SiC Growth by PVT Method

Ming Ruan

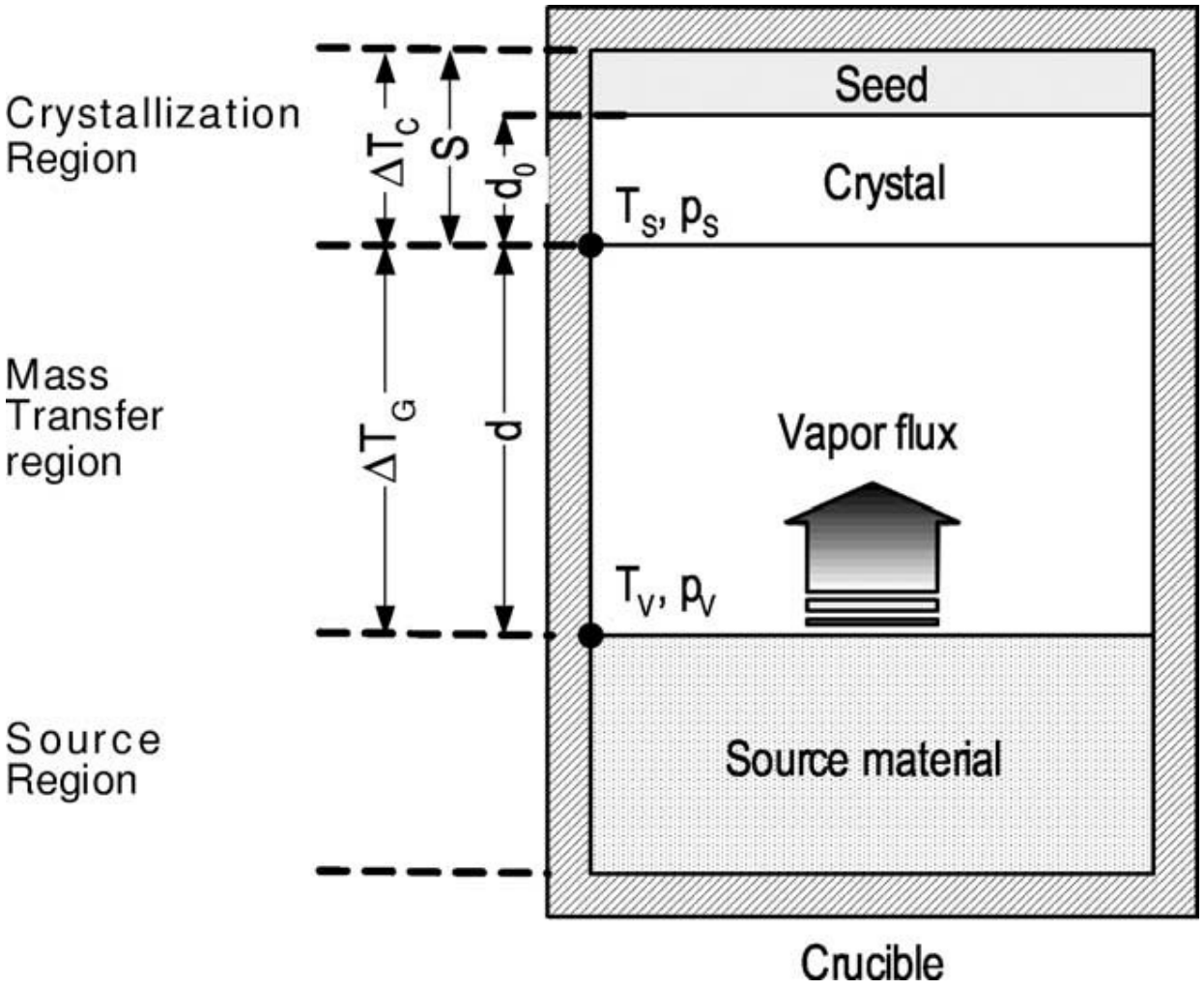
School of Physics

2008.12.02

Why SiC

- Advantage:
  - High Voltage: MV/cm breakdown field
  - High Thermal Conductivity 4.9w/cm*k
  - Large Band Gap: 3ev
  - High Electron Drift Velocity: 2e7 cm/s
  - Chemical Stability
- BUT
  - No liquid state at regular pressure
  - About 150 polytypes
  - Defect formation

