# Silicon wafer shaping

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# Silicon Wafer shaping

- After the single crystal is obtained, this needs to be further processed to produce the wafers. For this, the wafers need to be shaped and cut. Usually,industrial grade diamond tipped saws are used for this process.
- The shaping operations consist of two steps
  - 1. The seed and tang ends of the ingot are removed.
  - 2. The surface of the ingot is ground to get an uniform diameter across the length of the ingot.

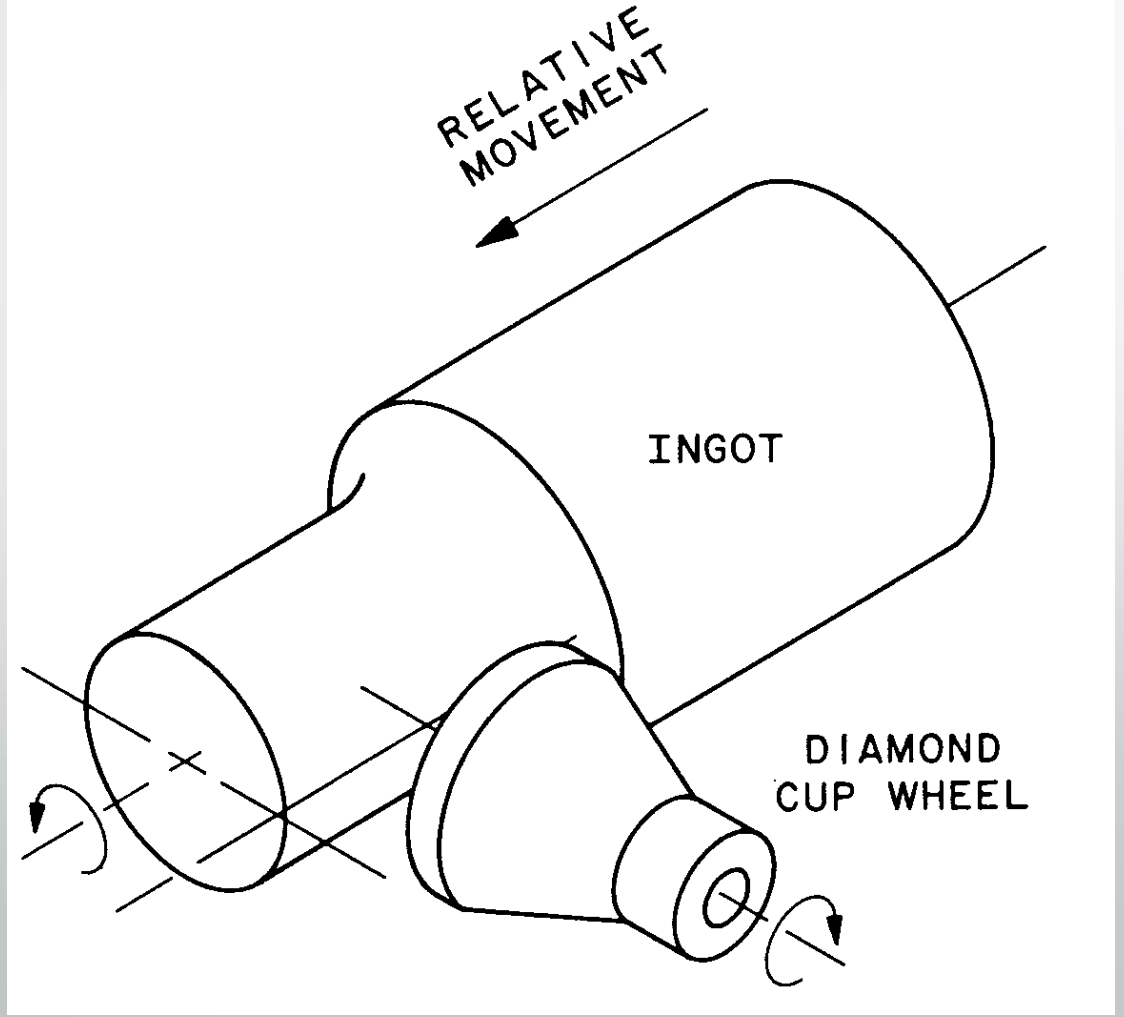
# Silicon Wafer shaping

- The first step of silicon shaping operation is the removal of seed and tang end using a circular saw.
- Before further processing, the ingots are checked for resistivity and orientation. Resistivity is checked by a four point probe technique and can be used to confirm the dopant concentration. This is usually done along the length of the ingot to ensure uniformity. Orientation is measured by x-ray diffraction at the ends (after grinding).

