Using MEMS Processes to Teach a 6-Step Approach to Solving Problems

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Project Definition

Using a process from the microtechnology or MEMS manufacturing industry, students are required to solve a *process problem* or production problem using a systematic approach to problem solving.

Project Criteria

- Select a MEMS process
- Develop a process flow chart with process steps and quality checks.
- Identify quality criteria
- Identify equipment requirements
- Determine throughput times for each process step and for the total process.

6-Steps to Problem Solving

- Recognize the a problem exists
- Analyze the problem (Collect information)
- Identify possible causes to the problem
- Evaluate possible causes
- Develop an action plan to correct the problem and take action.
- Verify that the problem has been corrected.

Student Example

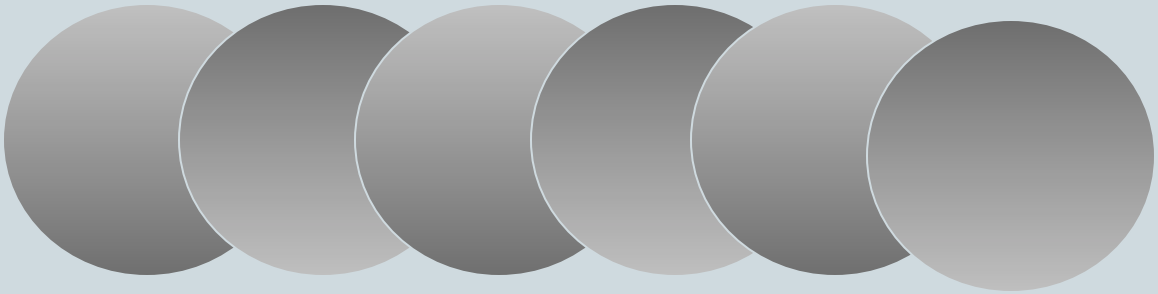
Process: Silicon wafer manufacturing

Process start @ raw materials

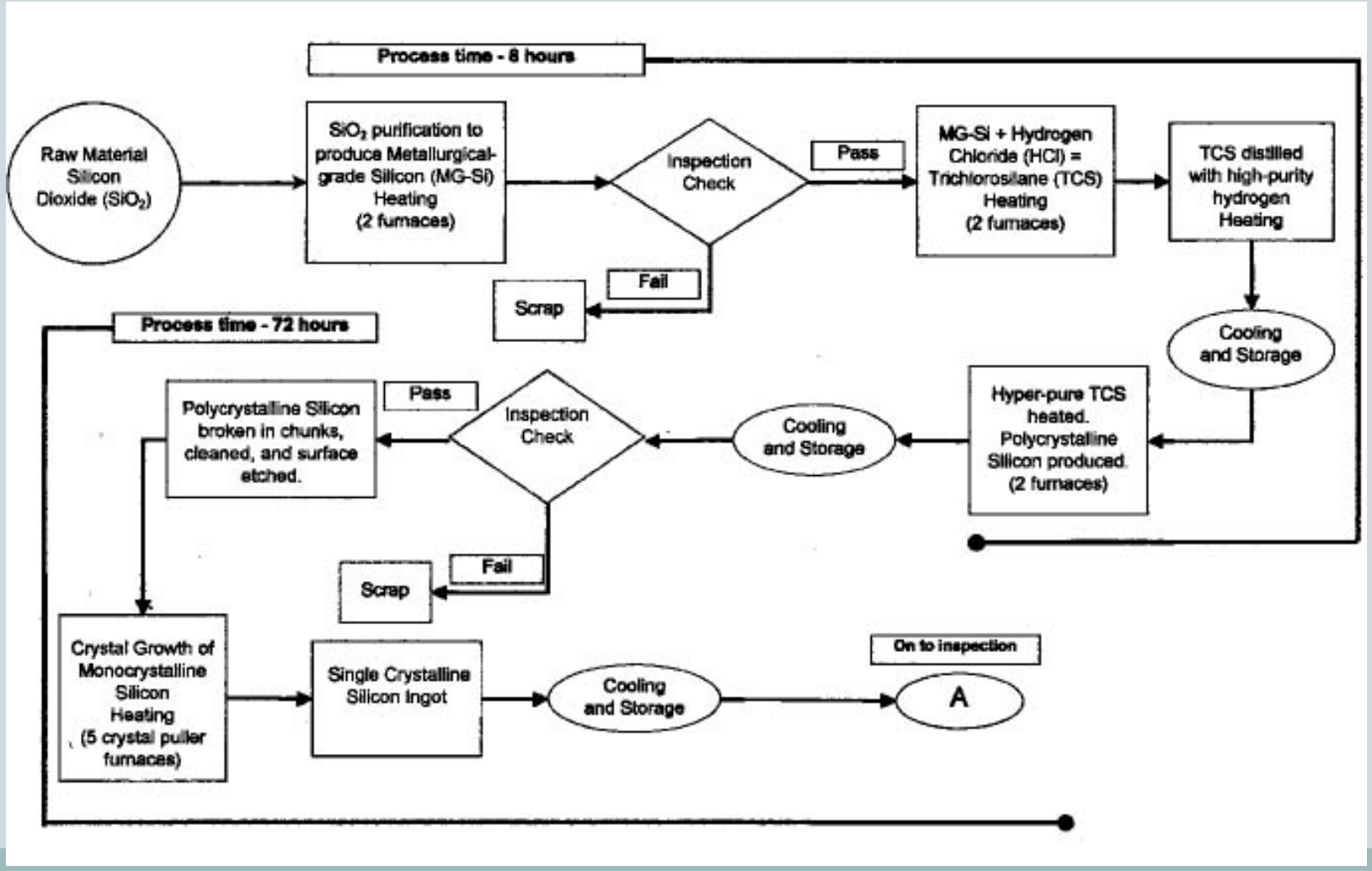
Process end @ finished silicon wafer

300 mm process

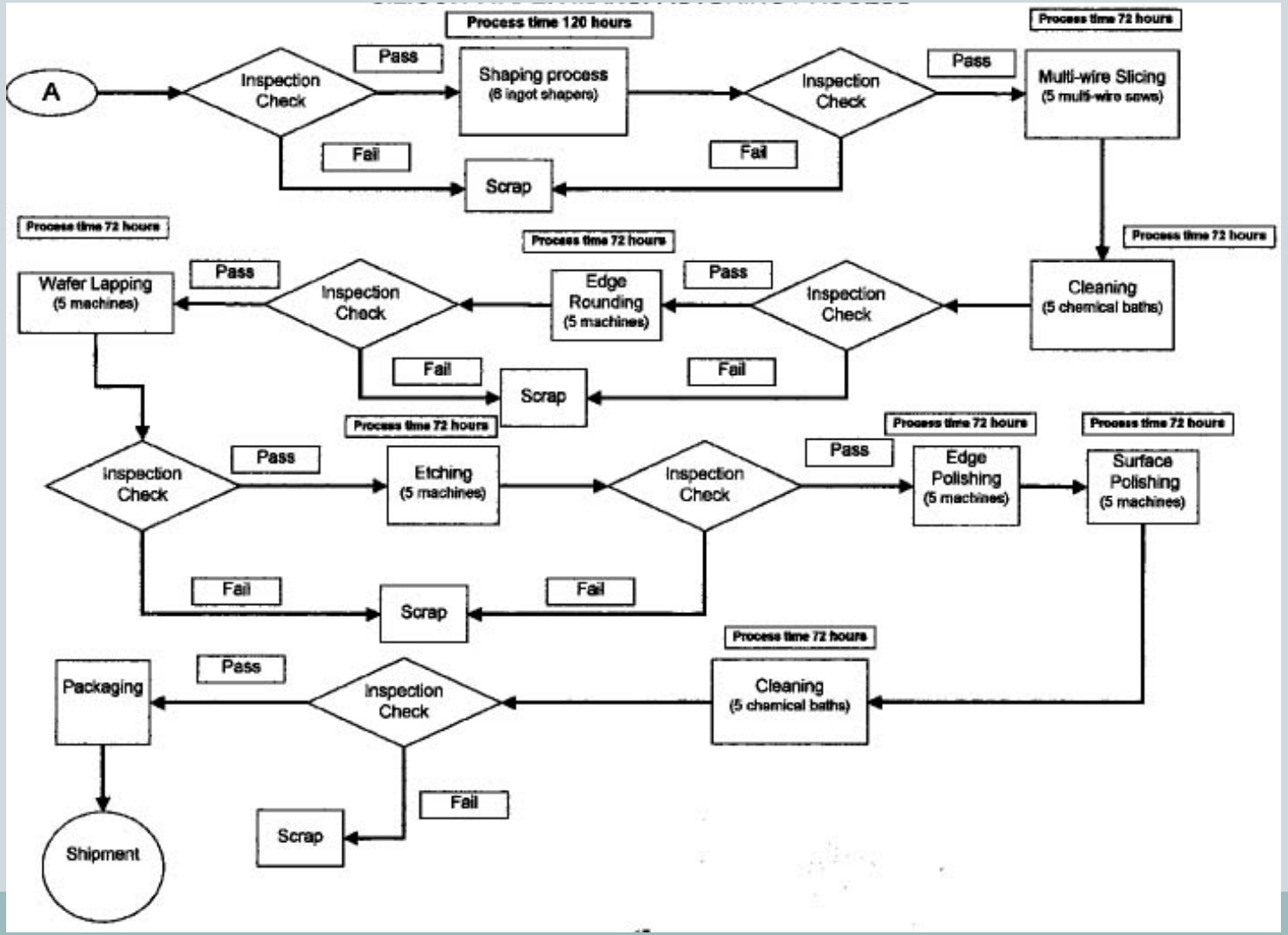