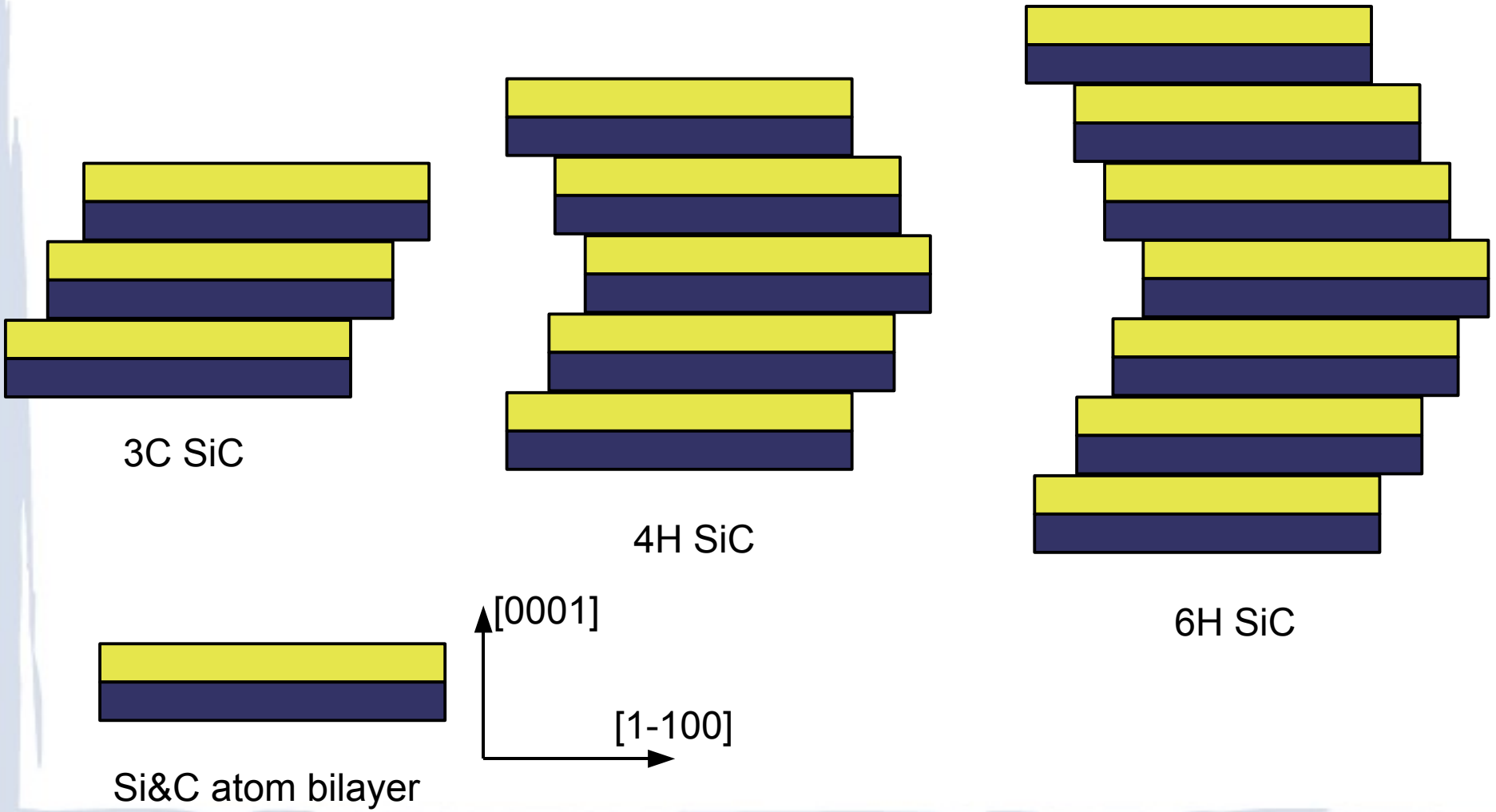
Solution: Physical Vapor Transfer(PVT)



