ASM

Paving the road to electrification - Approaches to Silicon Carbide epitaxy

Materials and challenges

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15/11/2023

Agenda

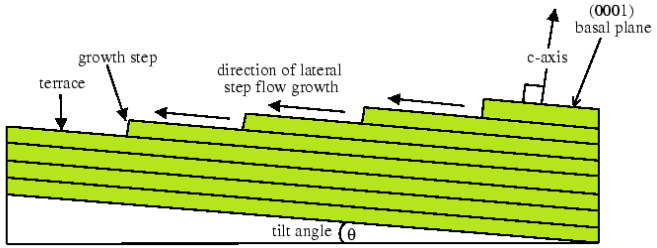
1. Introduction
2. Design choices – the epi reactor
3. How hardware impacts defects
4. The winning formula

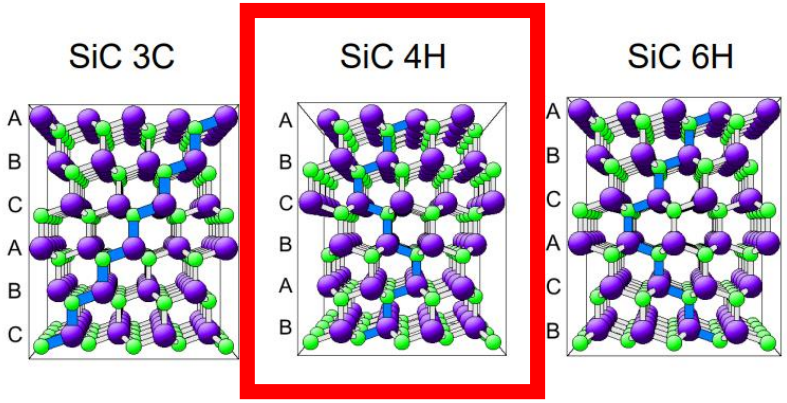
SiC

CVD EPI

provides better control on

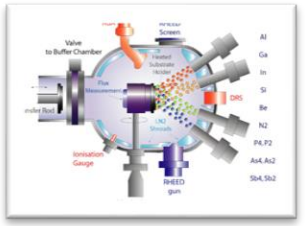
- Uniformity
- Defect density
- Growth rate



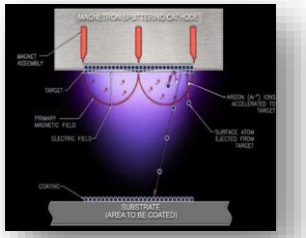


CVD EPI

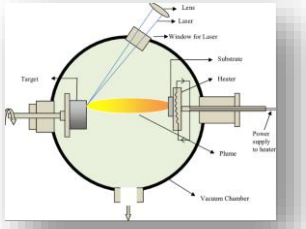
MBE



Magnetron sputtering



Pulsed laser deposition



Epitaxy= ἐπί + τάξις

on top of

with order

SiC epitaxy

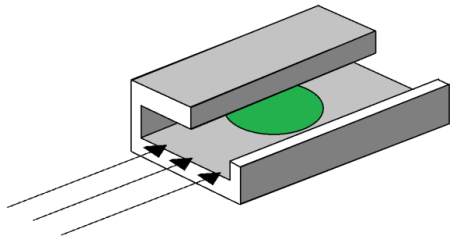
Temperature:	1550°C – 1700°C
Pressure:	50 mbar – 200 mbar
Gas involved:	C-Precursor, Si precursor, H2

