EE669: VLSI Technology

Chemical Vapor Deposition and Atomic Layer Deposition

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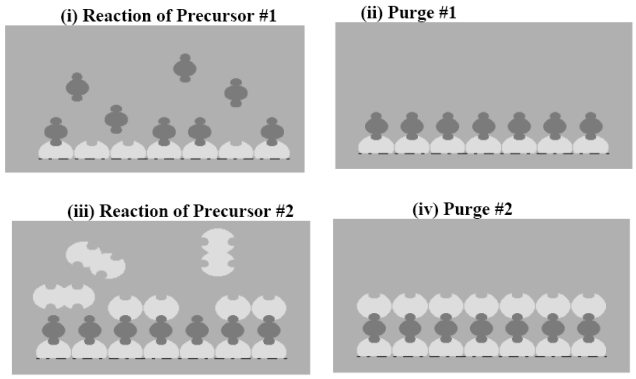
ALD cycle: ideal scenario



Jill Becker, Ph. D. thesis, MIT, 2002

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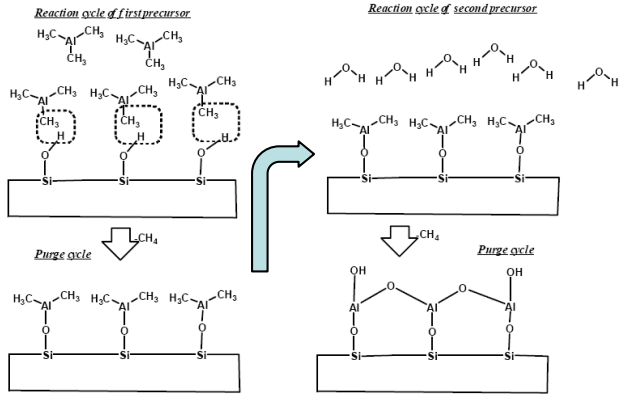
ALD cycle: Al_2O_3 example



Courtesy: Dr. Mrinalini, CEN, IIT-B

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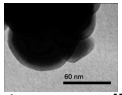
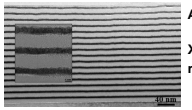
ALD cycle: ideal scenario (2)

- The reactions could be activated thermally (thermal ALD) or by plasma or by both (PE-ALD)
- Reactions 1 and 2 are surface limited and saturating, and hence self limiting
  - Excellent control over thickness (monolayer by monolayer)
  - Film uniformity
  - Excellent conformality (step coverage)
    - Full coverage of surfaces on 3D structures possible
  - Sharp interfaces between materials
  - Processing of nano-laminates
  - Easy to scale up
  - But slow deposition rate



ZrO_2 nano particles coated with Al_2O_3



Al_2O_3/W

X-ray reflectivity

S. M. George, Atomic Layer Deposition: An Overview, Chemical Reviews 2010.

Jill Becker, Ph. D. thesis, MIT, 2002

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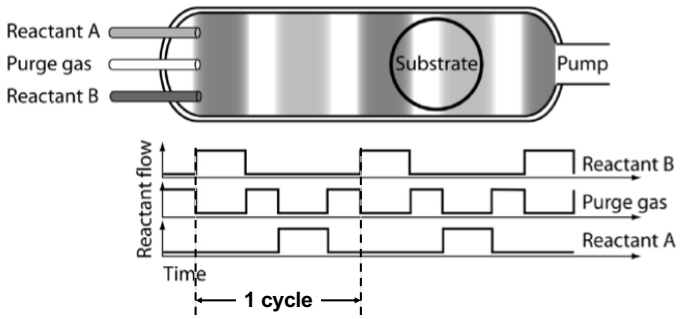
ALD System: Schematic



Angus Rockett, "Material Science of Semiconductors", Springer Verlag, 2008

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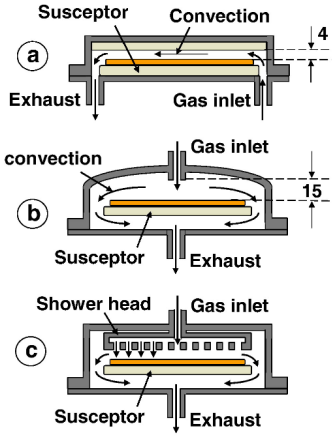
Single wafer ALD: Designs



Granneman, et al (ASM); Surface & Coatings Technology 201 (2007)

