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CHE323/CHE384
Chemical Processes for Micro- and Nanofabrication
www.lithoguru.com/scientist/CHE323

Lecture 18
Ion Implantation, part 3

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Reading:
Chapter 5, *Fabrication Engineering at the Micro- and Nanoscale*, 4th edition, Campbell

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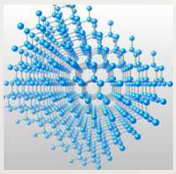
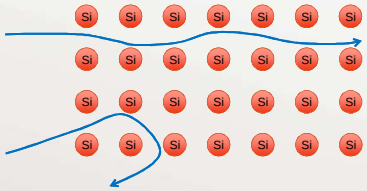
Channeling

- If the incoming beam is aligned with a crystallographic axis, channeling can occur



Source: www.powerguru.org/doping-silicon-wafers



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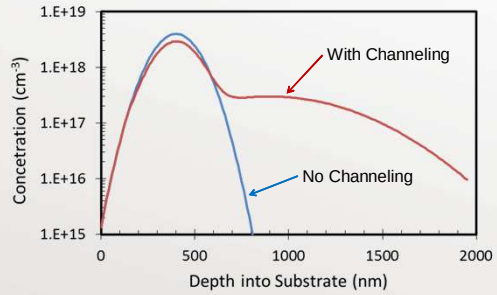
Channeling



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To Reduce Channeling

- Ion implantation at an angle can essentially eliminate channeling
- The critical angle at which channeling begins:

$$\psi \approx 9.73^\circ \sqrt{\frac{Z_i Z_t}{Ed}}$$

i = ion, t = target
d = atomic spacing

- Typically, 7° is used, which works well for everything except very low energy Boron

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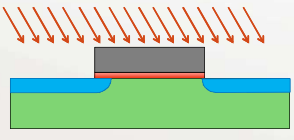
Shadowing

- A consequence of angle implantation is shadowing



- Solutions
  - Use ±7° implants, both left/right and top/bottom
  - Rotate the wafer

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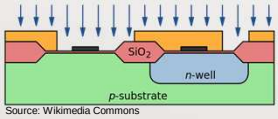
Implant Masking

- Selective doping requires the use of implant masks
  - The gate acts as a mask for source/drain implants (which are thus self-aligned)
  - Photoresist and field oxides are often used
  - Typical rule of thumb: the mask must be thick enough to stop 99.99% of the ions from penetrating



Source: Wikimedia Commons

Implant Damage

- Above a certain dose, ion implantation leaves the substrate amorphous
- To regrow the crystal and activate the dopant, an anneal step is used
  - If the temperature/time is too low, defects remain in the crystal (up to 1000ºC is required)
  - If the temperature/time is too high, too much diffusion occurs
  - Best compromise requires the use of Rapid Thermal Annealing (RTA)
- Note that ion implantation allows dopant concentrations above the solid solubility limit

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Lecture 18: What have we learned?

- How and why does channeling occur?
- What is the most common remedy for channeling?
- Explain shadowing and how it is mitigated
- What is required of an implant mask?
- How is implant damage repaired?

