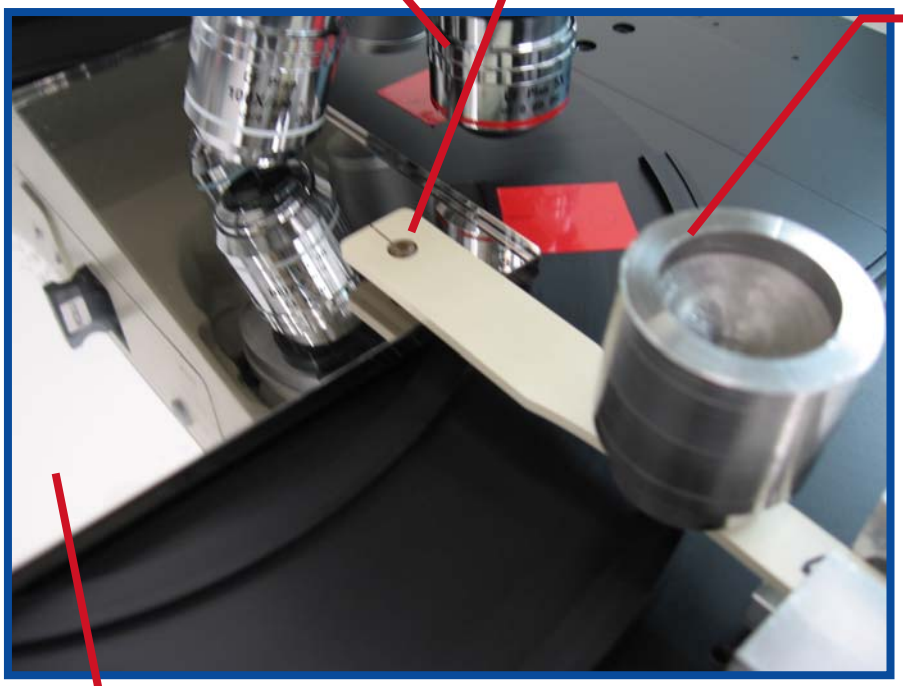
Patents Pending

EUV Inner Pod (EIP) Features



- Material of Contact Research

Materials of Contact – Test Setup



Tap and Scratch Test Setup on Mask

Tap and Scratch Test Setup on Wafer

- Optical Inspection on Mask

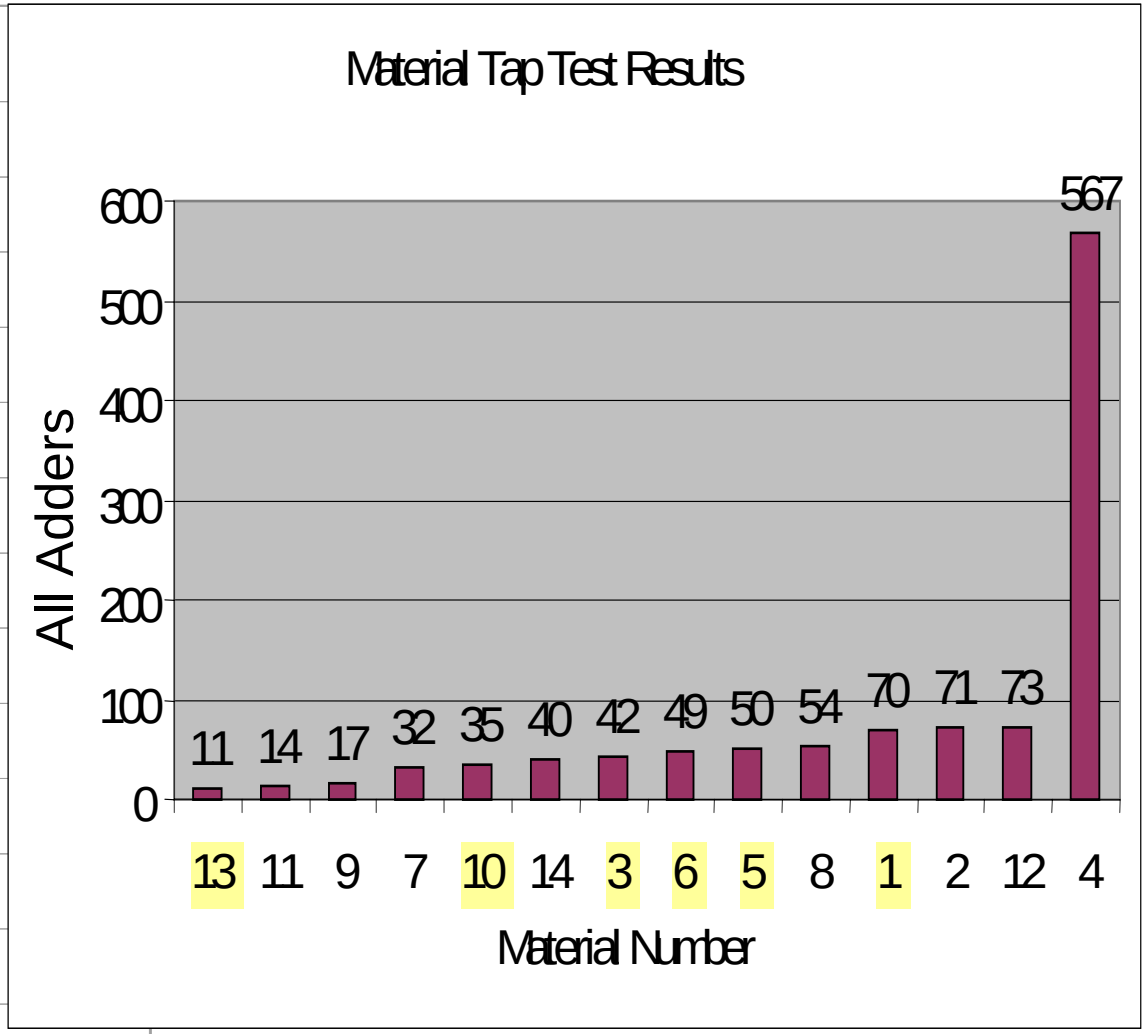
Material Marks on Mask – Microscope

All data generated with Image Pro-Plus software, version 4.5.0.19 and Nikon Optiphot 3000 microscope (50x – 1000x)

