

Fabrication of Micro-polarizer Array

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Outline

- Introduction for Polarization Imaging
- Fabrication of micro-polarizer
 - Positive photo-resist with wet and oxygen plasma dry etching
 - Negative photo-resist with Reactive Ion etching
- Concluding remarks

Introduction

■ Importance about Light Polarization

- What is light polarization
- Human eyes detection

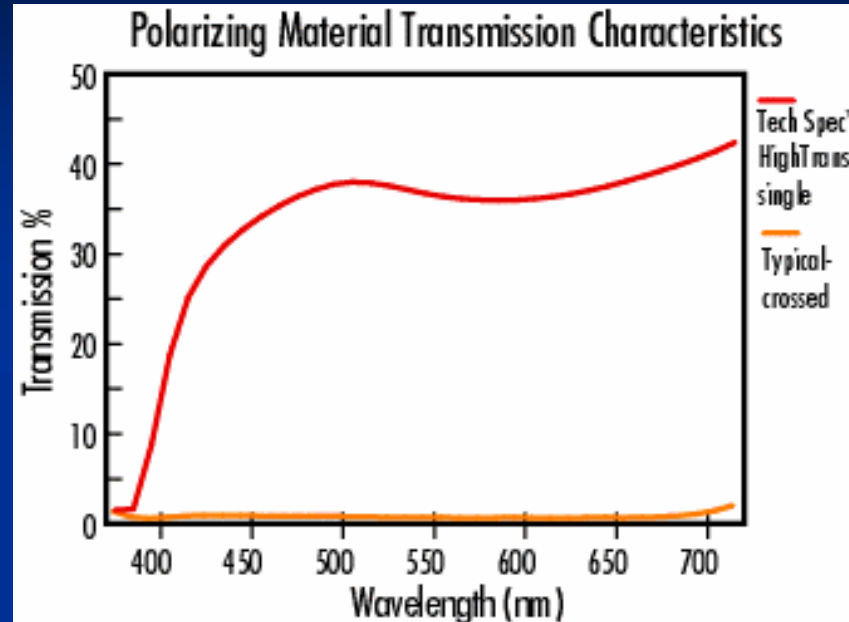
■ System overview

- Micro-polarizer Arrays using polymer films
- Implementation to imaging chip
- Applications
 - Underwater detection, etc
- Advantages
 - Low power system
 - Real-time extraction of polarization

Choosing Polarizer

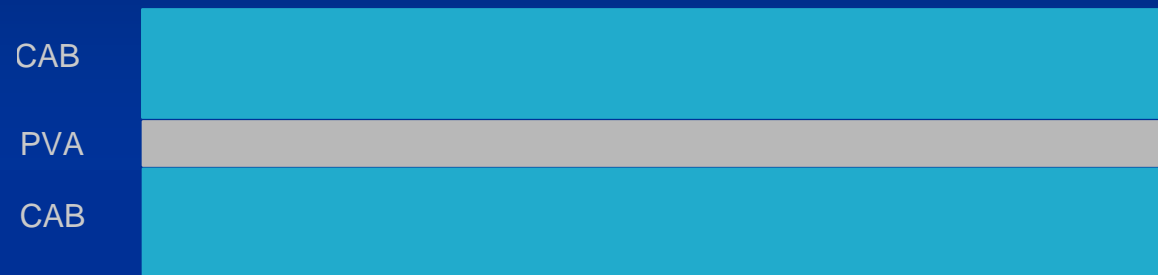
- Using commercially available polymer
 - Advantages: good proven data, cheap
 - Disadvantages: variable thickness
- Material
 - **TECH SPEC™ Linear Polarizing Laminated Film**

Optical Test



	No Polarizer	Single Polarizer	Cross Polarizer	Extinction Ratio
Red LED (700 nm)	480 mW/cm²	190 mW/cm²	2 mW/cm²	40dB
Green LED (600 nm)	480 mW/cm²	180 mW/cm²	0.2 mW/cm²	60dB

