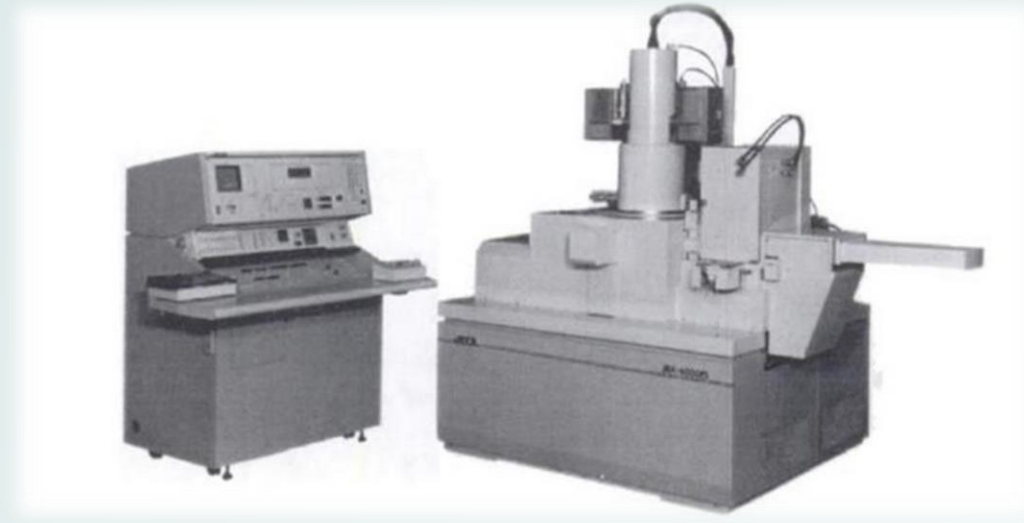


# Recent Development in E-Beam Lithography techniques

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# Contents

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- Intro to E-beam Lithography
- Blocks of a typical E-Beam tool
- Schemes of E-Beam Lithography Process
- Techniques in Projection Printing
- Modified SEM's
- Developments in Direct Writing and Lift-Off Process
- Few More Recent Developments
- Conclusion
- References

# 1. Intro to E-beam Lithography

Moore's Law

Why E-Beam ?

How does E-beam Lithography Work ?

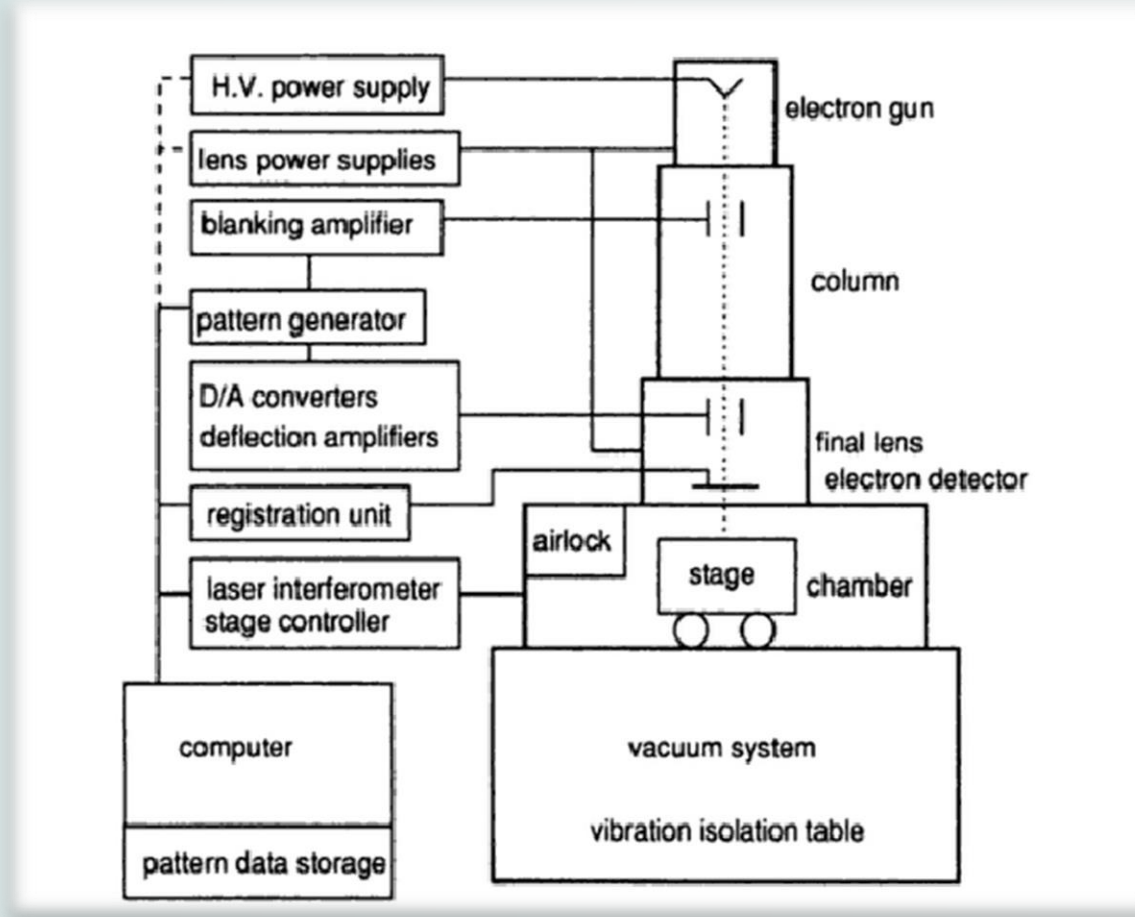
Advantages of E-beam :