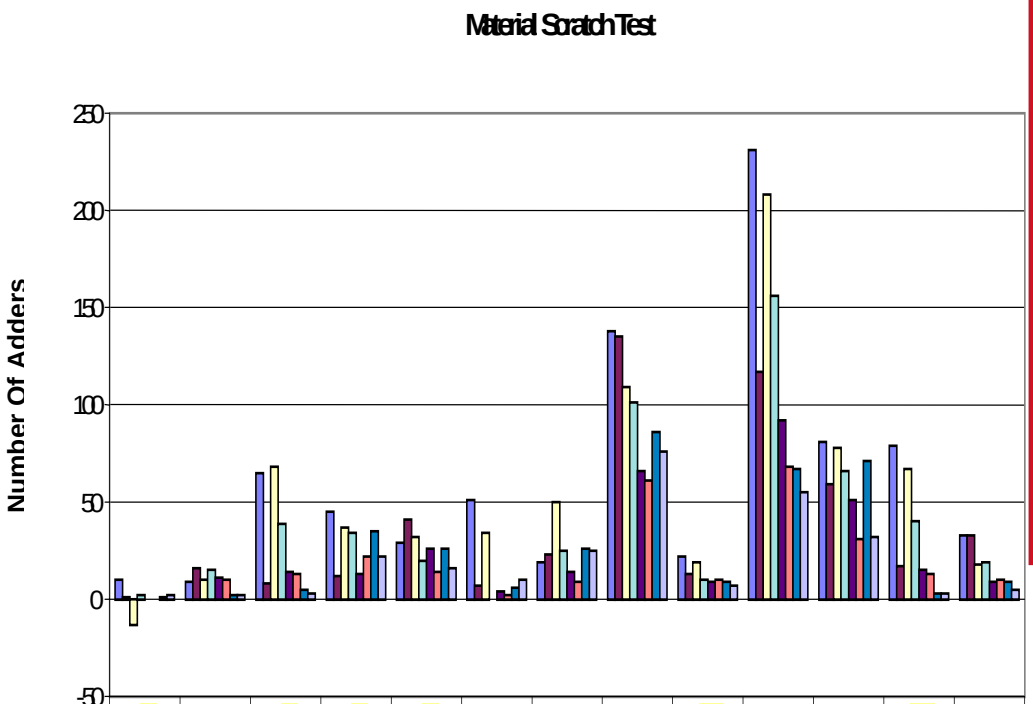
- Light scattering on Si wafers with KLA SP1

Tap Test on Wafers – KLA SP1 Data

Material Number	Type
1	Metal A
2	Metal B
3	Ceramic A
4	Ceramic B
5	Ceramic C
6	Polymer A
7	Metal C
8	Glass
9	Polymer B
10	Polymer C
11	Polymer D
12	Metal A with Engineered Surface
13	Polymer A with Engineered Surface
14	Polymer A with Engineered Surface