Projection of 17,000 wafers / week



Process Flowchart



Process Flowchart



Quality Criteria

QC1: Oxygen content, purification check

QC2: Purification

QC3: Handling temperature

QC4: Resistivity, dimensions

QC5: Flatness, chemical contamination, particle count

Quality Criteria (con't)

QC6: Edge damage, chemical contamination, particle count

QC7: Thickness, uniformity, chemical contamination, particle count

QC8: Chemical contamination, defect distribution, particles

QC9: Particles, dimensions, roughness, flatness, crystal defects, resistivity, contamination, oxygen content

Equipment List

- Furnace
- Fluidized - Bed Reactor
- Deposition
- Crusher
- Crystal puller
- Diameter Grinder
- End Remover
- Wire Saw
- Scribe Machine
- Wafer Cleaner
- Edge Grinder
- Lapping Machine
- Etcher
- Edge Polisher
- Surface Polisher
- Wafer scrubber

Problem Statement - Step 1

The winter of 2012-2013 showed a 45% decrease in the sell of silicon worldwide and projections for the remainder of 2013 show a continued decrease in sells of about 5% per quarter.

In an effort to show a positive revenue for 2013, company management has calculated that it needs to decrease its production by 25% of its current output and decrease its current defect rate from 16% to 8%.

Deliverable

Management has asked you to present an action plan that shows how the production team will decrease the defect rate from 16% to 8% and decrease production by 25% by the September of 2013.

(Assume this project was assigned May 1, 2013 for the purpose of your timeline. You have been given 3 weeks to develop a plan and put it in place by June 1.)

Analyze the Problem - Step 2

What are the specific defects? *See defect analysis*

When are they happening*?* *See % scrap rate chart*

Where are the defects happening?(at what stage)

See defect analysis

Did we lose customers or are they ordering less product? *Ordering less product*

Is the defect in the same area?

See the %scrap rate chart and defect analysis

Did we change to our backup equipment?

Because of the decrease in orders, you did not use your backup equipment

Analyze the Problem

Did we change our routine?(specs, raw materials, suppliers, personnel) *You added a chemical supplier*