1. Very High resolution.
2. Infinite patterns can be generated with an ease.
3. Can work with different materials

E-beam resists



# Blocks of E-beam Tool and its working

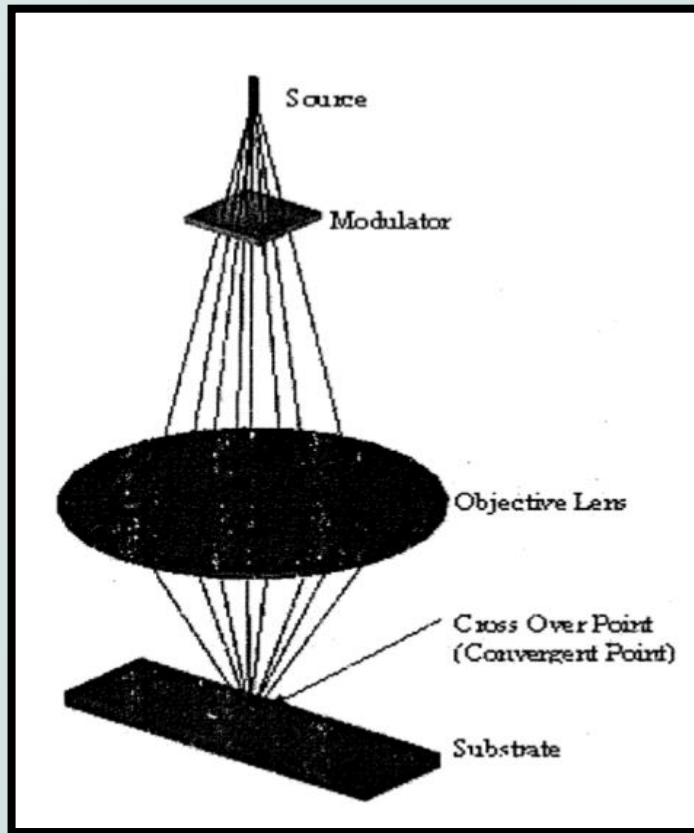