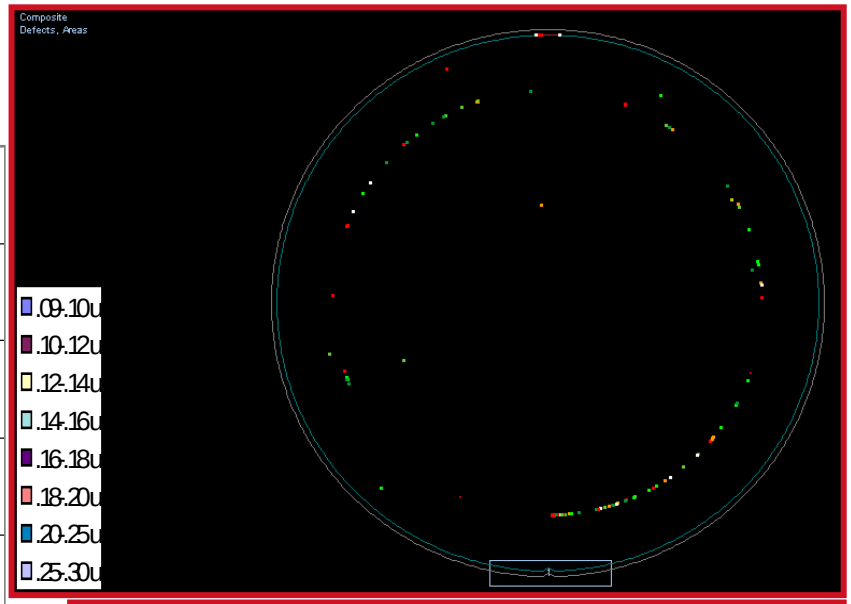


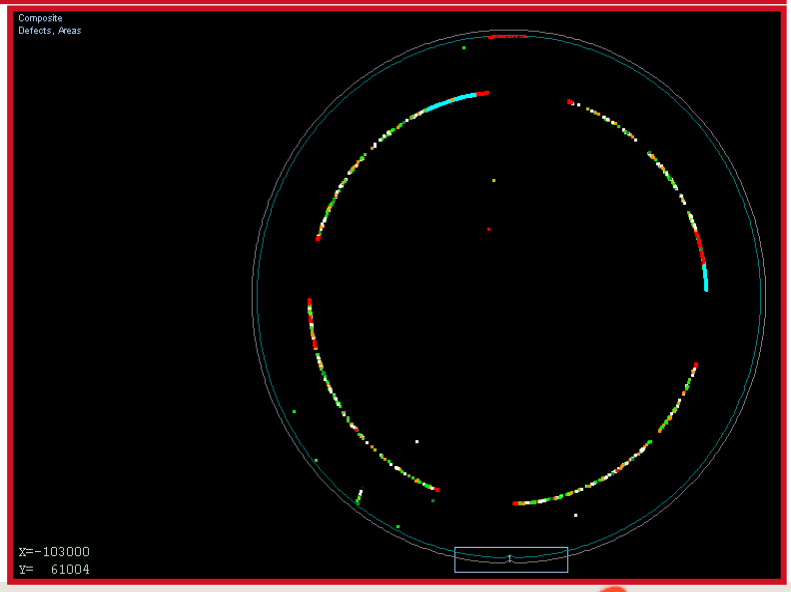
Scratch Test on Wafers – KLA SP1 Data



	1	2	3	5	6	7	8	9	10	11	12	13	14
.09-.10u	10	9	65	45	29	51	19	138	22	231	81	79	33
.10-.12u	1	16	8	12	41	7	23	135	13	117	59	17	33
.12-.14u	-13	10	68	37	32	34	50	109	19	208	78	67	18
.14-.16u	2	15	39	34	20	0	25	101	10	156	66	40	19
.16-.18u	0	11	14	13	26	4	14	66	9	92	51	15	9
.18-.20u	0	10	13	22	14	2	9	61	10	68	31	13	10
.20-.25u	1	2	5	35	26	6	26	86	9	67	71	3	9
.25-.30u	2	2	3	22	16	10	25	76	7	55	32	3	5