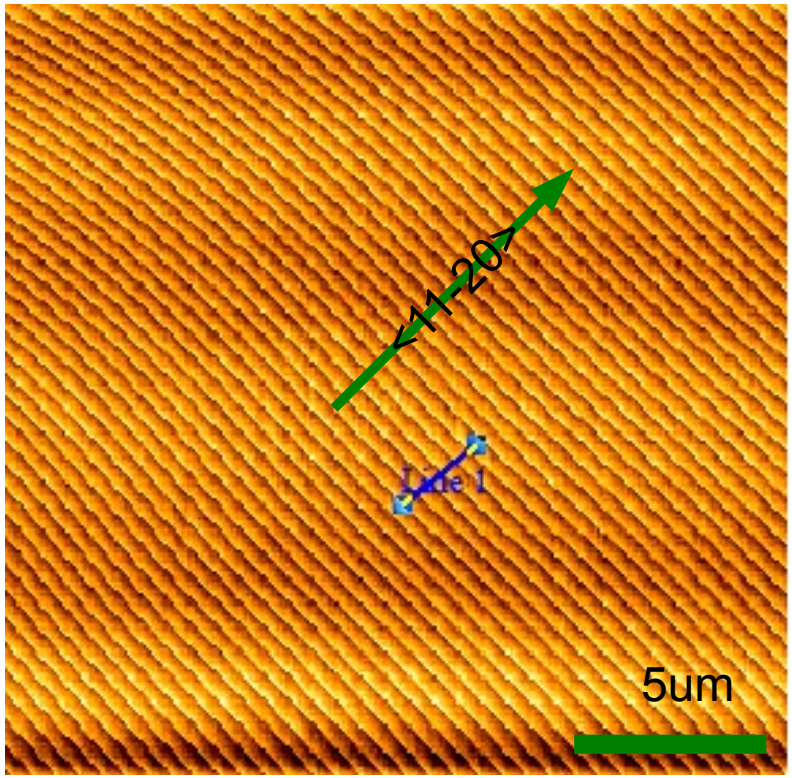
Temperature	2000-2200C
Pressure	1-400torr
Growth rate	100-500um/h
Separation	1-10mm
Temp. Diff.	1-10C

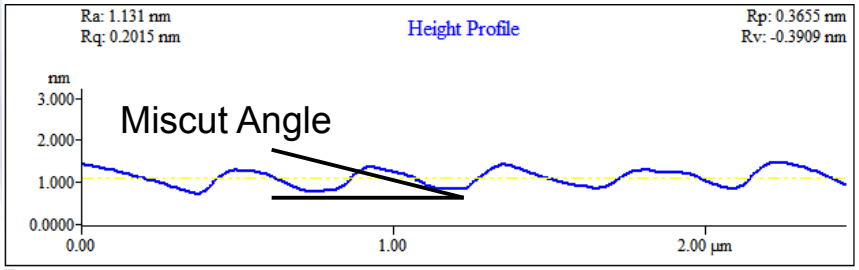
Picture from: T.S. Sudarshan et.al: Microelectronic Engineering 83 (2006) 155–159