Block Diagram of E-beam Tool components

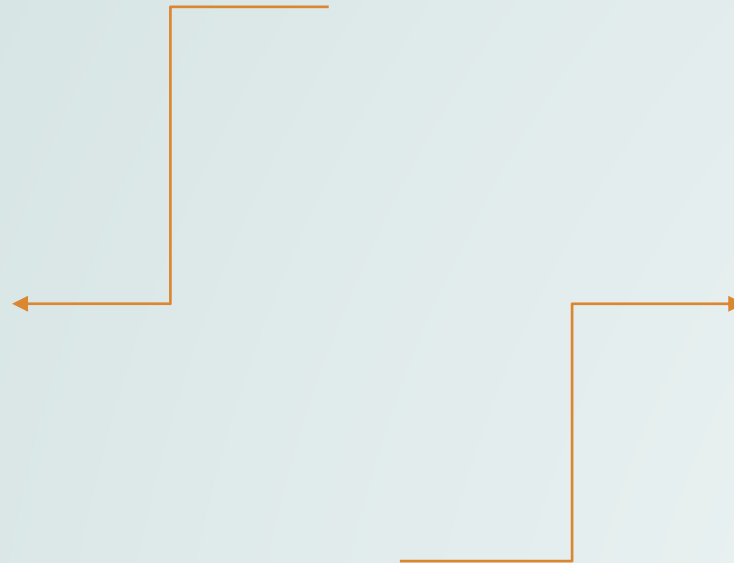
# Direct Writing

vs

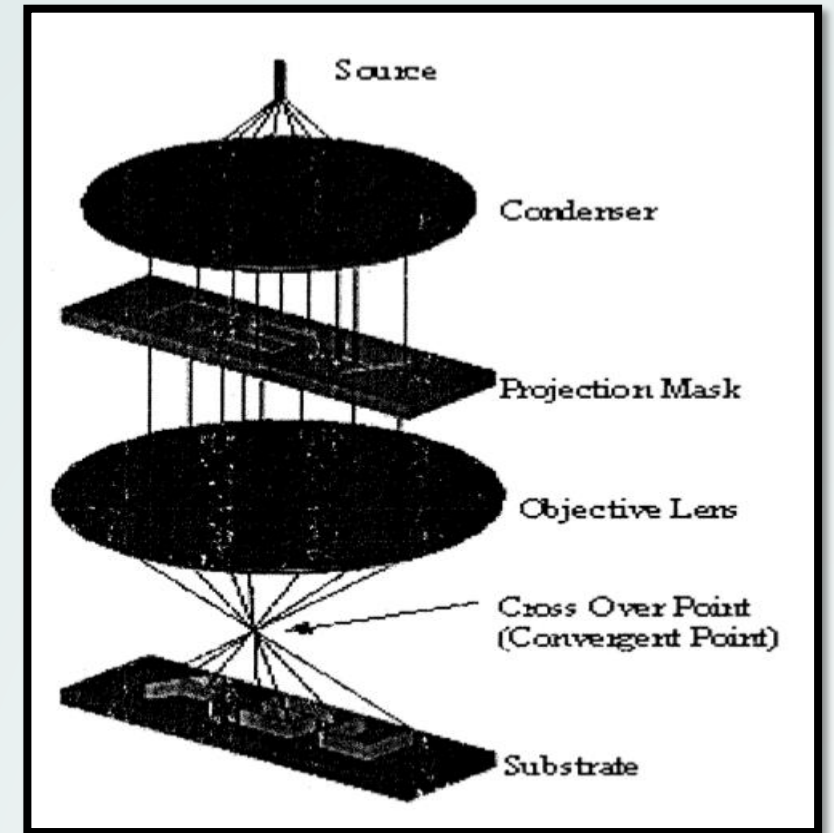
# Projection printing



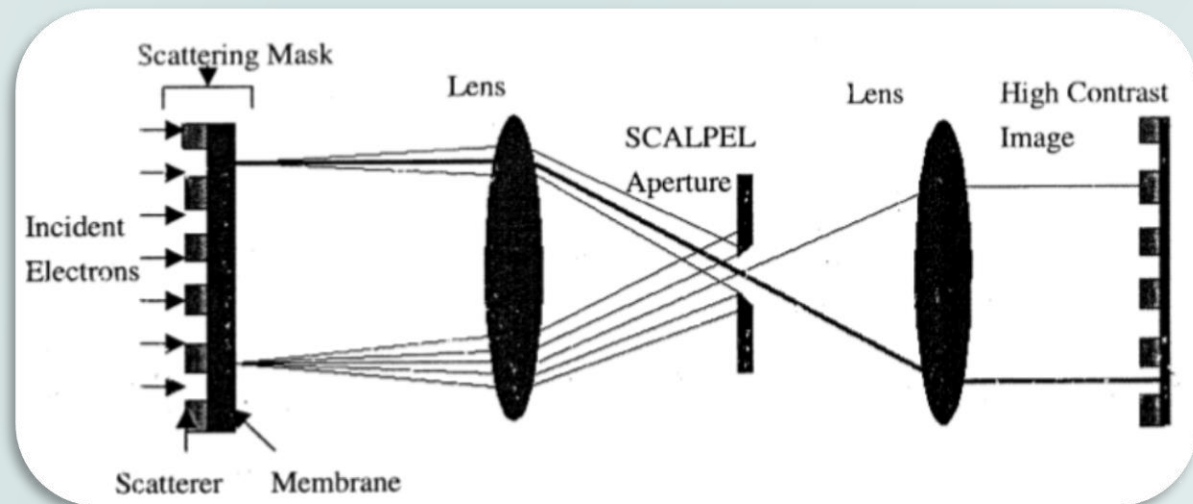
“Maskless Writing”