# Silicon Wafer shaping

- At the time of crystal growth, the growing process is not uniform.So there is variation in diameter along the ingot length. This is because of the inability to control the growth rate properly.
- So these oversized ingots (at some point) have to be grinded on the surface so has to have uniform diameter throughout the ingot surface.
- A lathe machine tool is used to grind the ingot using a rotating diamond grinding tool.The machine tools move along the ingot surface and grind the ingot to the required diameter.
- Surface orientation is usally checked after the grinding.

# Silicon Wafer shaping



# Silicon Wafer shaping

- After the orientation and resistivity checks, one or more flats are ground along the length of the ingot.
- There are two types of flats.
- 1. Primary flat - this is ground relative to a specific crystal direction.This acts as a visual reference to the orientation of the wafer.
- 2. Secondary at - this used for identification of the wafer, dopant type and orientation.

# Silicon Wafer shaping

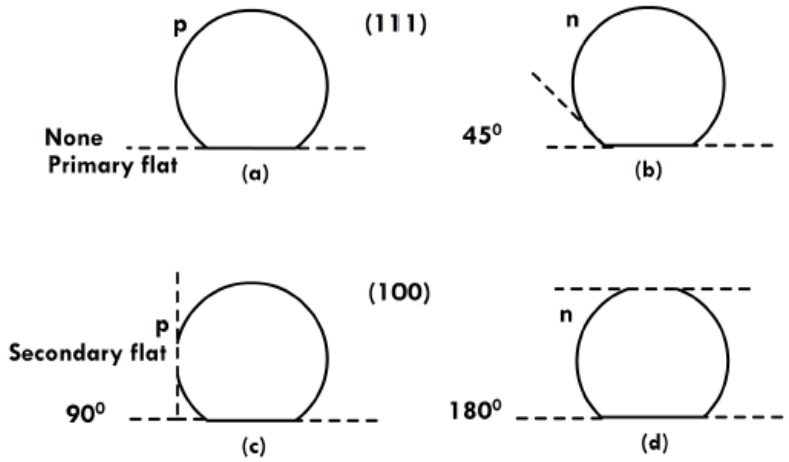


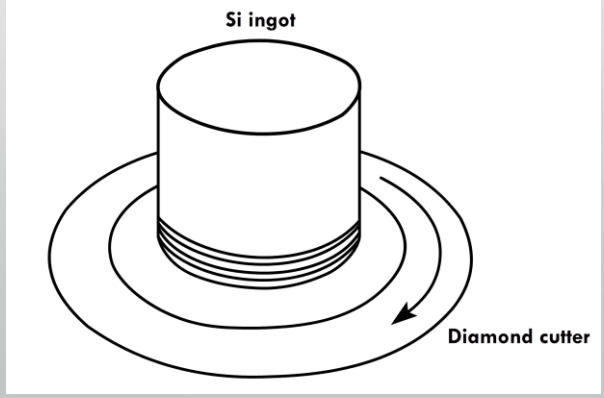

Figure 7: Flats for the different wafer types and orientations. All orientations and doping types have a primary flat, while there are different secondary flats for different types (a) p(111) (b) n(111) (c) p(100) and (d) n(100). Adapted from *Microchip fabrication - Peter van Zant.*

Table 4: Specs of a typical 150 mm wafer

| Specs | Value |
|---|---|
| Diameter | $150 \pm 0.5$ mm |
| Thickness | $675 \pm 25\ \mu m$ |
| Orientation | $100 \pm 1^{\circ}$ |
| Bow | $60\ \mu m$ |
| $\Delta t$ | $50\ \mu m$ |
| Primary flat | 55-60 $mm$ |
| Secondary flat | 35-40 $mm$ |

# Silicon Wafer shaping

- After making the flats, the individual wafers are sliced per the required thick-ess. Inner diameter (ID) slicing is the most commonly used technique. The cutting edge is located on the inside of the blade, as seen in fig. Larger wafers are usually thicker, for mechanical integrity.