SiC Polytypes

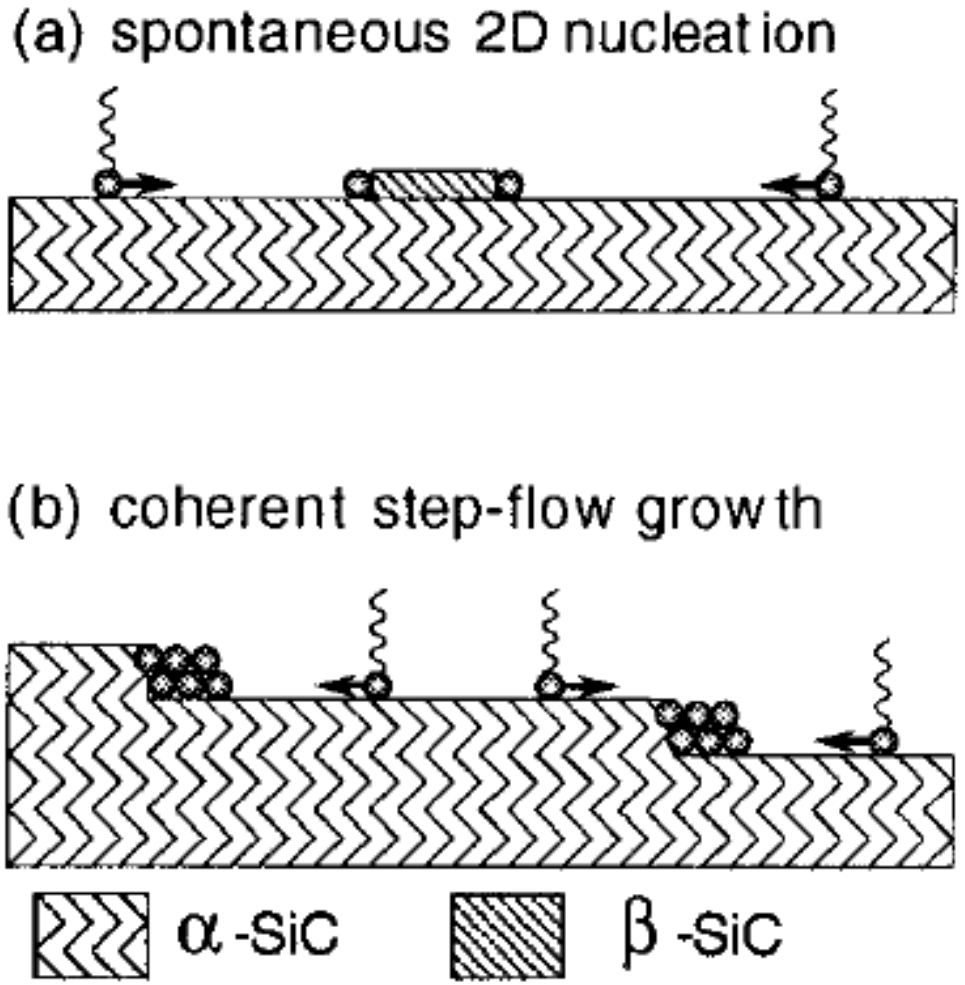


Seed: Step Flow Growth



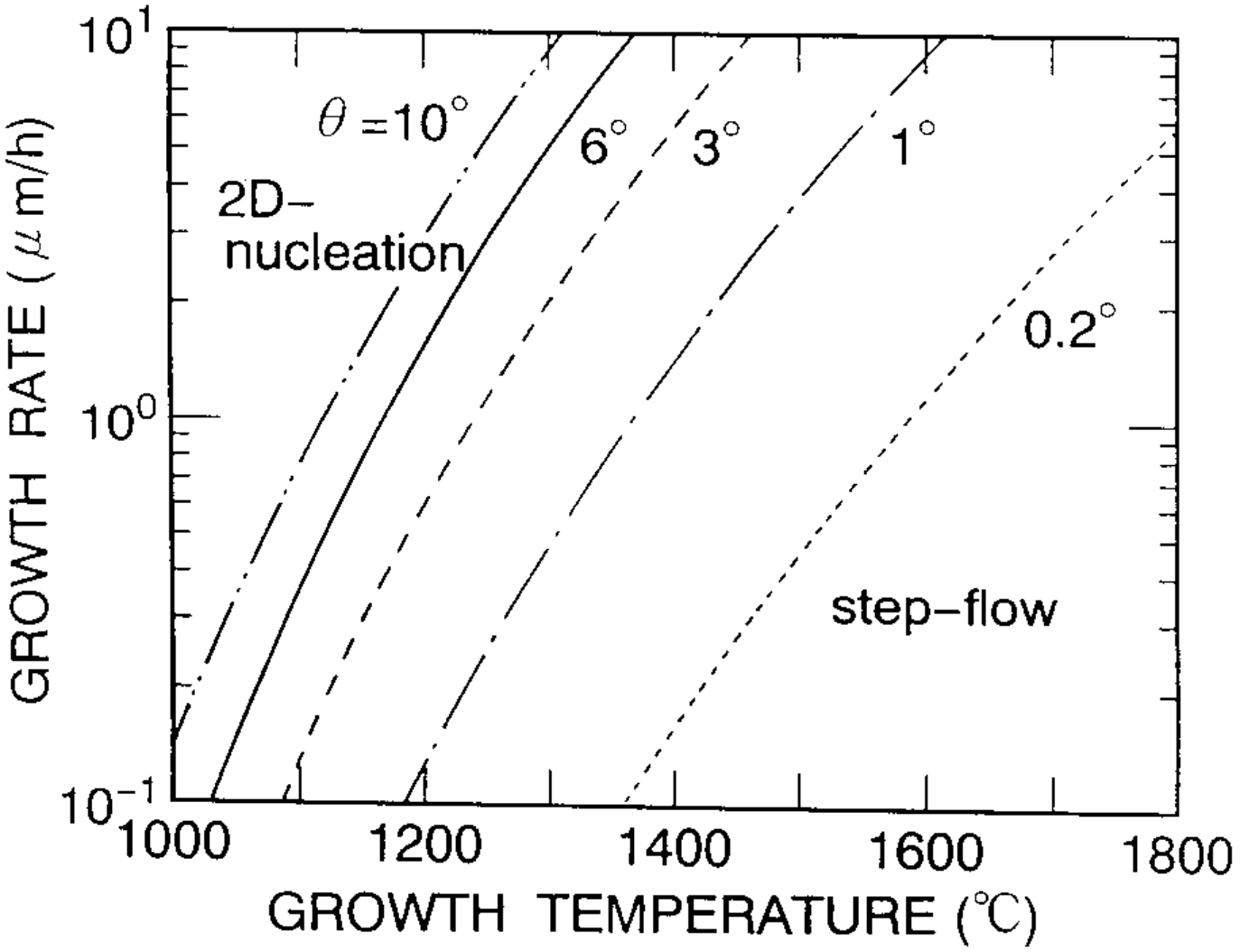


(000-1) face cut toward <11-20>
H_2 etching at 1600C for 30min



Above Image from A.O. Konstantinov et.al
J. Appl. Phys. 80 (10), 15 Nov 1996

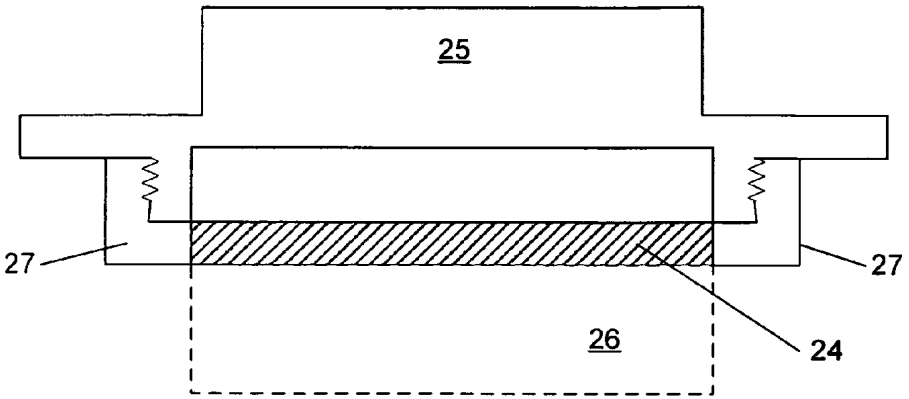
Seed: Step Flow Growth



From T. Kimoto et.al Phys. Sta. Sol(b) 202, 247(1997)

Seed: Holder

- Conductive, not radiation, dominate heat transfer.
- No warp nor bow on wafer
- Distance between holder and less than 10um.
- Holder made of resin mixed graphite to match thermal expansion with seed.
- Edge ring seed cap to minimum mechanical force on seed.
- Eliminate crystal defect developed from seed/holder edge.