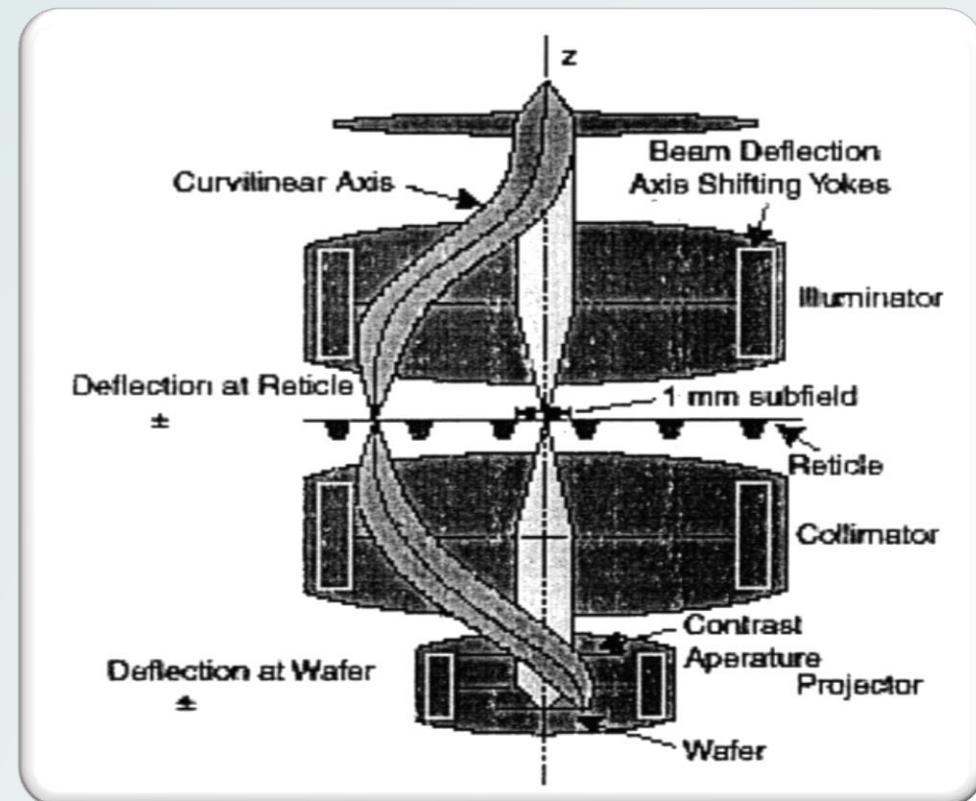
Projection through Mask



# Technical Improvements in Projection Writing



Scattering with Angular limitation in projection electron beam lithography (SCALPEL)



Projection reduction exposure with variable axis immersion lenses (PREVAIL)