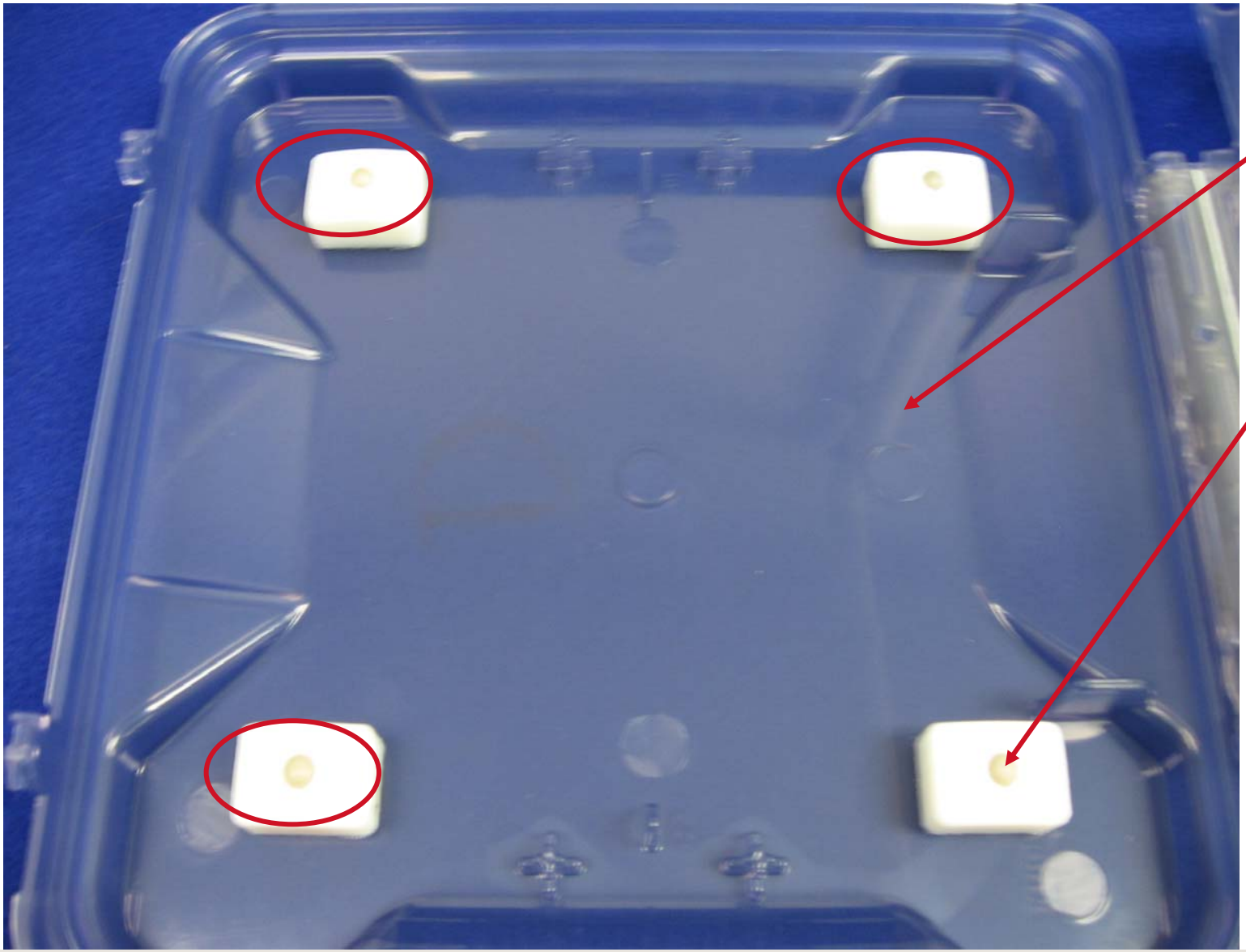
Material





- Lasertec results

Test Coupon – Modified Single Mask Package

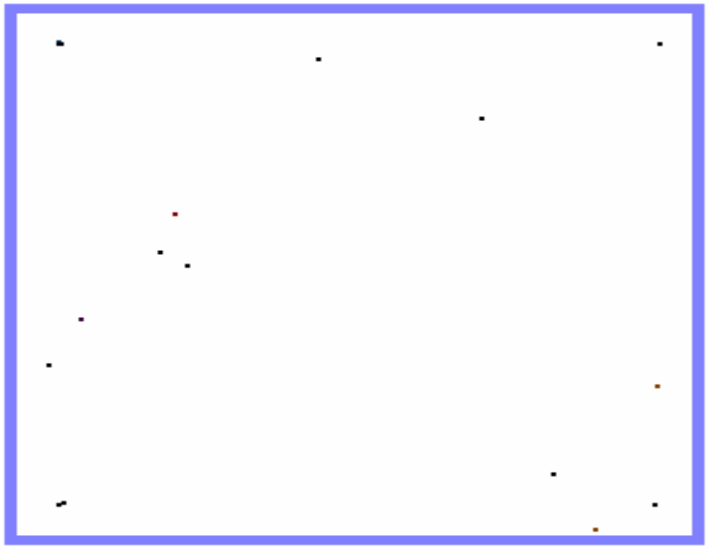


Package used for ship test

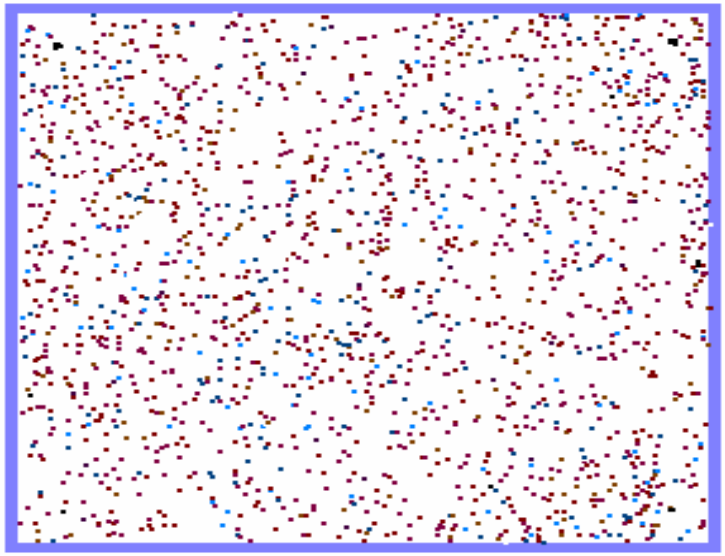
Material Sample Sphere

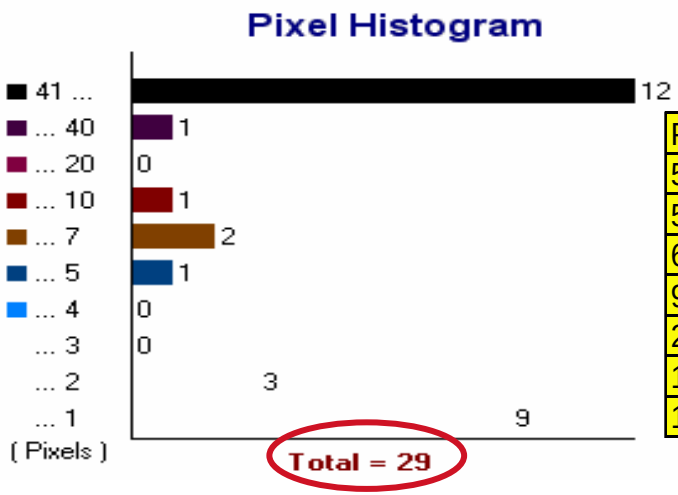
Ship Test Results – SEMATECH (ISMT) Lasertec Data

Material Selected

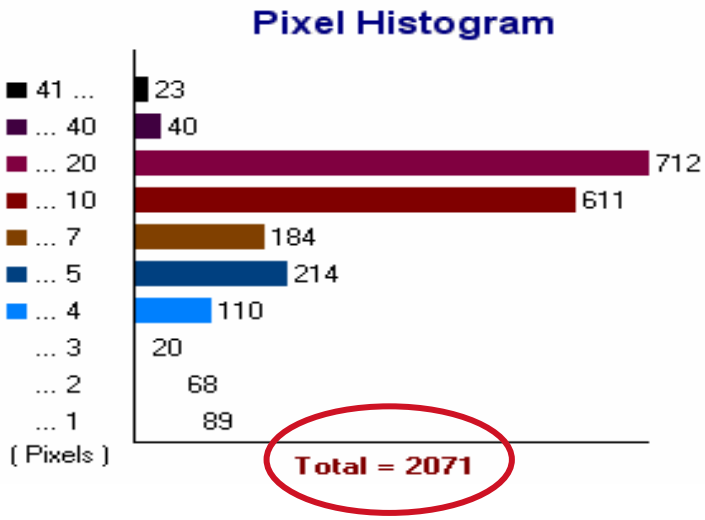


Example Material





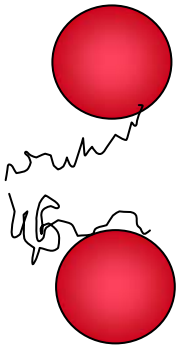
PSL (nm)	BIN #
53.8	4
58.7, 63.9	5
69.6, 75.9, 82.7	7
90.1	10
212.3, 500.4	20
1,179.5	40
1,285.2	41