Design choices – The EPI Reactor

Most common approaches to CVD epitaxy

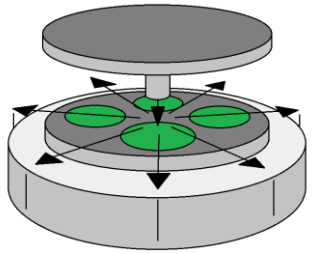
CROSS-FLOW

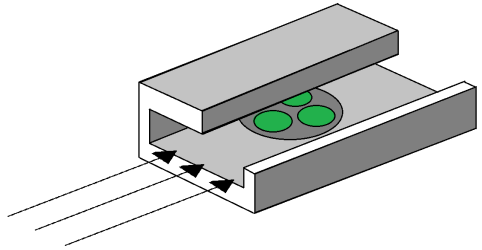
1



Single wafer

2

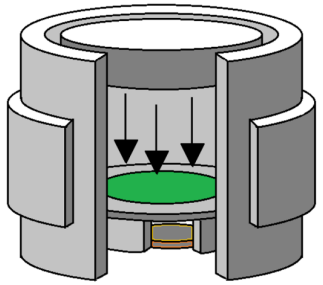




Batch

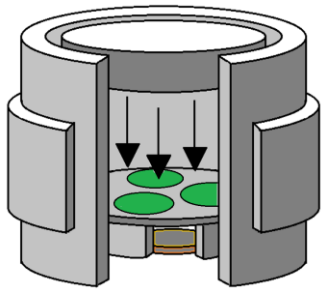
SHOWER HEAD

3



Single wafer

4



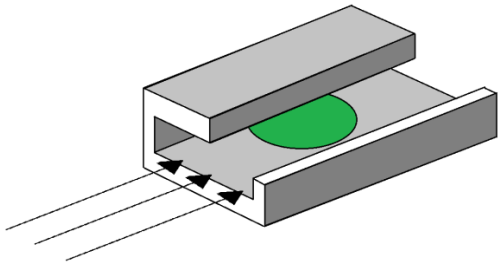
Batch

Design choices

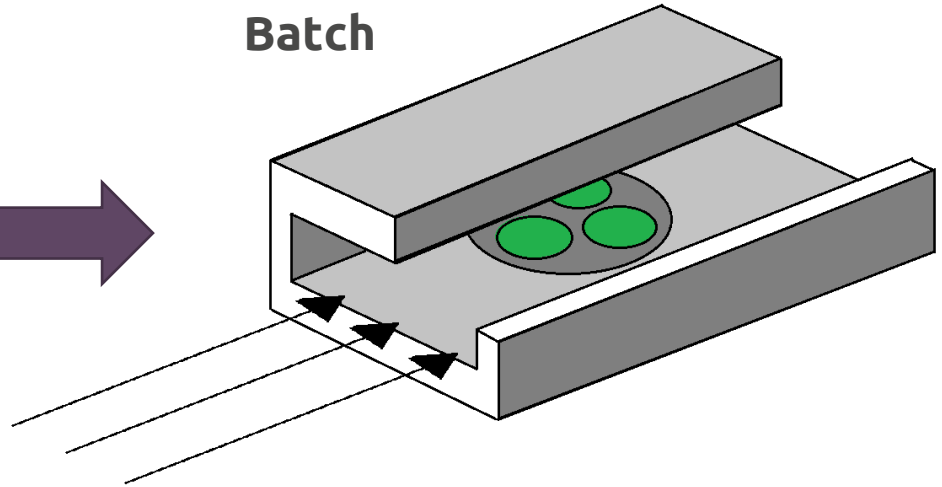
Single wafer	vs	Batch
Cross flow	vs	Shower head
Hot wall	vs	Cold wall
Resistive/Lamps	vs	Induction
Single chamber	vs	Cluster

Design choices – Single wafer vs Batch

Single wafer



Batch

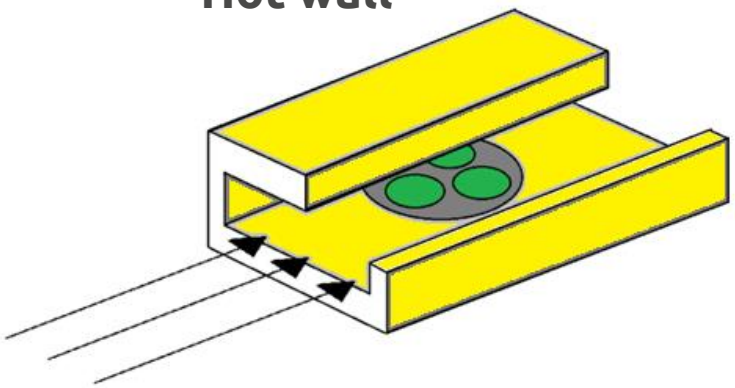


- Lower usage of consumables
- Smaller Footprint
- Easier to improve uniformity
- Shorter cycletime