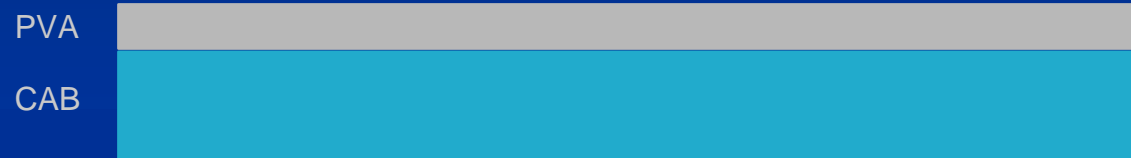
Polarizer Thin Film Structure



■ Layers

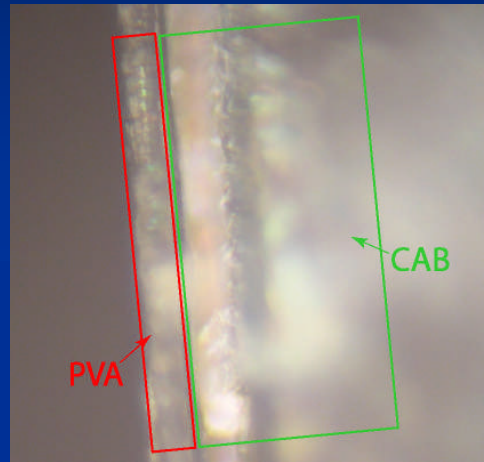
- Polyvinyl Alcohol (PVA)
- Acetate Butyrate (CAB)