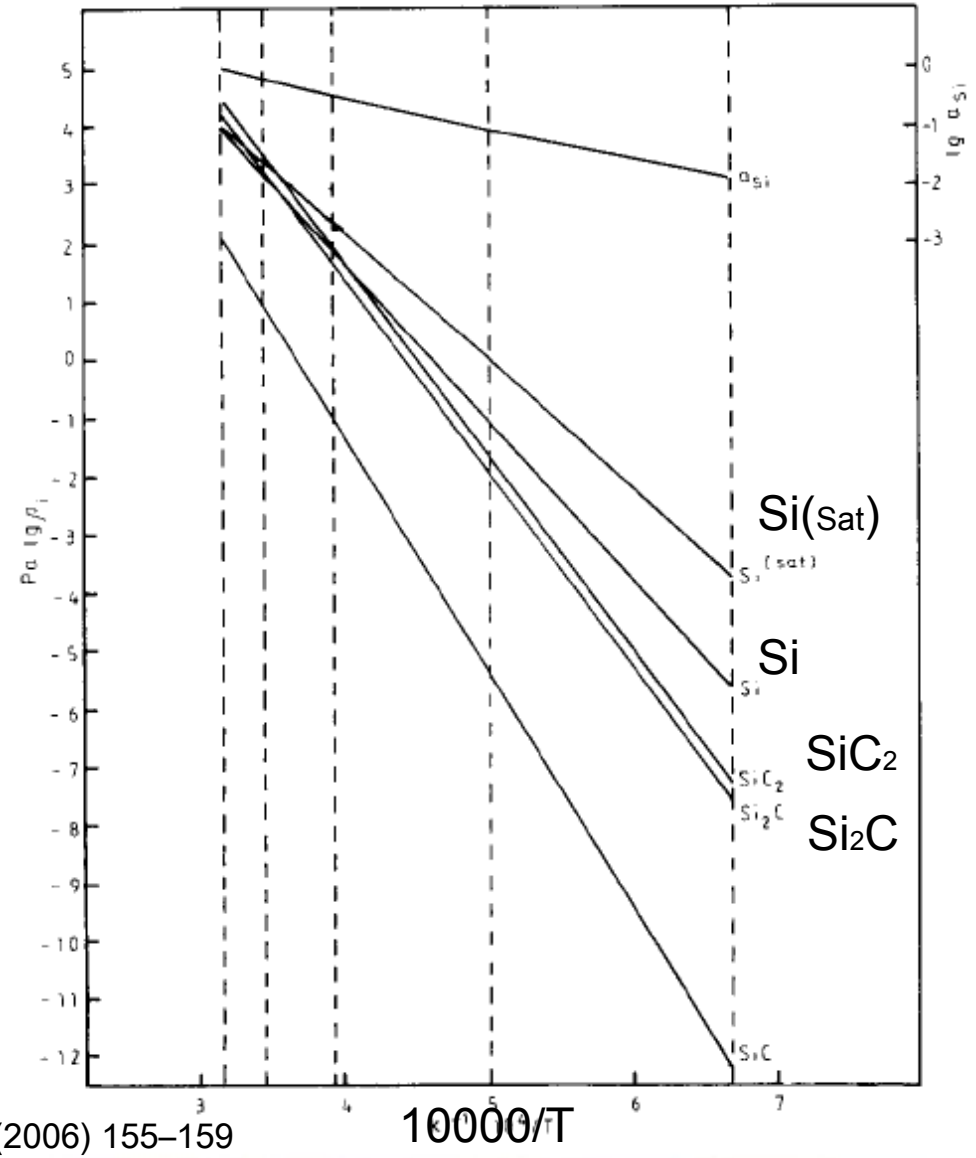
Picture from
US Patent 7316747 by Cree Inc.