- Embodied higher Throughput

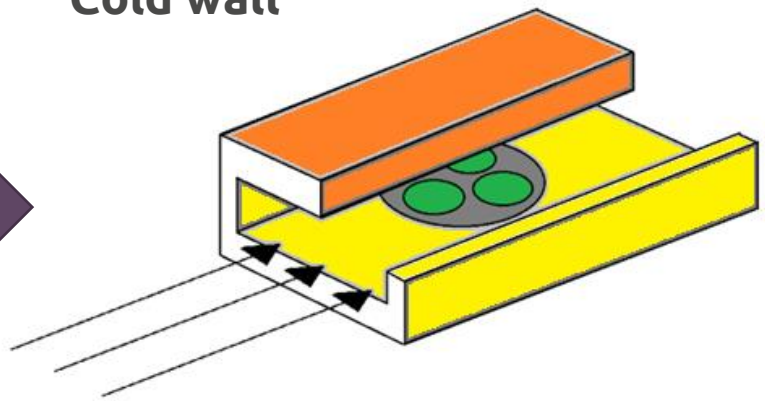
Design choices – Hot wall vs Cold wall

Hot wall



- Deposits are more stable
- Lower defect density

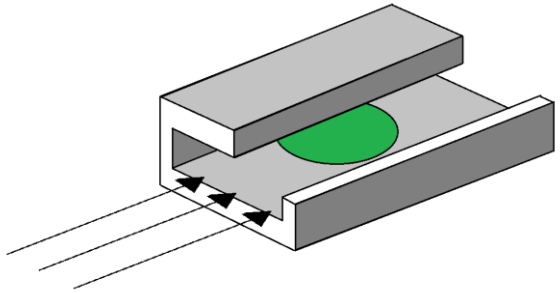
Cold wall



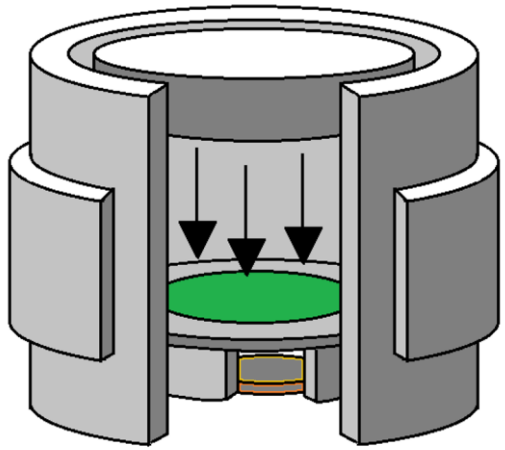
- Lower deposition rate on the cold walls
- Simpler heating system

Design choices – Cross flow vs Shower head

Cross flow



Shower head

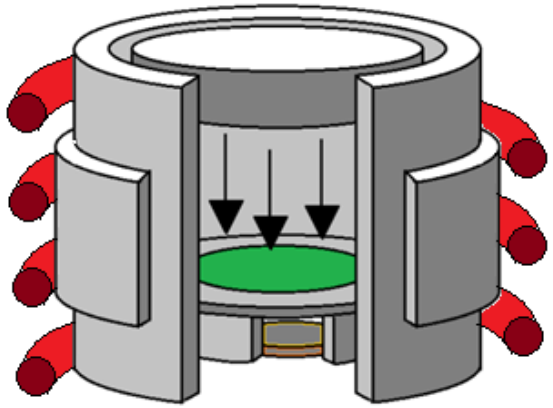


- Smaller reaction chamber
- Naturally high growth rate, no need to rotate fast

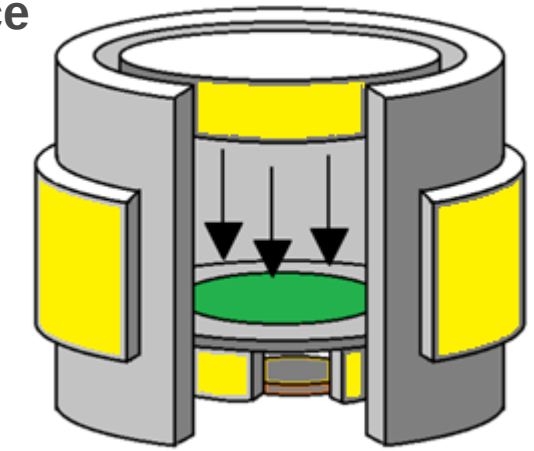
- Naturally low defect density
- Bigger distance from wafer to walls