Are the quality checks being done properly? *Step 3*

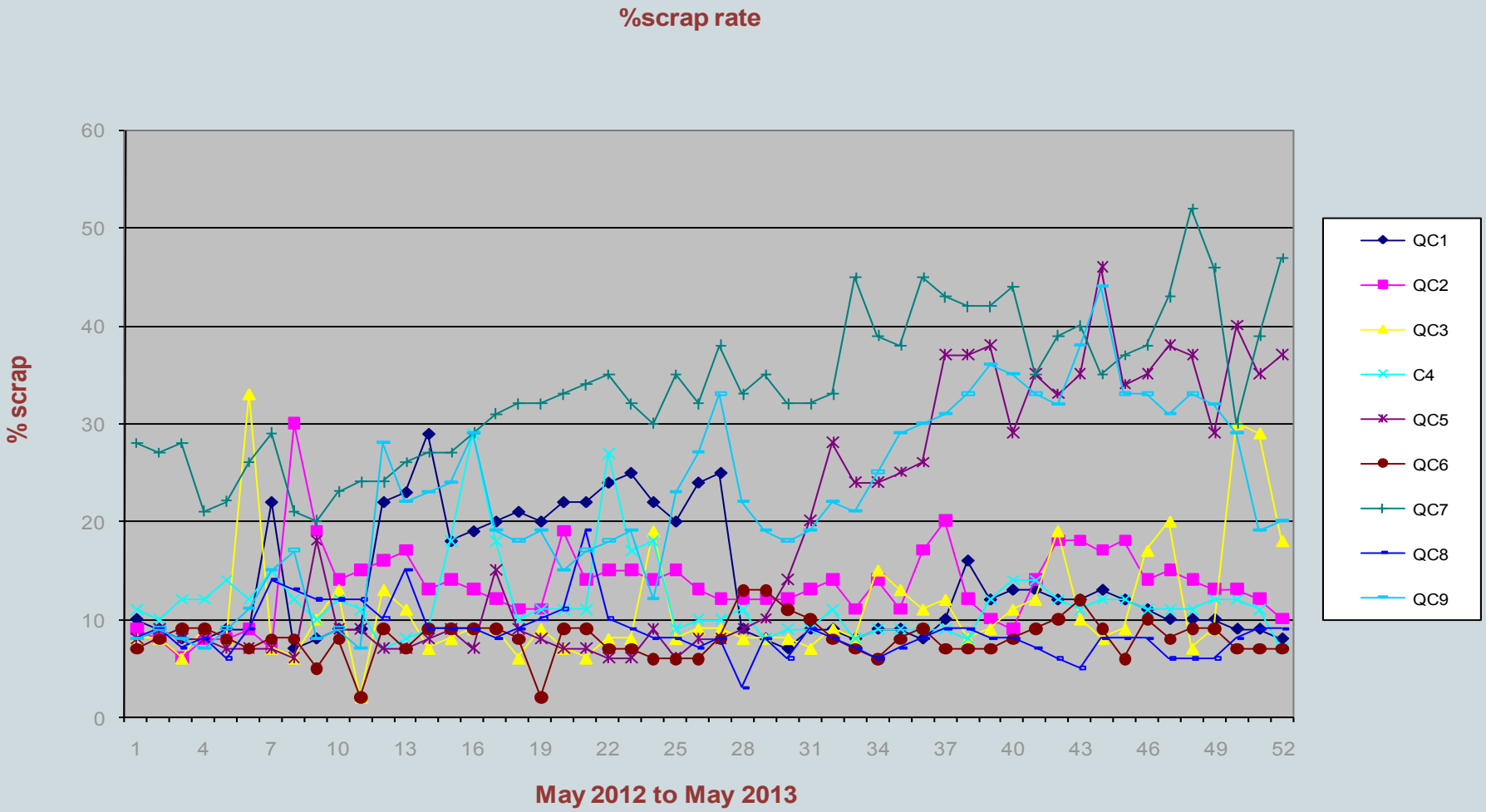
Is there possible storage of materials or product? *Step 3*