Vapor Transfer

- Major component
  - Si
  - SiC2&Si2C
- Mass flux: F

$$F = \frac{D}{d \cdot k \cdot T} \cdot (Pv - Ps) \quad [1]$$

- Ar is used as on/off switch

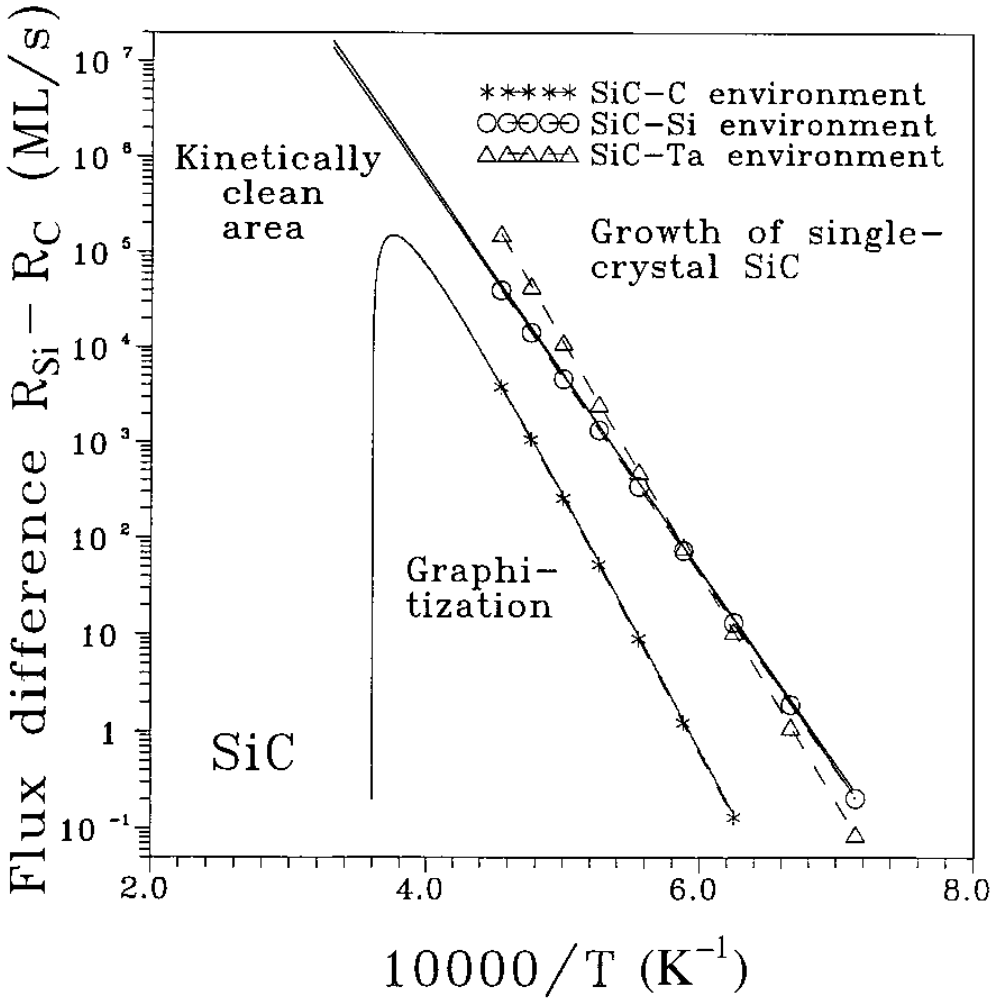


[1] T.S. Sudarshan et.al: Microelectronic Engineering 83 (2006) 155–159

Picture from: Lilov et.al Mat. Sci. Eng. B21(1993)65-69

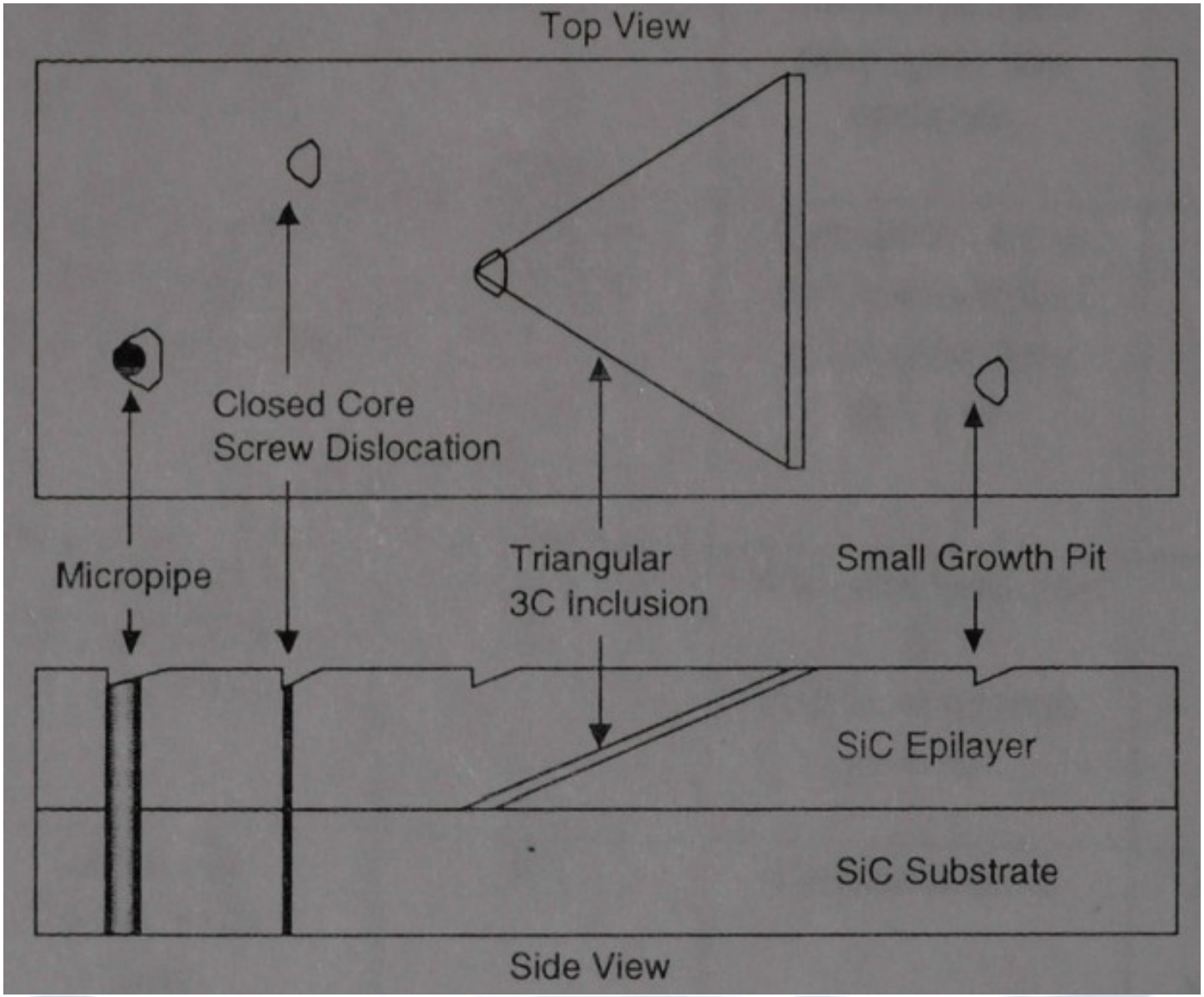
Source: Si/C ratio

- Si/C ratio matters
  - graphitization/silicon droplet formation
- Method to prevent both C and Si inclusion: Tantalum
  - Ta absorb C to form TaC
  - 1mm Ta foil is enough for hours of growth
  - Pretreat of Ta is require to prevent Ta inclusion on grown SiC.



Yu.A. Vodakov et.al Phys. Stat. Sol(b)202,177(1997)

Major Defect Forms



Picture from: P. Neudeck, Mater. Sci. Forum 338–342 (2000) 1161