Design choices – Induction vs Resistive / Lamps

Induction



Lamps/resistance

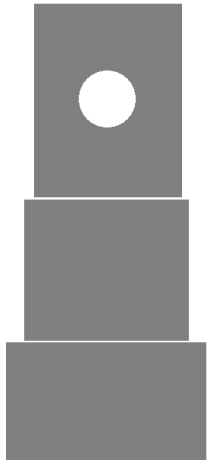


- Better heating system stability & reliability
- Good for thick deposition
- Lower running cost

- Easier to make multizone heating and to control thermal profile

Design choices – Single vs Cluster

Single chamber



Cluster

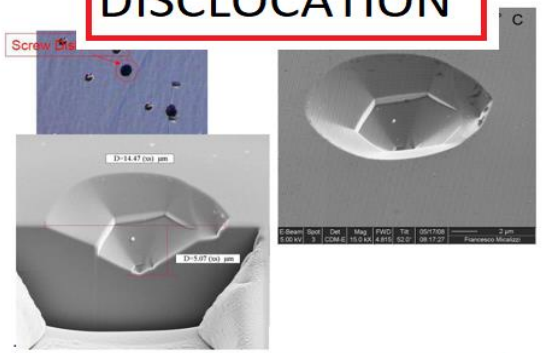
- Easier to engineer
- Easier to maximize uptime

- Modularity
- Potentially higher throughput density
- Possibility to split deposition steps

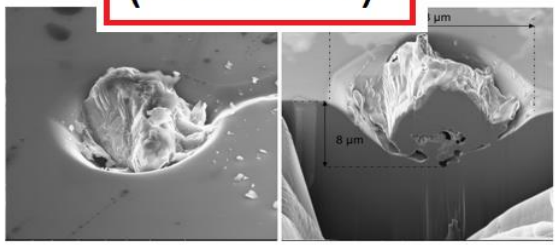
How hardware impacts defects

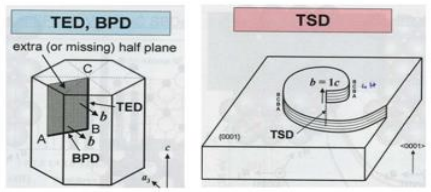
ROUGHNESS

SCREW DISCLOCATION



DOWNFALL (DROPLET)



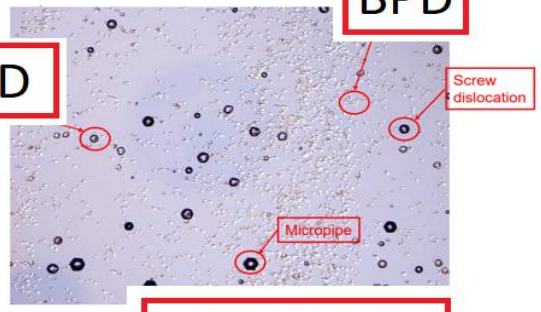


MICROPIPE

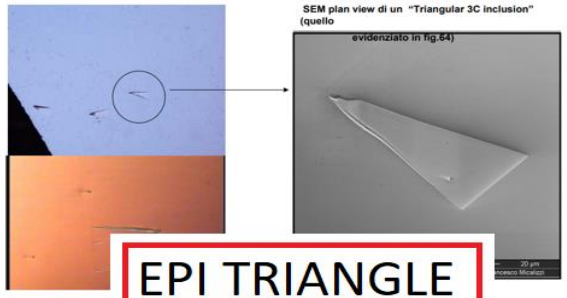
CARROT

BPD

TED

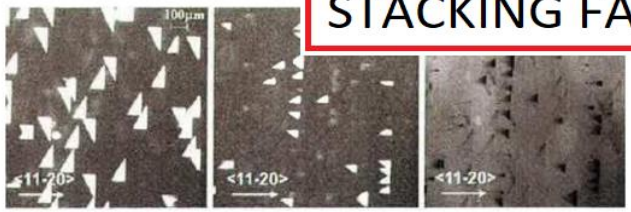


MICROPIPE



EPI TRIANGLE

STACKING FAULT

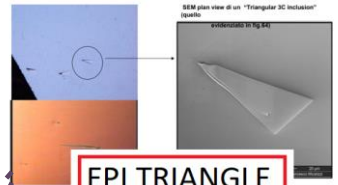


Handling precision

Thermal profile

Gas control

Substrate related



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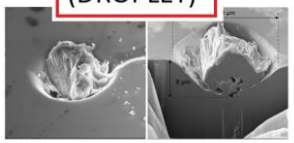