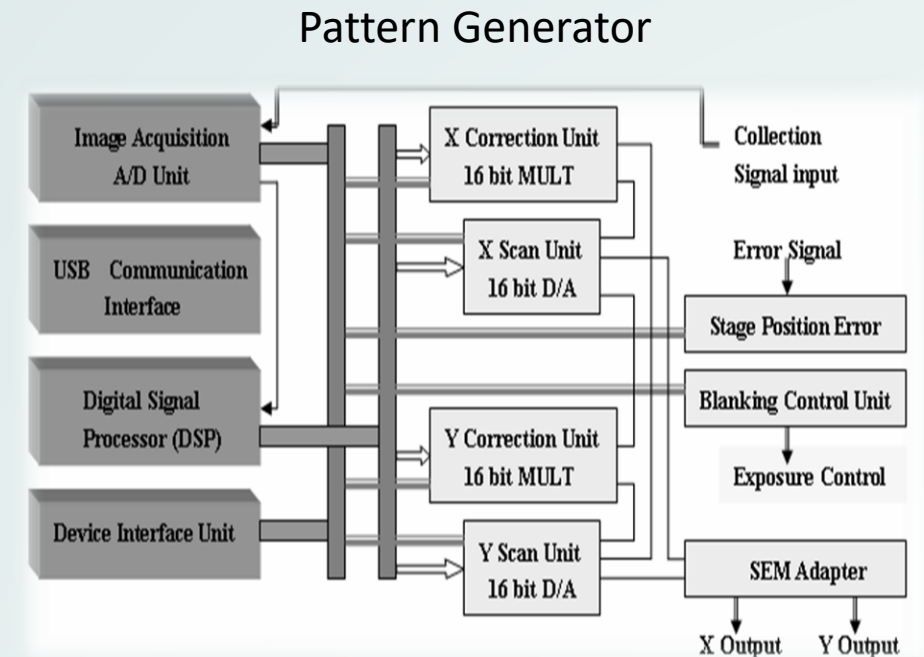
# Modified SEM's

What is SEM ?

How does it work ?

How is it used in EBL ?

Advantages ?



Block Diagram of typical Pattern Generator

\*Flexible Nanofabrication Equipment: E-beam Lithography System Based on SEM - Shuhua Wei, Lan Dai, Jing Zhang ( Education Purposes only)

# Improvements in Direct Writing and Lift-off Process

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## Direct Writing :

- Gaussian Beam to Variable Shaped Beam

## Lift-Off Process:

- What ?
- How ?



New Improvement ?



# Some of the Recent Developments

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Electron  
Sources

Nano  
Patterns

Organic and  
CA Resists

# Electron Sources and its Recent Developments

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Multi Column EBL

Proximity Effect ?.

\*Hiroshi Yasuda, Takeshi Haraguchi,  
Akio Yamada, A proposal of MCC  
(Multi-Column Cell with Lotus Root  
Lens) system to use as a mask  
making e-beam tool, Proc. of SPIE  
vol.5567

Filaments

Tungsten

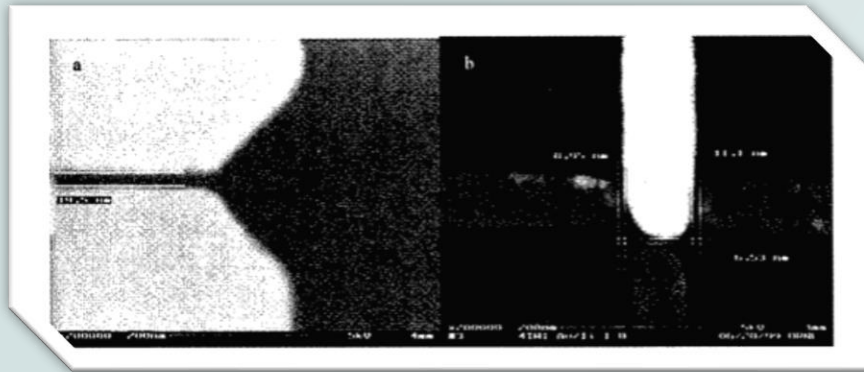
LaB<sub>6</sub>

Tungsten with coating of Zirconium Oxide

# Nano Patterns

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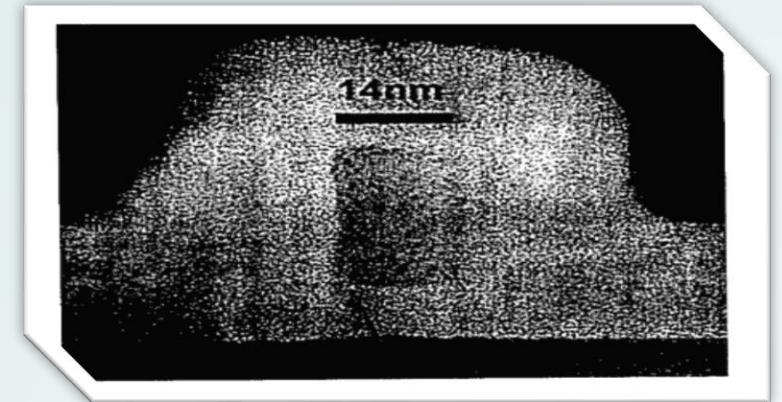
- Contacts



Two Electrodes consisting of two different metals with 20nm Gap

\*Direct-Write Electron Beam Lithography: History and State of the Art -Dustin W. Carr and Richard C. Tiberio ( Education Purposes only)

