Low-pressure CVD and Plasma-Enhanced CVD

CVD overview

- “Chemical Vapor Deposition”
- Thin films on substrate
- Chemical oven + insert gas = deposited film

CVD overview

- Four steps[1]:
  1. Transport gas species to surface
  2. Gas species absorption into surface
  3. Reaction deposits products
  4. Remove unwanted products and leftover reactant

CVD overview

- Velocity ratio (molecules/s, not meters/s!):
  - Mass transport velocity
    - Depends on pressure
  - Surface reaction velocity
    - Does not depend on pressure
- Low ratio -> pure; well-controlled thickness
- High ratio -> contaminants; poorly-controlled thickness

CVD overview

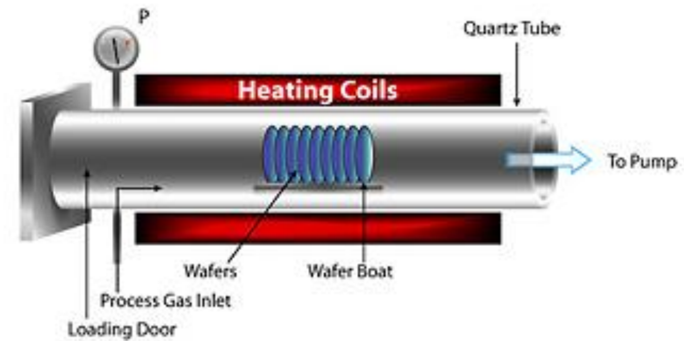
- Atmospheric-pressure CVD (APCVD) velocity ratio too high: ~1:1
- Mass transport velocity proportional to 1/pressure[2]
- 1 atm ~= 100 kPa

LPCVD

- LPCVD typical pressure: 10-1000 Pa
- Ratio 1:100–1:10,000!
- Reduced film variation
- Increased purity

LPCVD

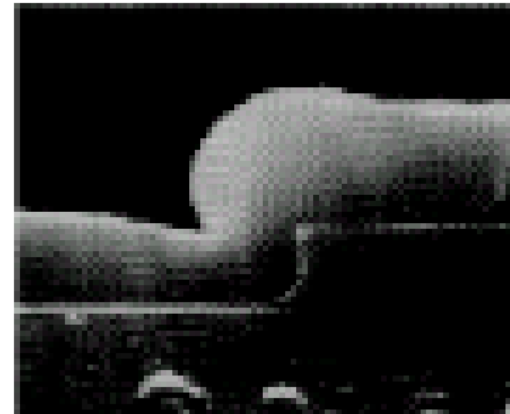
- Substrate inserted
- Tube evacuated to 0.1 Pa
- Process gas ("working gas") added at 10-1000 Pa
- Reaction performed
- Substrate removed



Source: [3]

LPCVD

- Best for polysilicon, using SiH_4
- Oxides, PSG as well
- Nitride encapsulation



Source: [4]

LPCVD

Advantages:

- Excellent uniformity of thickness & purity
- Simple
- Reliable/reproducible
- Homogenous layer

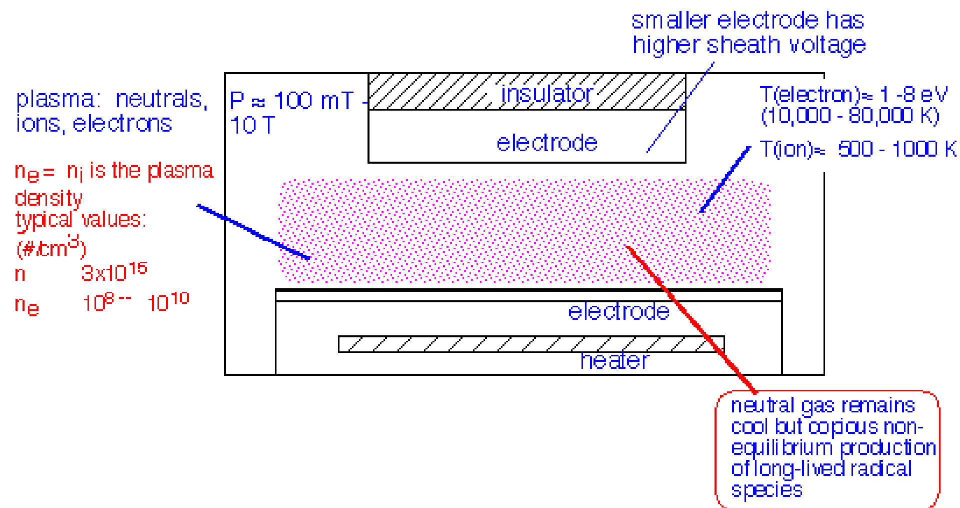
Disadvantages:

- Slows down deposition rate
- Requires high temperatures, <600°C

PECVD

- Plasma added with reactive gases
- RF voltage excites plasma
- Only electrons are hot, not ions: low temperatures possible

PECVD



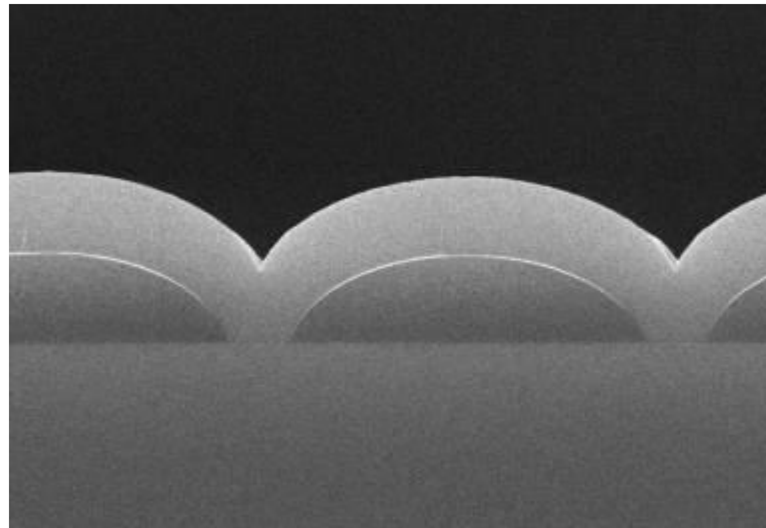
Picture: http://timedomaincvd.com/CVD_Fundamentals/plasmas/capacitive_plasma.html

Film	Reactive Gas	Thermal Deposition CVD (Celsius)	Plasma Enhanced CVD (Celsius)
Silicon Nitride	SIH4 or S1H2C12 & NH3	750	200-500
Silicon dioxide	SiH4 & O2	350-550	200-400
Amorphous silicon	SiH441	550-650	200-400

Table: http://www.eng.auburn.edu/~tzengy/ELEC7730/ELEC%207730%20Fall%202003/Fall%202003%20Presentation%201/Park%20-%20PECVD.ppt

PECVD

Conformal step coverage of PECVD Si_xN_y



http://www.hitech-projects.com/dts/docs/pecvd.htm

PECVD

Advantages	Disadvantages
• Low temperature • Higher film density • Higher dielectric constant • Good step coverage • Chamber easy to clean	• Equipment is expensive • Plasma bombardment is stressful • Small batch sizes: 1-4 wafers, one side • Compare to LPCVD: at least 25 wafers, both sides[5]

Questions?

References:

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[6] "Plasma-Enhanced CVD." Hitech-Projects. 2011. 28 Nov. 2011 <http://www.hitech-projects.com/dts/docs/pecvd.htm>.

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[9] "Fundamentals of Chemical Vapor Deposition – Plasmas for CVD." TimeDomain CVD, Inc. 2002. 29 Nov. 2011.<http://timedomaincvd.com/CVD_Fundamentals/plasmas/plasma_deposition.html>.