PVA Structure



- CAB Removal
 - Acetone Solution bath

PVA Thickness



- Thickness of PVA
 - 10~30 μm
- Problem
 - Non uniformity

Positive Photo-resist Masking

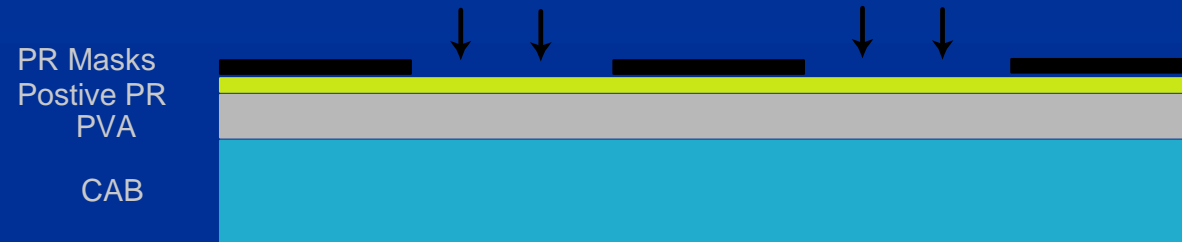


- Spin coating positive Photo-resist
 - Thickness: from 1 μm to 3 μm *

*Measured by Tencor Instruments TM Profilometer

Positive Photo-resist Masking

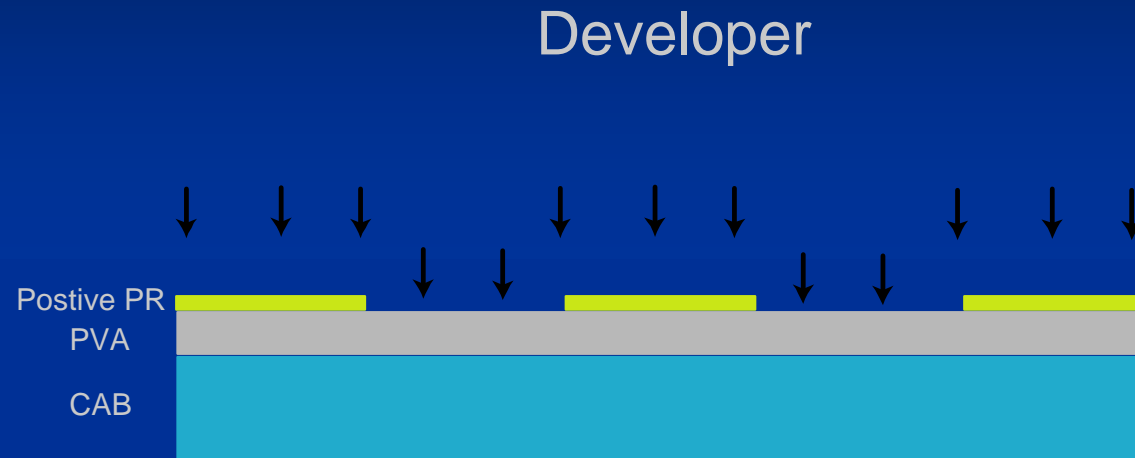
UV light



■ UV Photolithography*

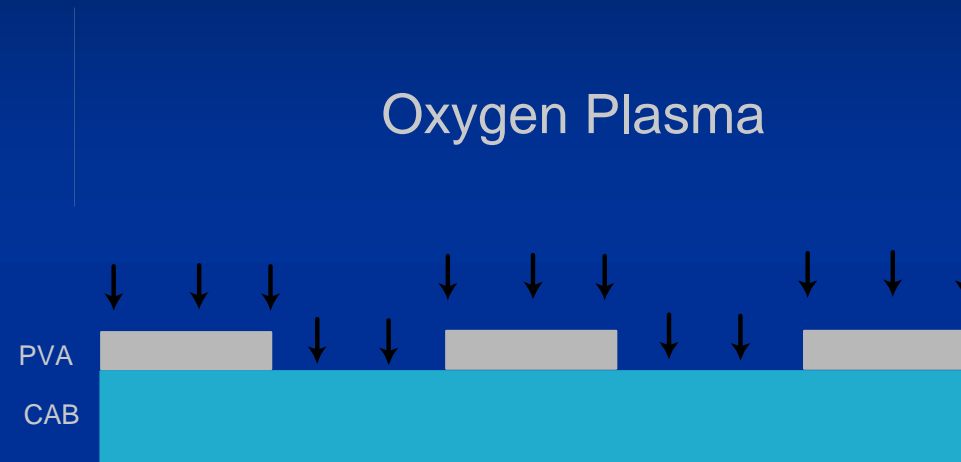
* Performed by Kasper System™ 2001 Mask Aligner