- Shallow Junctions in MOSFETS



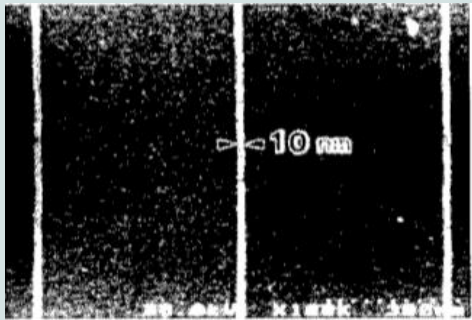
TEM Cross-Section of 14nm Gate Fabricated with E-beam

\*Nanostructure Fabrication Using Electron Beam by Shinji Matsui ( Education Purposes only)

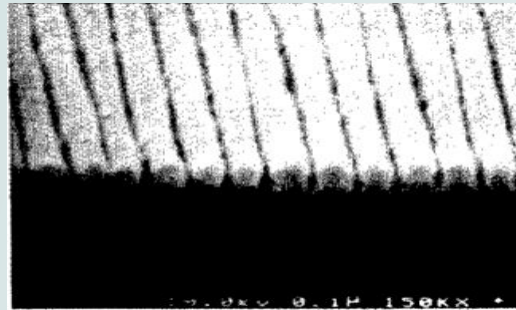
# Organic and CA Resists

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## Organic Resists

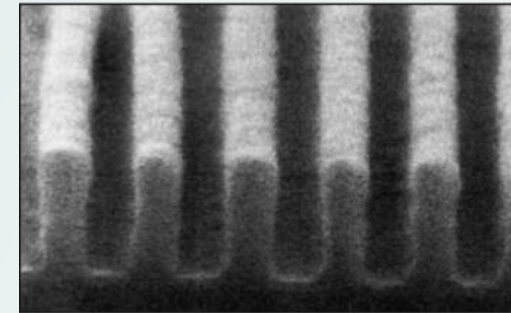


10nm Calixarene Patterns



10nm Patterns on ZEP Resists

## Chemically Amplified Resists



55nm Equal Lines and Spaces

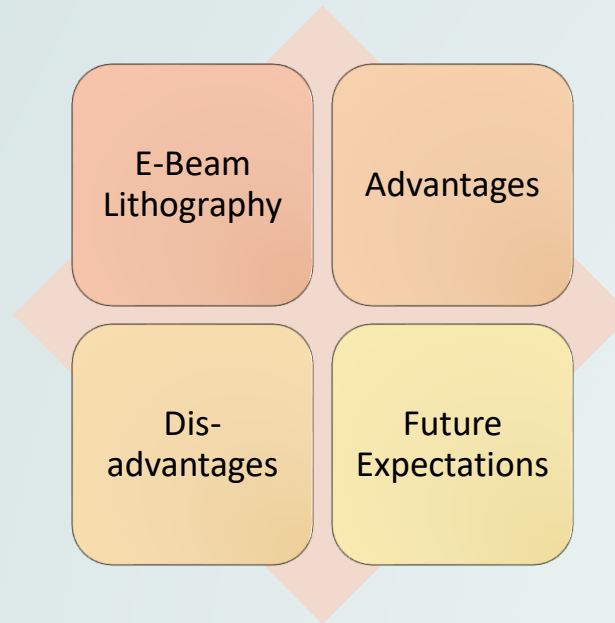
- Materials Issues and Modeling for Device Nanofabrication, Symposium (1999)  
( Education Purposes only)

\* D.R. Medeiros et, al., Recent Progress in Electron beam Resists for advanced mask-making, IBM J RES & DEV, vol 45, September 2001 ( Education Purposes only)

# Conclusion

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## 30 Seconds Summery



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- [5] Dustin W. Carr and Richard C.Tiberio , Direct-write Electron beam lithography : History and state of the Art, Chapter from Materials Issues and Modeling for Device Nanofabrication, Symposium (1999)
- [6] Kevin Scott, Fabrication and Characterization of Magnetic Nanostructures, Graduate thesis and Dissertations, University of south Florida., (2014)
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- [11] S. D. Berger and J. M. Gibson, "New approach to projection electron lithography with demonstrated 0.1micron linewidth," Appl. Phys. Lett., vol. 57, pp. 153– 155, 1999

THE END

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- Thankyou -

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