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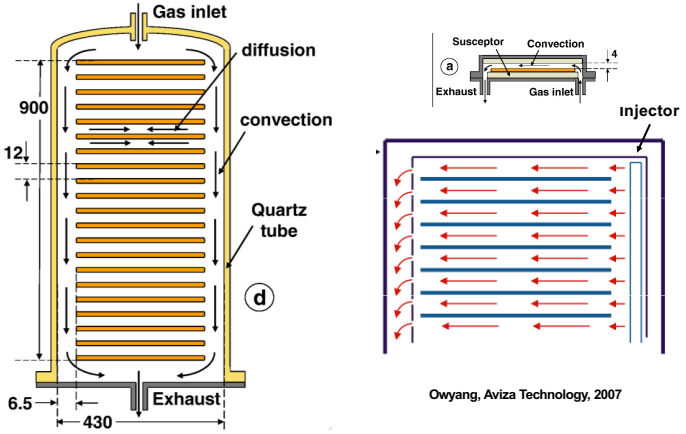
Batch ALD: Designs



Owyang, Aviza Technology, 2007

Granneman, et al (ASM); Surface & Coatings Technology 201 (2007)

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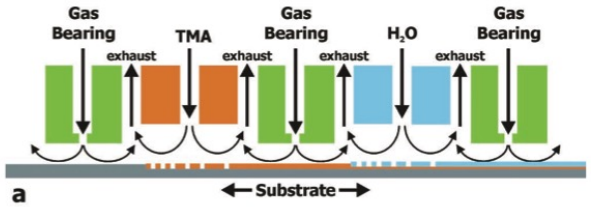
Batch ALD designs (2)



Poodt et al., Advanced Materials, vol. 22, p. 3564, 2010

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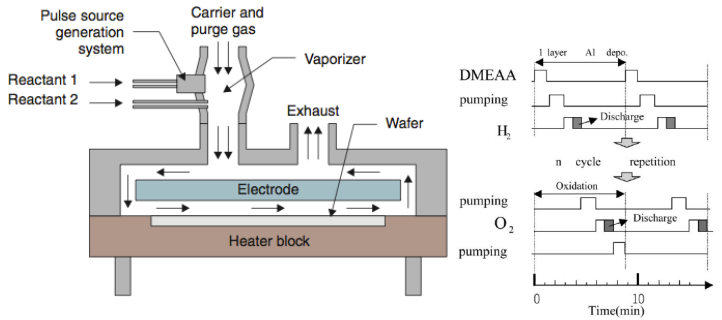
Plasma Enhanced ALD

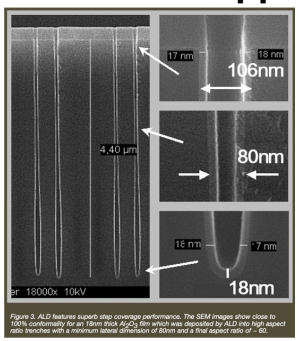


IC Knowledge LLC, 2004

Chang-Wook Jeong, et al; Materials Science and Engineering © 16(2001)59–64

DMEAA: dimethylethylamine alane [AlH3N(CH3)2(C2H5)

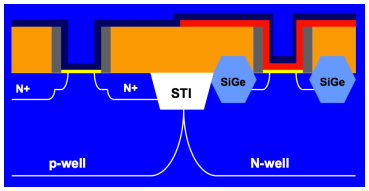
ALD: Applications



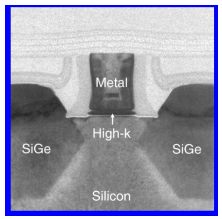
W. Gutsche et al., Atomic Layer Deposition of rAdvanced DRAM Applications, Future Fab International 2003.

- DRAM trench capacitor
  - high aspect ratio trenches and hence conformal deposition is critical
  - Low temperature process is important for transistor scaling

ALD: Applications (2)



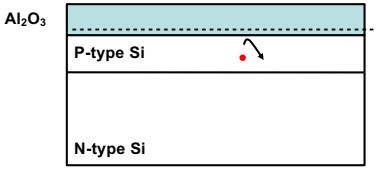
K. Mistry et al., IEDM 2007



- High-k/metal gate integration in CMOS Technology
  - High-k => low levels of contamination, low temperature process
  - Metal gate => conformal deposition, low temperature process

ALD: Applications (3)

- Passivation of crystalline Si solar cells fabricated on n-type substrates using Al_2O_3 is an application for ALD



- Electrons diffusing to the top of the p-type region would be repelled by the negative charges in the Al_2O_3