# Edge Profiling

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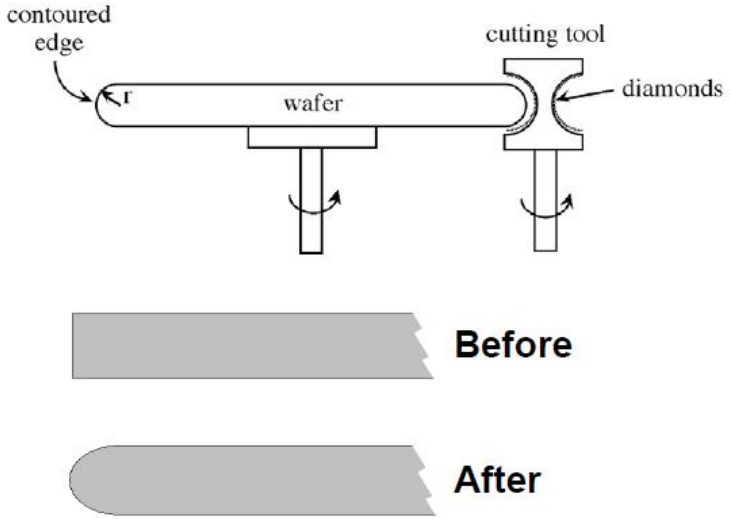
Purpose

- Produce a rounded wafer edge that is tougher and more resistant to chipping during handling
- Minimize edge surface roughness
- Minimize depth of damage on edge

# Wafer Etching and Polishing

- After cutting, the wafers are chemically etched to remove any damaged and contaminated regions.
- Chemical etching of wafer is basically of two type
  - Acid etching
  - Alkali etching
- Acid etching is usually done in an acid bath with a mixture of hydrofluoric acid, nitric acid, and acetic acid in the ratio of4:1:3.
- This is batch process, ivovling ten of wafers. Etching is an oxidation-reduction process.
- In acid etching the dimensional uniformity is not maintained for larger wafer, so alkali etching is preferred for larger wafers.
- The hydrodynamics of rotating a larger wafer in solution do not allowed for uniform boundry layer, so a taper is introduced in wafer.

# Wafer Etching and Polishing

- In alkali etching a mixture of sodium hydroxide and water or potassium hydroxide and water is used.
- Alkali etching is limited by reaction rate and is orientation dpendent and in this wafer do not have to be rotate in the solution .

# Wafer Etching and Polishing

- After etching, the surfaces are polished, first a rough abrasive polish, followed by a chemical mechanical polishing (CMP) procedure.
- In CMP, a slurry of fine $SiO_2$ particles suspended in aqueous NaOH solution is used. The pad is usually a polyester material. Polishing happens both due to mechanical abrasion and also reaction of the silicon with the NaOH solution.
- Wafers are typically single side or double side polished.
- Large wafers are usually double side polished so that the backside of the wafers can be used for patterning.

# Wafer Etching and Polishing

- But wafer handling for double side polished wafers should be carefully controlled to avoid scratches on the backside.
- Typical 300 mm wafers used for IC manufacture are handled by robot arms and these are made of ceramics to minimize scratches.
- Smaller wafers (3" and 4" wafers) used in labs are usually single side polished.

# Lapping, Etching and Polishing

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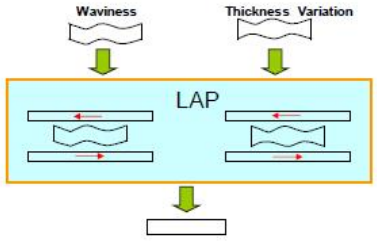
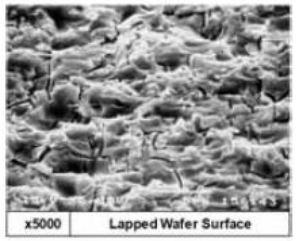
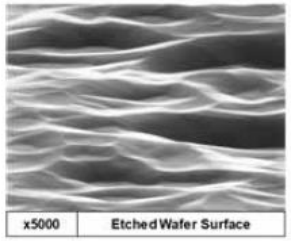
Lapping removes saw damage and produce a flat wafer. Etching and chemical mechanical polishing processes further improve the surface to almost atomically smooth.




Mechanical damage




Damage removed
Flat but not smooth