Positive Photo-resist Masking



- Developer Etches away both masked PR and unmasked PVA

Positive Photo-resist Masking

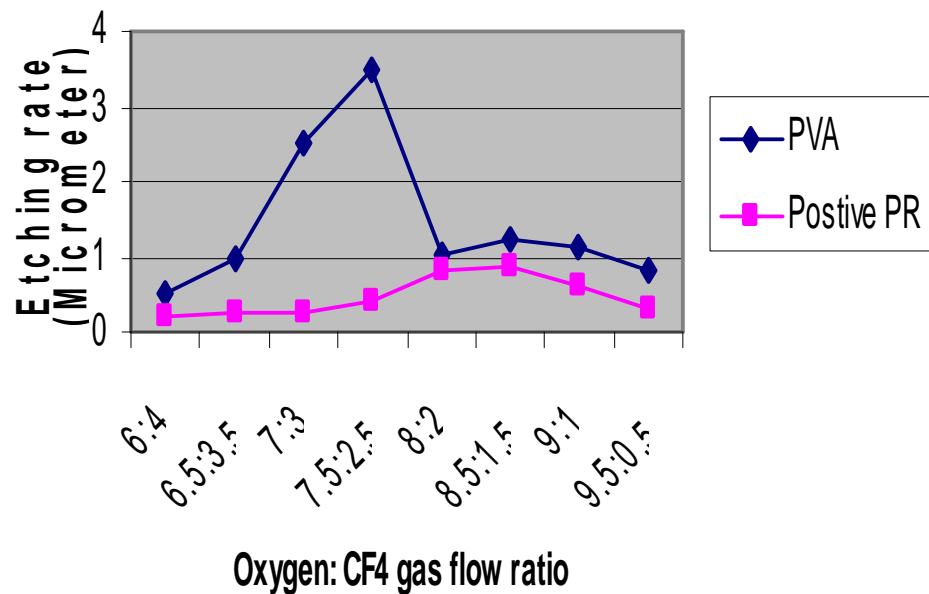


- Oxygen Plasma Etching (Ideal)*

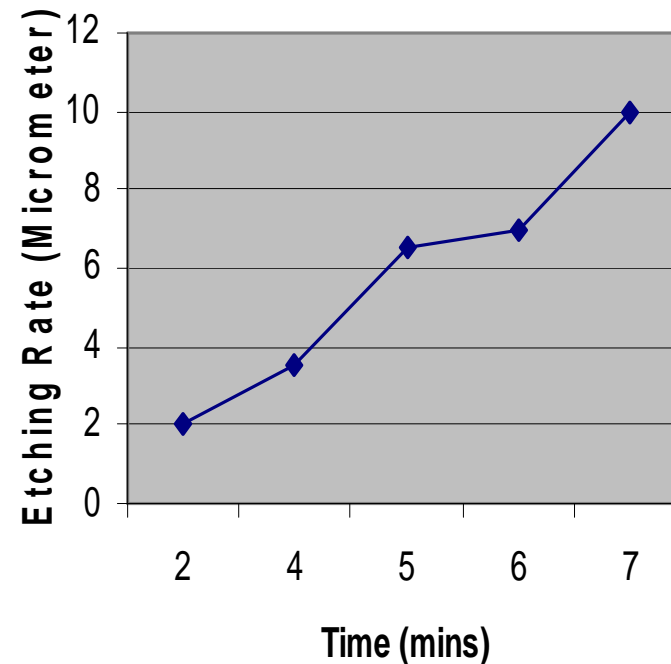
* Performed by Technics PlasmaEtch™ II Oxygen Plasma instrument

Oxygen Plasma Etching Rate Data (PVA & Positive Photo-Resist)

Oxygen Plasma Etching Rate for PVA & Positive PR (300 Watts, 2 minutes)

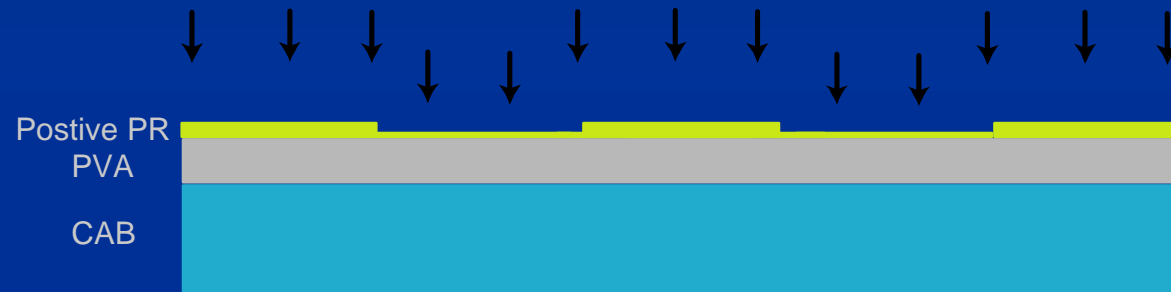


Oxygen Plasma Etching rate for PVA (80 Watts, O₂:CF₄ = 7.5:2.5)