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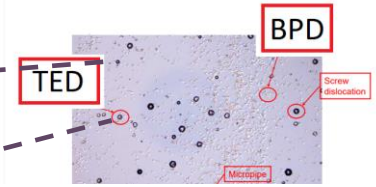
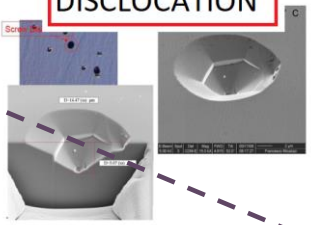


BPD

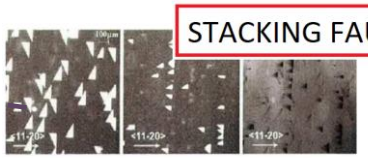
TED

SCREW DISCLOCATION



ROUGHNESS

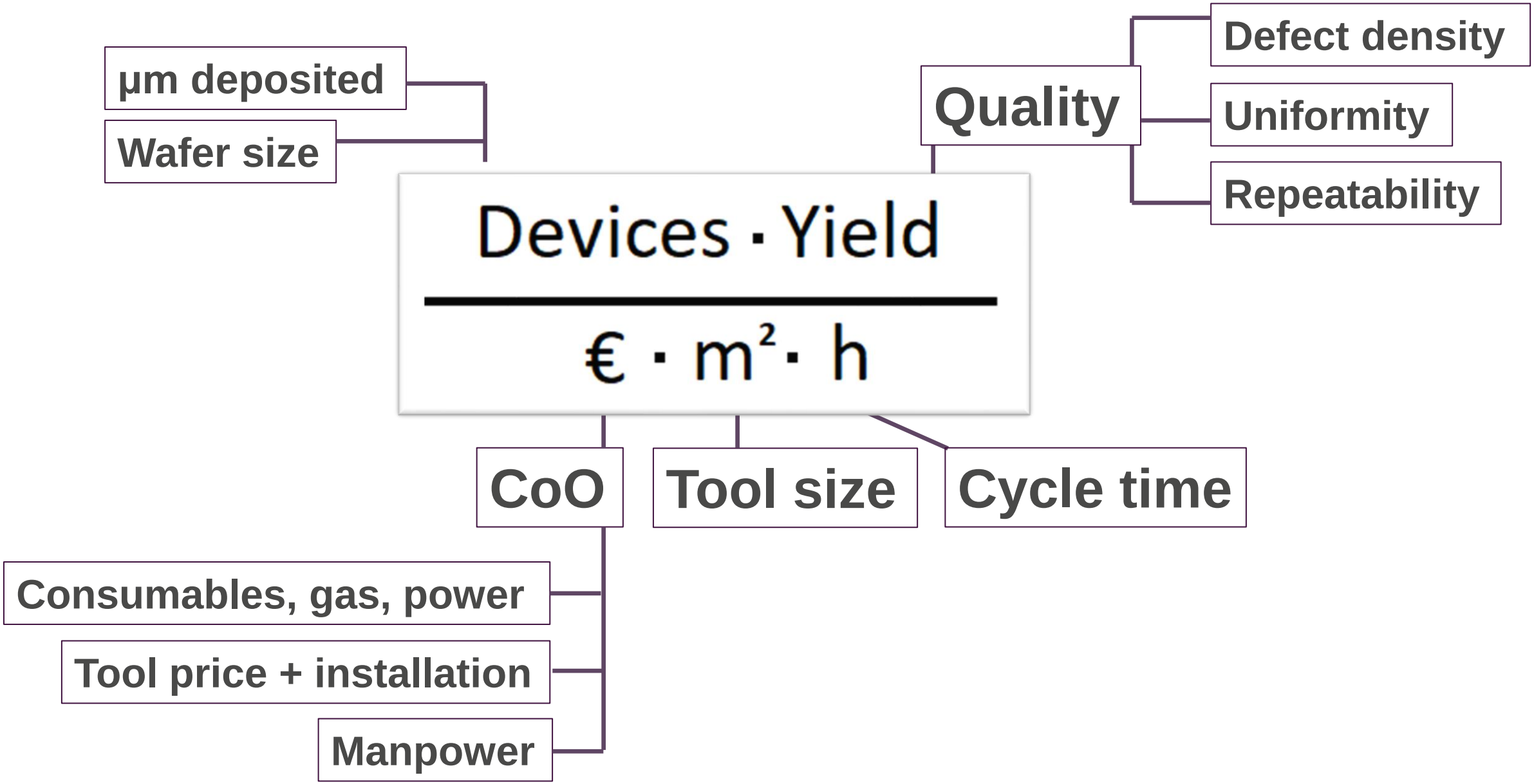
MICROPIPE



STACKING FAULT

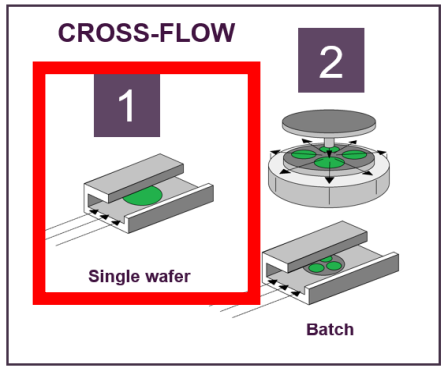
The winning formula

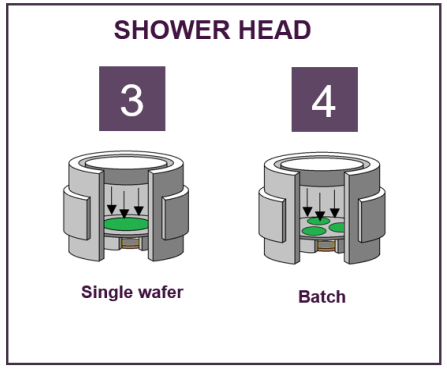