Are the quality checks precise enough? *Step 3*

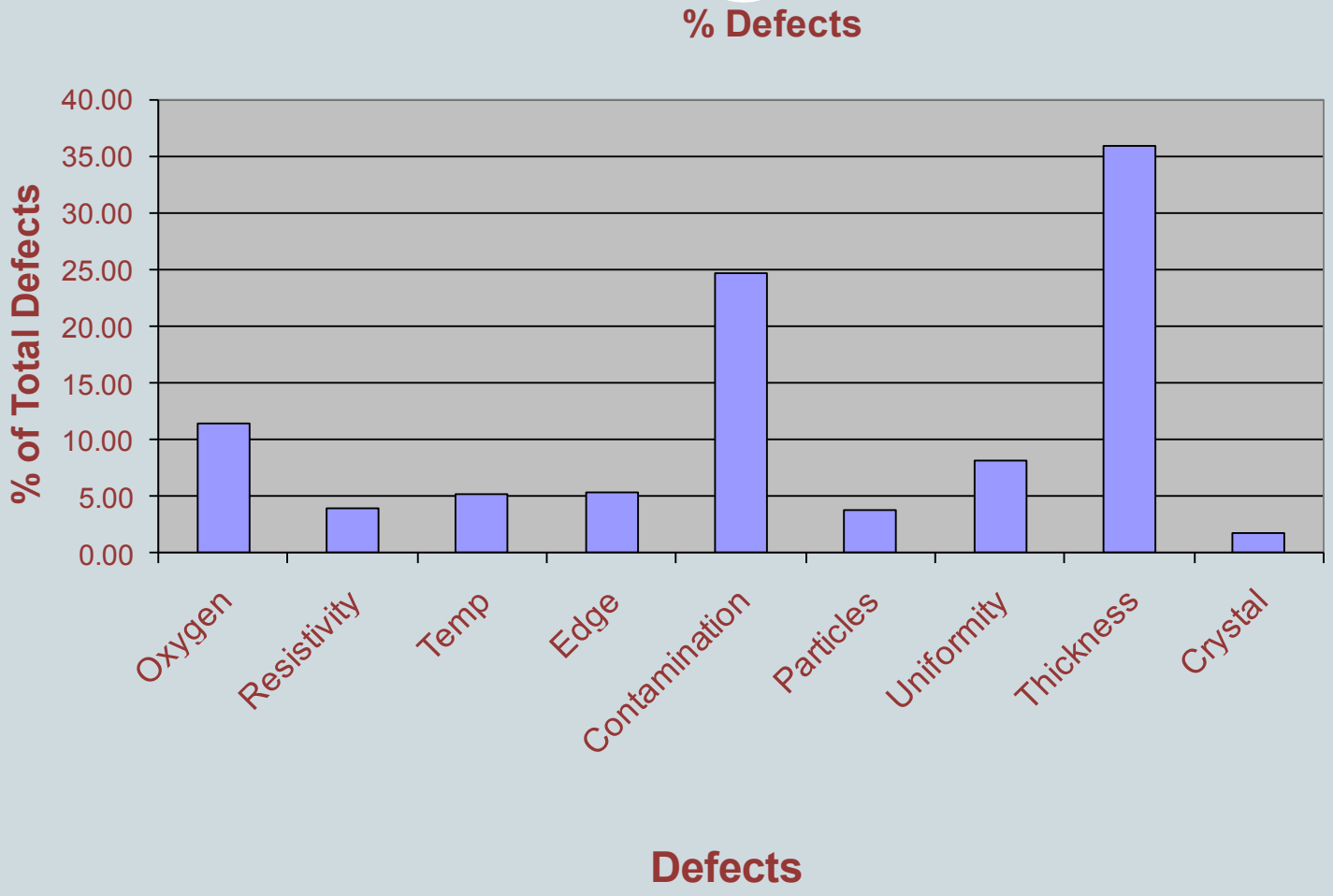
Are there possibilities for a merger or sell out?

No, not if you save your yearly revenues by decreasing defects and coming up with an efficient way of reducing production costs

Defect Analysis (%scrap)



Defect Analysis (Defects)



Analysis of contamination

What is the particle count at each checkpoint on the wafer? *Is particle count a problem?*

Is our cleanroom still functioning correctly? *Step 3*

When did we add our new chemical supplier? *December 2012*

Are we still using chemicals from other suppliers? *Yes*

Are the chemicals from the new supplier being used on all machines? *No, just one*

Did the problem start when we added this new supplier? *Yes - as seen on %scrap*

Analysis of wafer thickness

How many lapping machines were we using and how many how we now using?

You were using 4 machines and in October, you shut one down and produced all orders on 3 lapping machines.