Problems with Positive Photo-resist

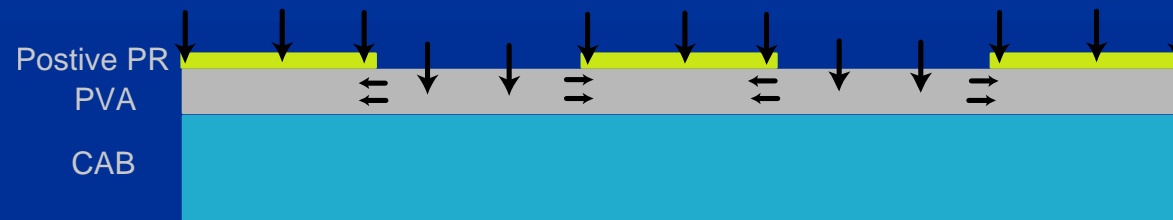
Developing Under-exposed PR



- Thickness
 - Multiple Layers: Un-uniform
- Developer
 - Can be used for wet etching of the PVA
 - Under-Exposing: Rough Surface

Problems with Oxygen Plasma Etching

Oxygen Plasma



- Oxygen Plasma Etching

- Isotropic Etching

- Vertical to Horizontal Etching Ratio:

2:1 at 40W ~ 150 W Oxygen : CF4 = 7.5 : 2.5

Important factors

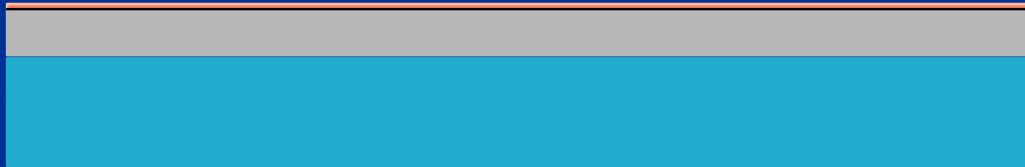
- The thickness of the photo-resist has to be relatively big comparing to PVA thickness
- Photo-resist has to have a different chemical structure from PVA
- An etching method that has less isotropic effects than oxygen plasma etching

Negative Photo-resist

- Material: Su-8 2000 series
 - Advantages: thickness, high aspect ratio (20:1)
- Developer
 - No significant effects on PVA
- Reactive Ion Etching (RIE)
 - Combination of O₂, CF₄ and Ar
 - The addition of Argon gas allows for more mechanical etching impact on sample