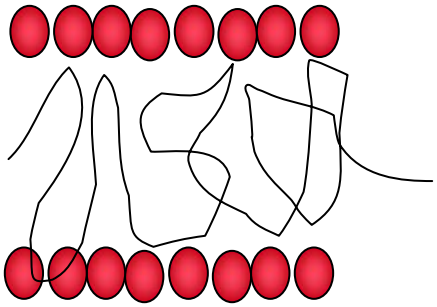


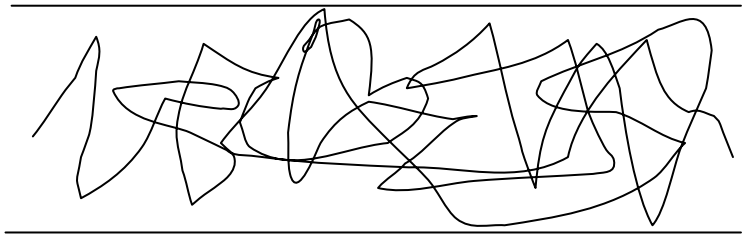
- Diffusion as a feature for vacuum environment

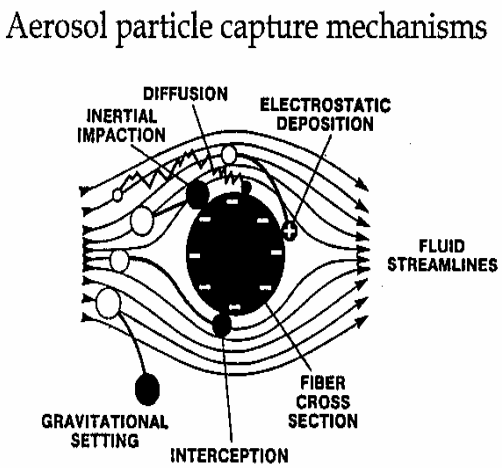
Diffusion Filter

- **A diffusion filter is no different from a fibrous or PTFE type filter with regard to removing submicron particle.**

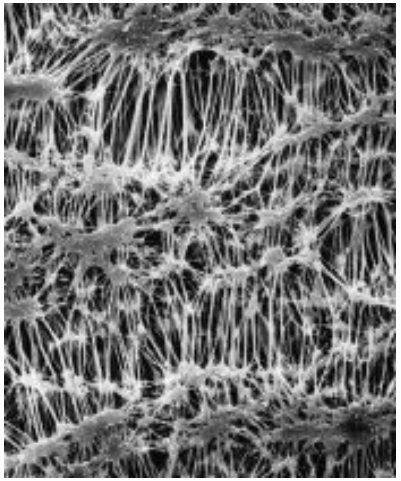








- **PTFE Stretched Membrane**



- **Micro-fiber Glass Media**

Diffusion Particle Collection Efficiency

- Particle penetration through a rectangular shape diffusion channel

$$P = 0.9104\exp(-2.8278\mu) + 0.0531\exp(-32.147\mu) + 0.01528\exp(-93.475\mu) + 0.00681\exp(-186.805\mu)$$