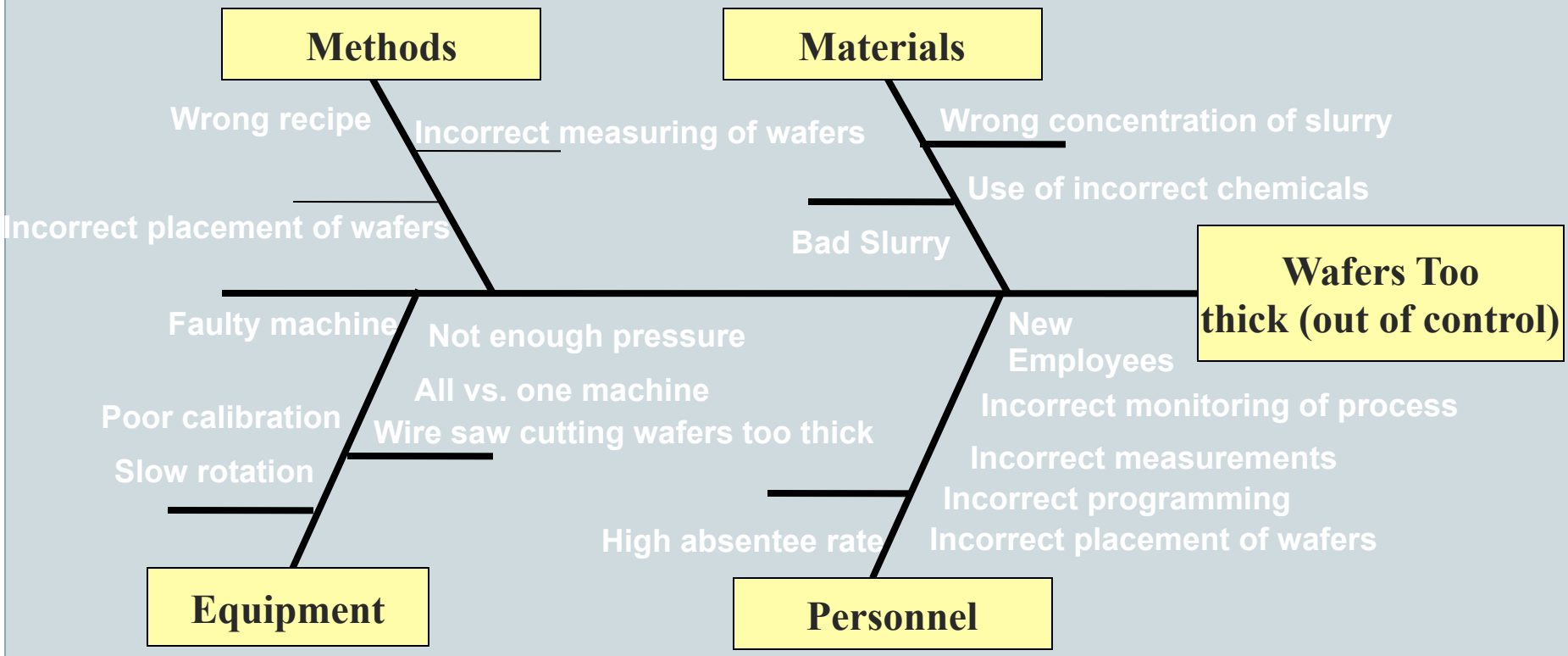
Are the wafers too thick / thin? *Too thick*

What is the deviation from the standard?

Average of 10 microns *(out of contr0l)*

Are the defective wafers found on all lapping machines? *No, just one*

Identify possible causes - Step 3



Evaluate possible causes - Step 4

Are the defects happening during a specific shift (day/night)?
No

What does the attendance of the techs look like?

You don't have an absentee problem

Are any of the operators new? *No*

Are the new employees being properly trained? *Yes*

Is the slurry recipe correct? *Yes*

Were the right chemicals used in the lapping machine? *Yes*

Evaluate possible causes - Step 4

When were the lapping machines last calibrated?

All lapping machines are calibrated quarterly

When were the measuring tools last calibrated?

Daily - Analytical tools are calibrated at the beginning of each shift

Are the wafers being placed in the lapping machine properly?

Yes

Have the machines been properly programmed? *Yes*

Is the program correct? *Yes*

Evaluate possible causes - Step 4

Are the machines receiving proper maintenance and cleaning?

All preventative maintenance procedures are being completed as scheduled

Are the chemicals being replaced as often as they should be?

Yes

Is the spin speed too slow? *Yes*

Do we have a problem with our rpm transducer? *Yes*

Action Plan - Step 5

Contamination

- Work with chemical company to set up a new SPC system
  - Who? Process Engineering
  - When? 3 months
- Audit the chemical company regularly
  - Who? Technicians (Trained as auditors)
  - When? Quarterly

Action Plan - Step 5

Wafer Thickness

- Rotate lapping machine out of production
  - When? Immediately
- Replace transducer
  - Who? Equipment technicians
- Test
  - Who? Equipment technicians and calibration technicians

Verification - Step 6

Contamination

- Audit the supplier quarterly to ensure highest standards

Wafer Thickness

- Incorporate rpm check to quarterly calibration
- QC wafers from individual machines instead of random wafer check

Project Presentation

Students defend their solution and action plan to the *Management Team*.

The Management Team is composed of other students, instructors, and industry representatives.