Negative Photo-resist Masking

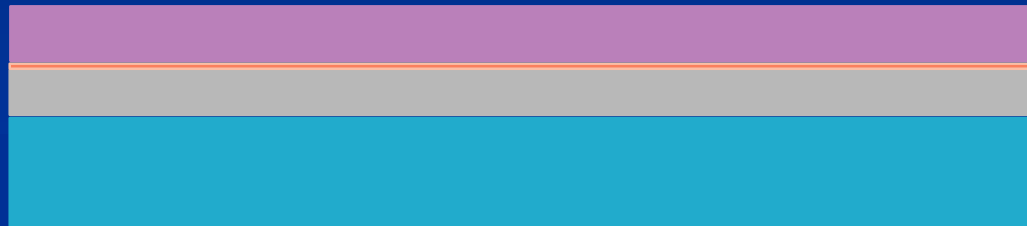
Adhesion Promoter
PVA
CAB



- Adhesion
 - Humidity
 - Adhesion Promoter: Ti O₂

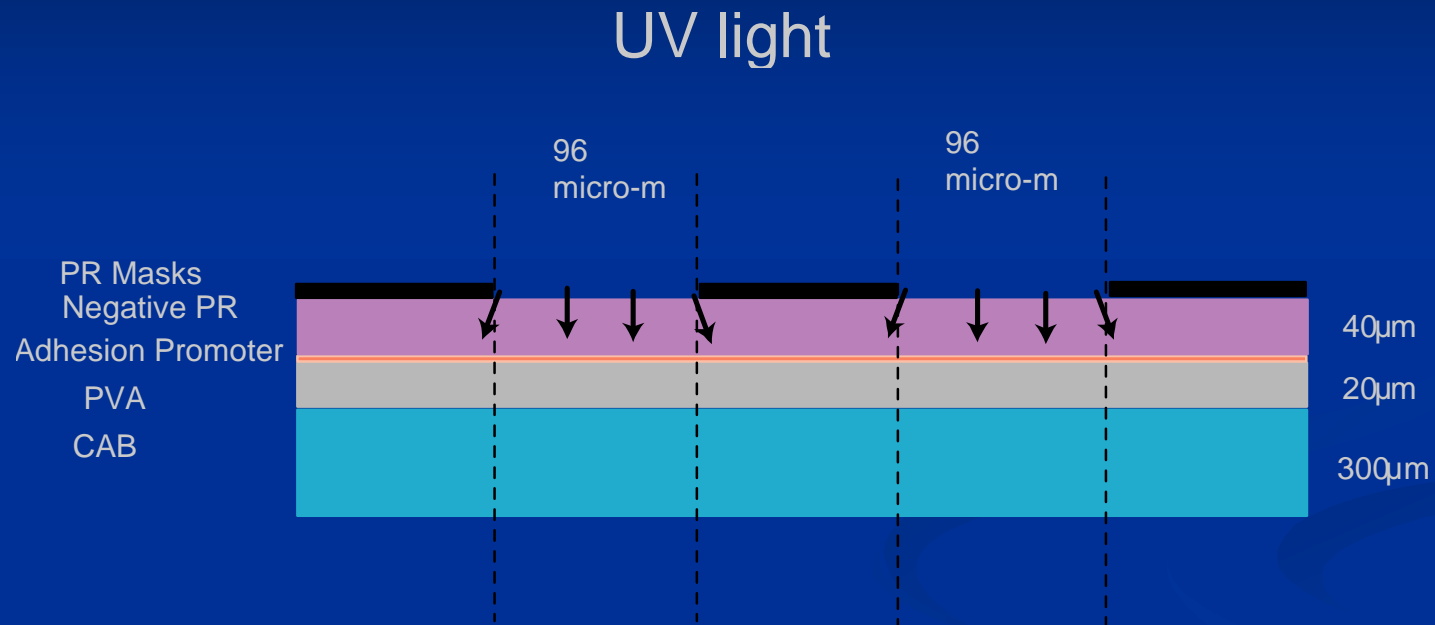
Negative Photo-resist Masking

Negative PR
Adhesion Promoter
PVA
CAB



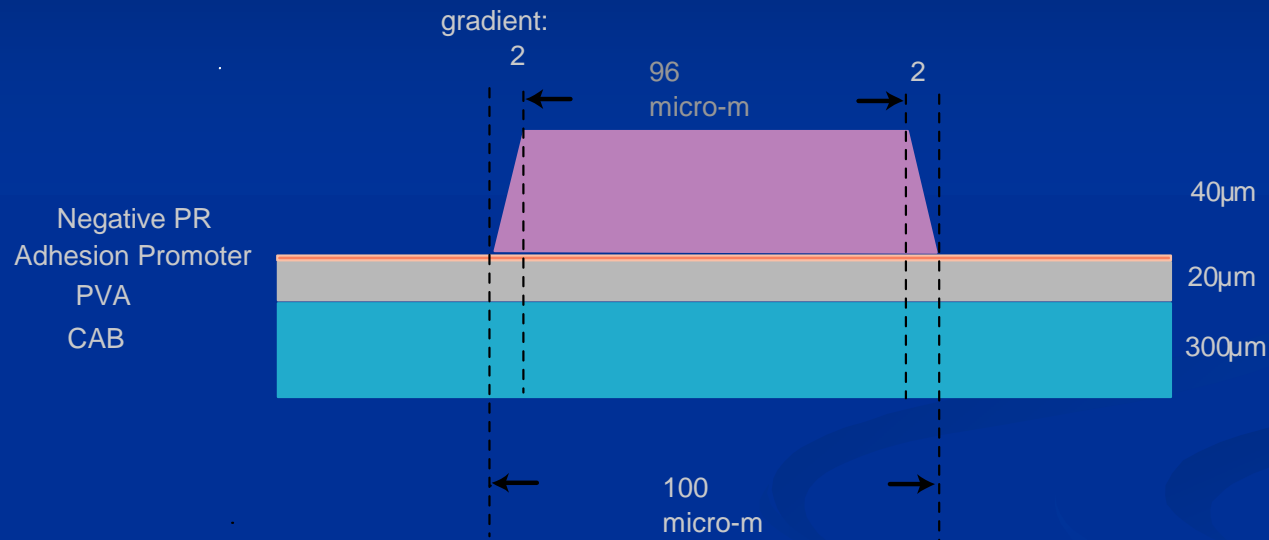
- Spin-coating Su-8

Negative Photo-resist Masking



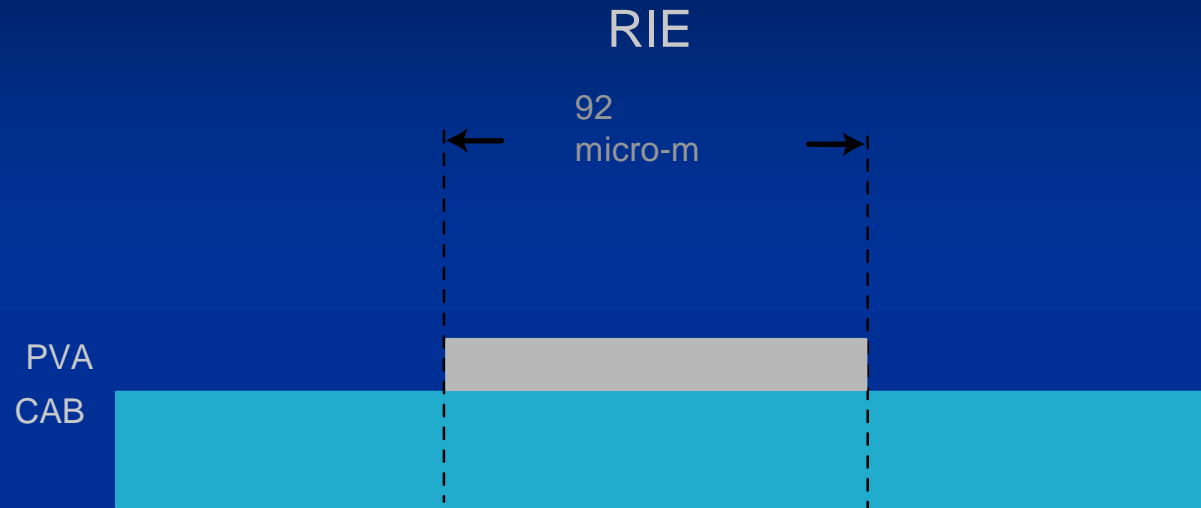
- UV Exposure
- Gradients

Negative Photo-resist Masking



- If the thickness of Su-8 is:
 - 1 micro-m, the gradient is $0.05 \mu\text{m}$
 - 15 micro-m, the gradient is $0.75 \mu\text{m}$
 - 40 micro-m, the gradient is $2 \mu\text{m}$

Negative Photoresist Masking



- PVA VS Su-8 RIE rate*:
 - 3:1
- Anisotropic Etching

* Performed by Plasma Lab™ RIE Instrument

Conclusion

- Su-8 2000 negative photo-resist allows for high aspect ratio masks.
- Reactive Ion etching allows for very good anisotropic etching.
- Smallest dimensions that can be produced will be about 4 μm square.
- Refinement for the entire process will be needed

Acknowledgements

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