for $\mu > 0.05$

$$P = 1 - 1.526\mu^{2/3} + 0.15\mu + 0.0342\mu^{4/3}$$

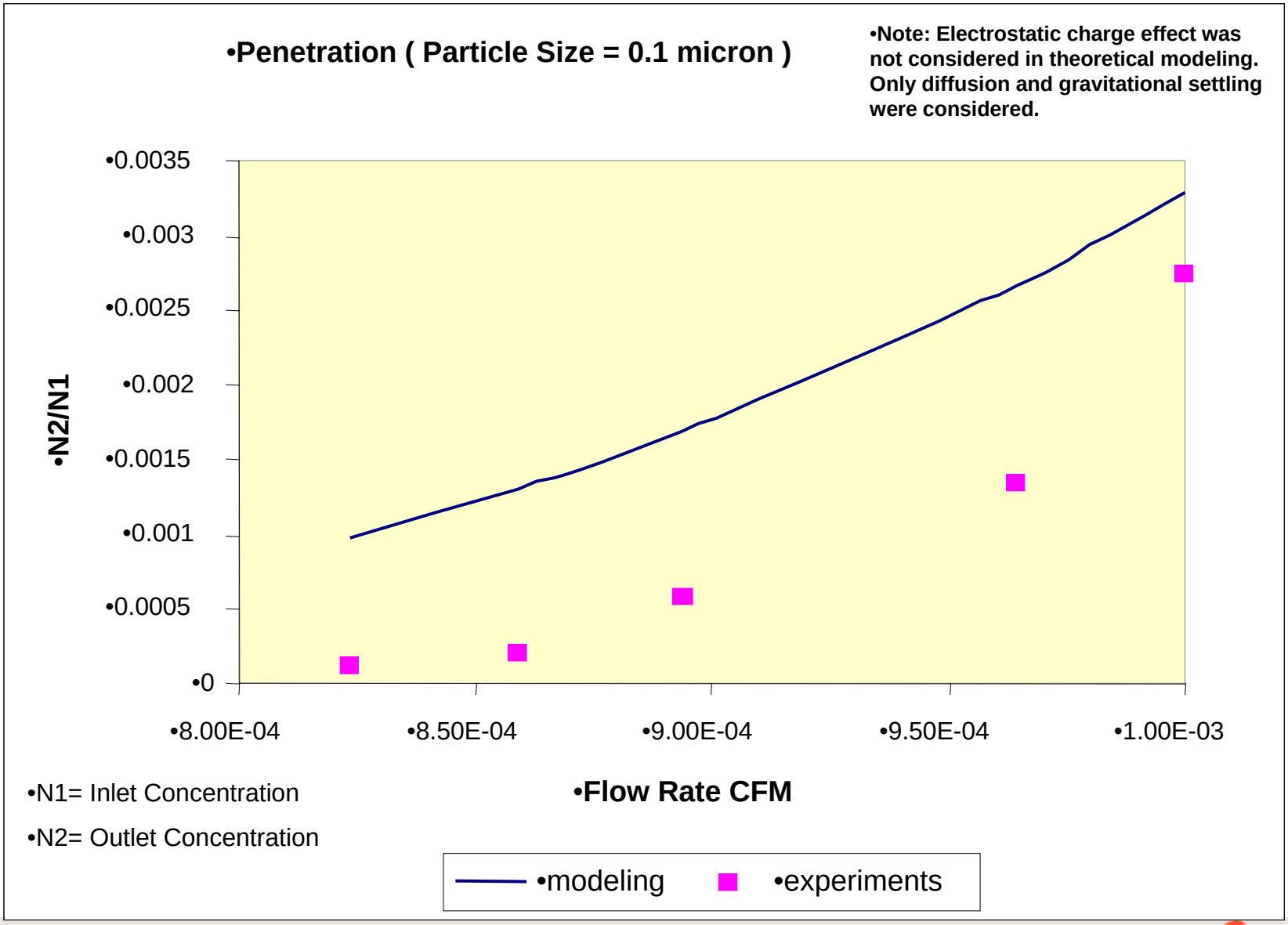
for $\mu <= 0.05$

Where $\mu = 8DLW/3QH$

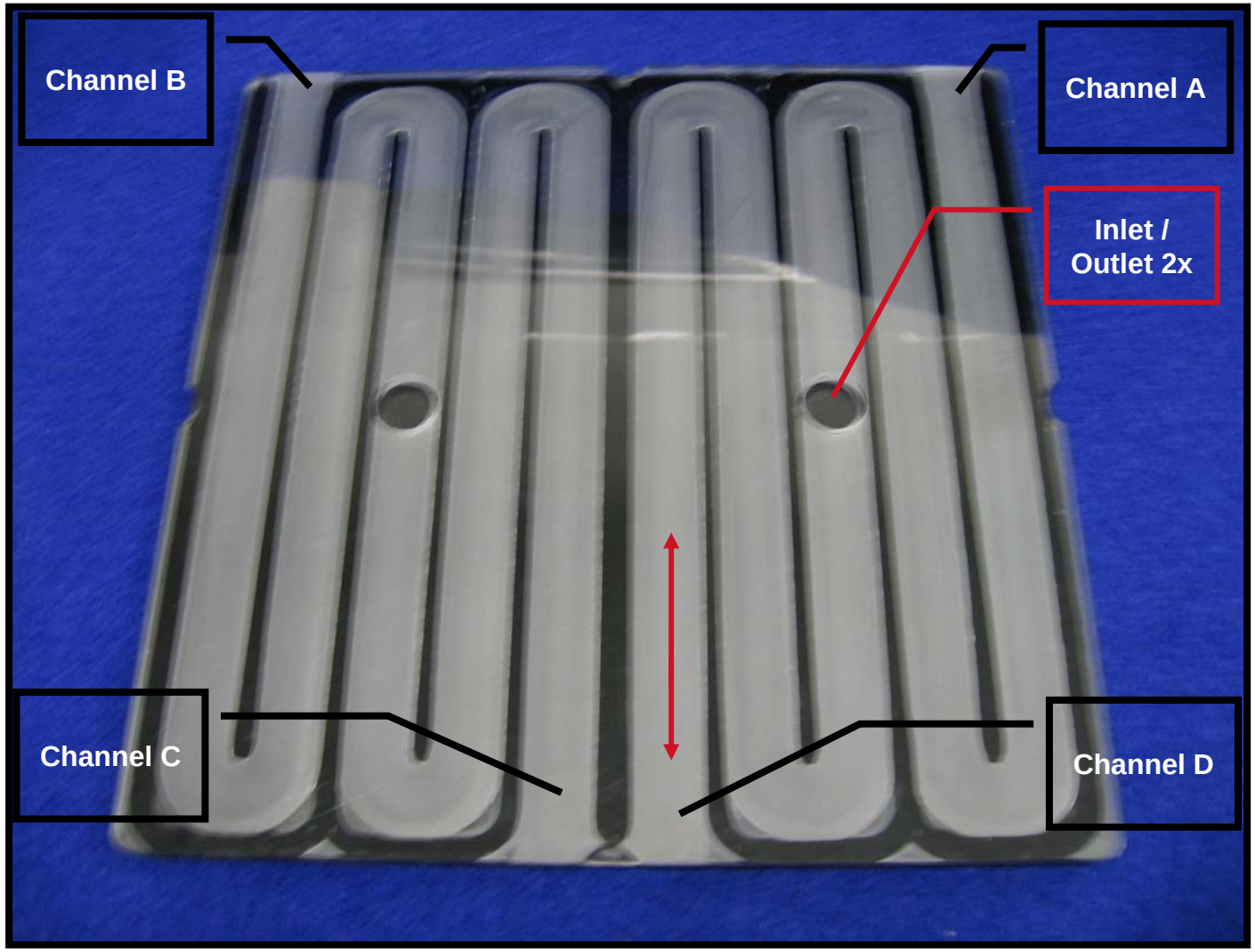
D is diffusion coefficient of particle

Q is flow rate

Diffusion Particle Efficiency / Ratio =1-Penetration



Diffusion Filter – One Example of Application



- Test Results

Vacuum Outgassing Test Procedure

Steps

1. Test samples were cleaned, conditioned in a clean room for 48 hours, then double bagged and sealed to prevent contamination
2. Remove sample from bag and place in vacuum chamber on stainless steel stand to allow complete airflow