End user choice driven by



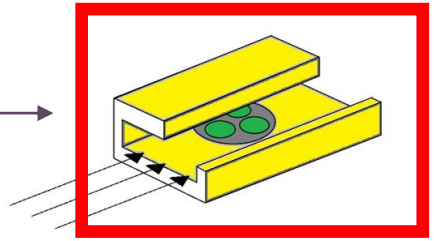
In the case of ASM PE2O8

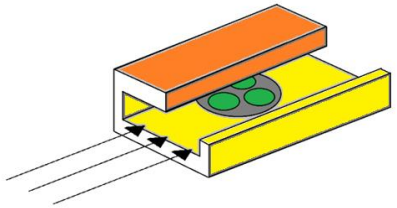
Cross flow →



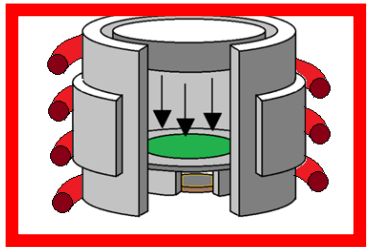


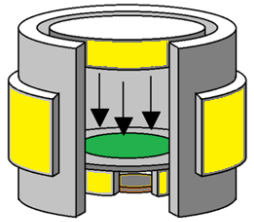
Hot wall →



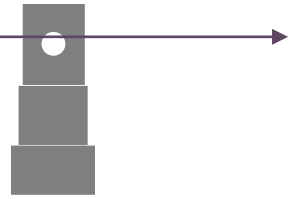


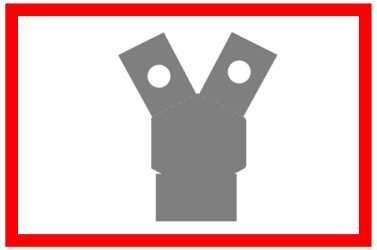
Induction →





Cluster →





Thank you