INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

CLASS TEST / LABORATORY TEST

Signature of the Invigilator

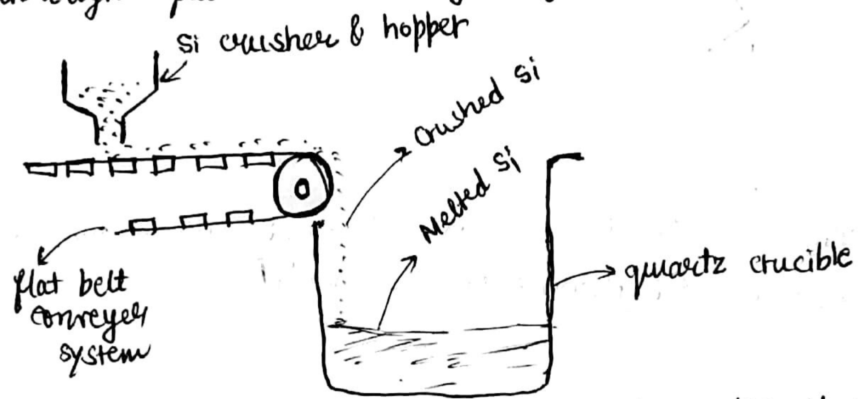
EXAMINATION (Mid-Semester / End-Semester)

SEMESTER (Autumn / Spring)

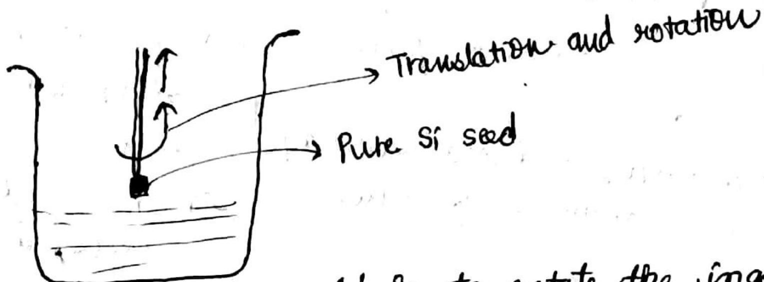
Roll Number	1 4 M E 0 0 0 0 0	Section		Name	FELIX KJELLBERG
Subject Number	M E 6 0 0 0 6 —	Subject Name			ELECTRONIC PKG. & MFG.

Q1 To make the Czochralski's bulk crystal growth process a continuous process, we would use the following method which is analogous to continuous ingot casting used in manufacturing science:

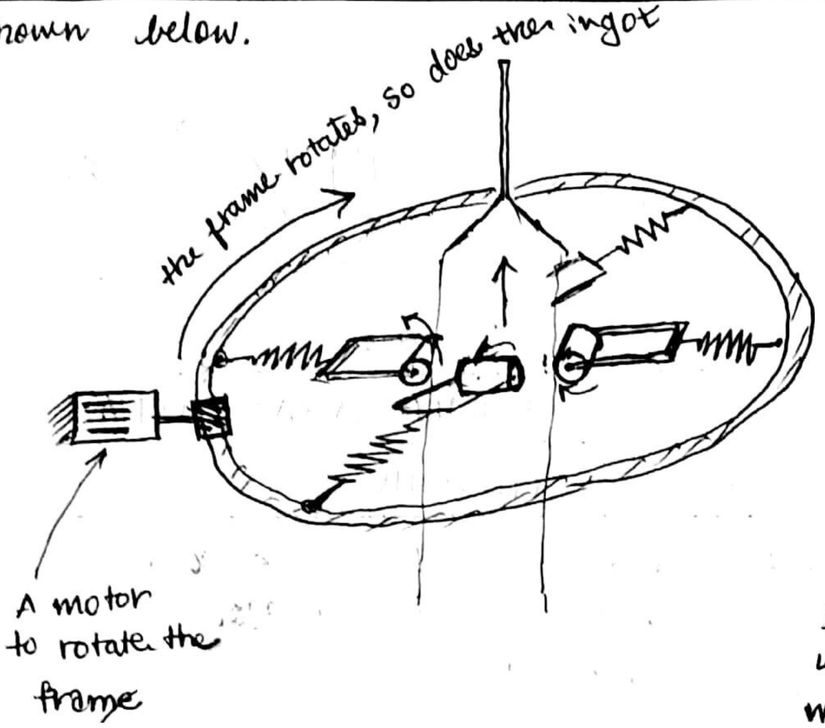
Step 1 : In the original Czochralski's process, the powdered silicon was put in a quartz crucible and was melted. To make this a continuous process, we have to use some mechanism that constantly supplies crushed silicon in the crucible. We can use a process similar to one used to supply pulverised coal in power plants, that is through flat-belt conveyer system.