3. Activate vacuum pump until chamber pressure is between 10^{-5} – 10^{-6} Torr
4. Turn off the vacuum pump
5. Record pressure versus time during pump down and pressure rise
6. Outgassing rate is calculated as follows

$$q_A = \left(\frac{dp}{dt}\right)_{t=0} \frac{V}{A}$$

7. To determine the outgassing rate of the sample, the empty chamber is measured first and then subtracted from the rate measured with the sample in the chamber as follows:

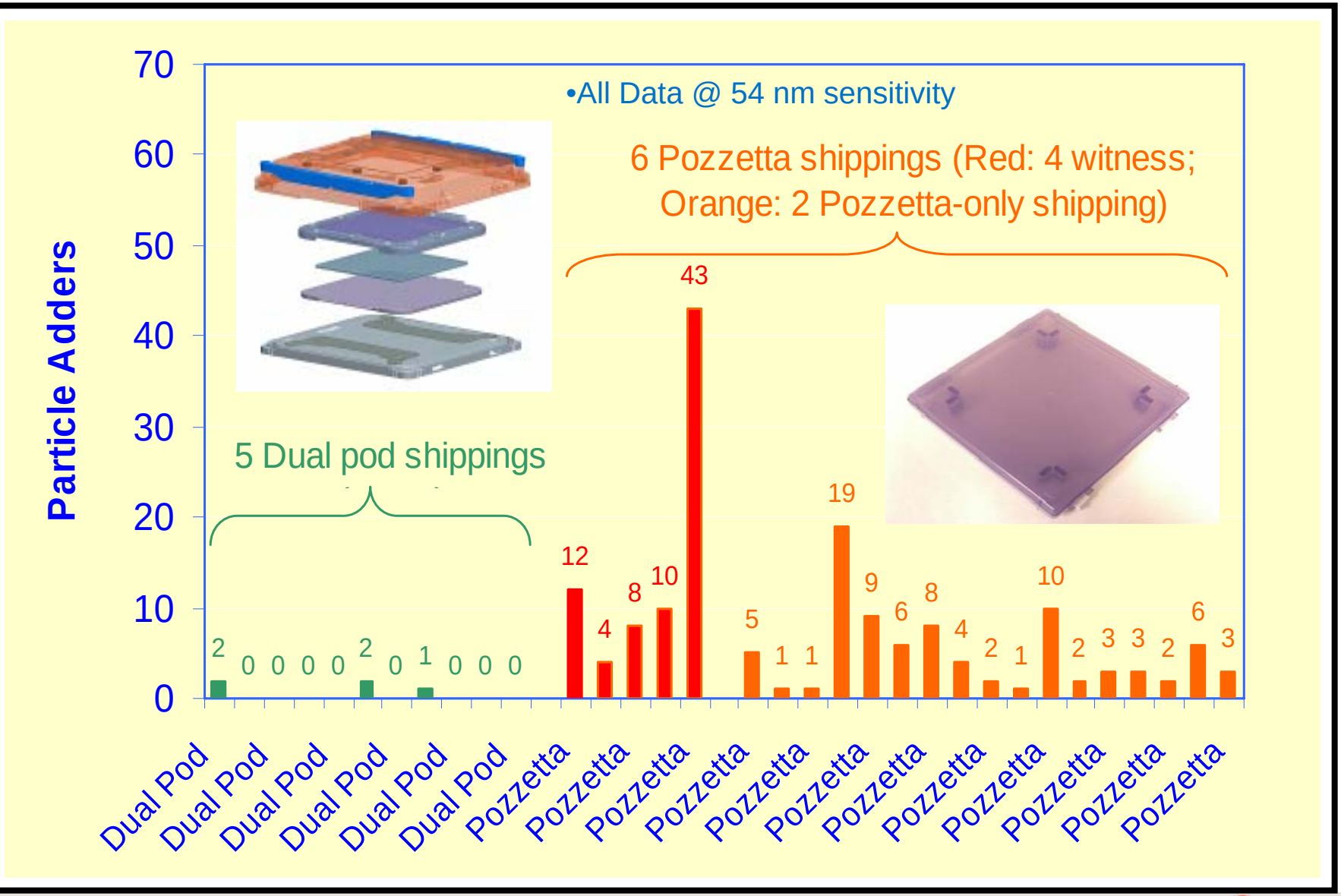
$$q_{A_S} = \left(\frac{dp}{dt}\right)_S \frac{V}{A_S} = \left[\left(\frac{dp}{dt}\right)_{S+C} - \left(\frac{dp}{dt}\right)_C\right] \frac{V}{A_S}$$

S = sample
C = chamber

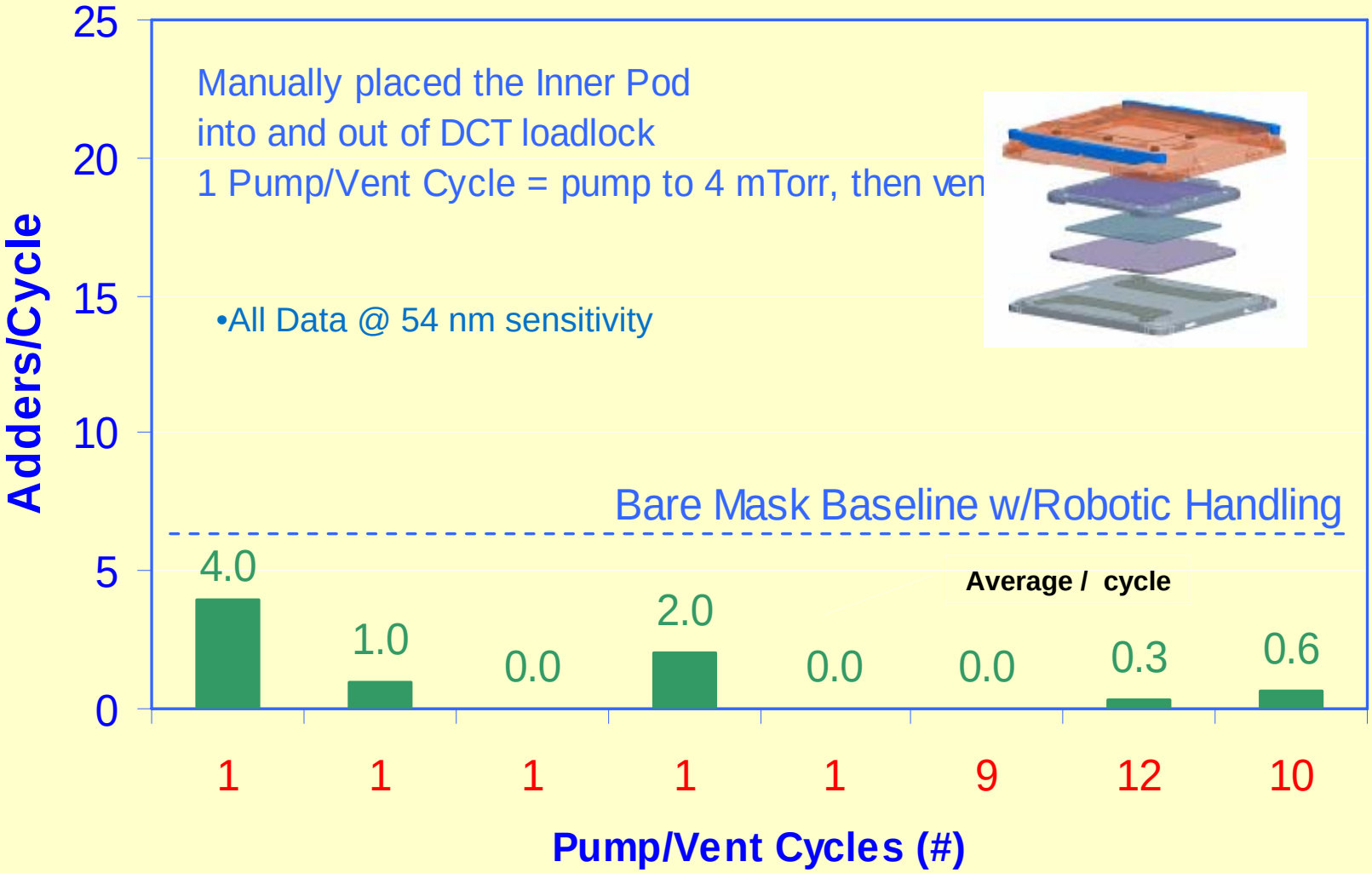
EIP Outgassing Table

	Vacuum Chamber	Sample A Material	EIP Material	Sample B Material	Sample C Material
dp/dt (Torr/s), first min. of pressure rise	3.09×10^{-7}	7.09×10^{-7}	1.46×10^{-6}	1.73×10^{-6}	4.55×10^{-7}
A (cm^2), surface area		1,083.87	1,083.87	1,205.81	870.97
q (Torr l s^{-1}) Gas Load Rate	3.51×10^{-5}	8.06×10^{-5}	1.65×10^{-4}	1.96×10^{-4}	5.17×10^{-5}
q (Torr l s^{-1}) Gas Load Rate Sample – Chamber		4.55×10^{-5}	1.30×10^{-4}	1.61×10^{-4}	1.67×10^{-5}
q_A (Torr l s^{-1} cm^{-2}) Material Outgas Rate		4.20×10^{-8}	1.20×10^{-7}	1.34×10^{-7}	1.91×10^{-8}

Test Results on Shipping (SEMATECH)



Test Results on Vacuum Cycles (SEMATECH)



Summary

- New EUV Inner Pod System can match the *current* metrology limits
- New metrology coming on line at SEMATECH can further define EIP performance
- Fully automated EIP handling is needed to characterize performance limits
- More work to be done……

Acknowledgments

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