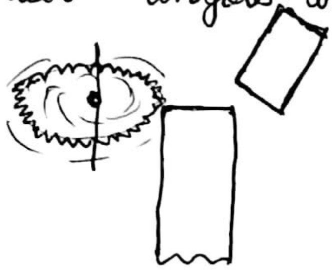
Step 2 ; To initiate the silicon ingot formation process, we would use the same method as the original Czochralski's process of initiating the ingot formation by introducing a pure Si crystal seed. We would dip that seed into that melt and start pulling it up with rotation



Step 3 : Perhaps the most difficult step would be to rotate the ingot and pull it up continuously. The Translation can be easily done, but the rotation causes a challenge. A proposed mechanism is shown below.



Step 4 A precise laser cutter or mechanical cutter to chop off the continuous ingots into required cylinders at the top.



Step 5 Once we combine them all, we can get our continuous Czochralski bulk crystal growth process (Voila!)

Advantages

(+) Pretty obvious, increased manufacturing yields.

(+) We would not be requiring the pure Si seed crystal every time.

(+) More automation, reduced average fixed costs, economies of scale

Disadvantages

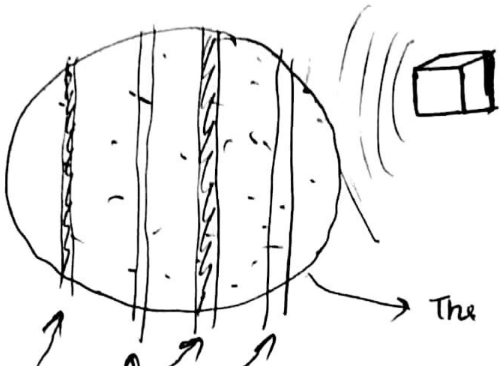
(−) More mechanical, hence more reliability and maintenance issues.

(−) To obtain a uniform ingot diameter, more sensors and electronics would be involved.

(−) Increased average variable costs, increased investment.

Q2 Since the soldering process takes place in the solder reflow oven, we would use the concept of a similar and much common other oven, <u>the microwave oven</u> (that cooks our food)

If in a microwave oven, we stop the rotation of the container in which food is kept and operate the oven, we would find interesting patterns of spots where the food is overcooked and where it isn't cooked at all.

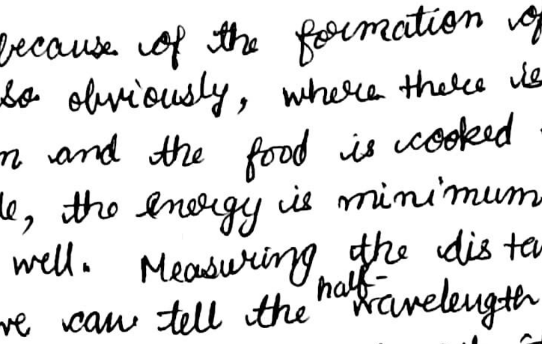


good thinking!

Use Wien's Law
$\lambda T = const.$

This happens because of the formation of standing waves in a microwave. So obviously, where there is a anti-node, the energy (amplitude) is maximum and the food is cooked way better and where there is a node, the energy is minimum (almost zero) and food isn't cooked very well. Measuring the distance between two adjacent cooked spots, we can tell the half-wavelength of microwave to be around 6 cm, which matches pretty well with its 2.4 GHZ frequency

Building on the same principle, to determine the frequency of the IR waves used, we would measure the distance between the adjacent solder bumps and will try to adjust the frequency in such a way that the half-wavelength of the wave matches this distance.



$\therefore c = \lambda f$

where $\lambda = 2d$

$$\Rightarrow \boxed{f = \frac{c}{2d}}$$

c → speed of light
f → frequency of IR source
λ → wavelength of standing wave
d → distance b/w solder bumps

A few protips:

① The multiples of this frequency which cause a anti-node at solder bumps can also work.

② It is also necessary to know the location of such anti-nodes in the oven.