Considerations on the design of high precision flip-chip bonder for mass production.

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Move to production.

Throughput improvement.

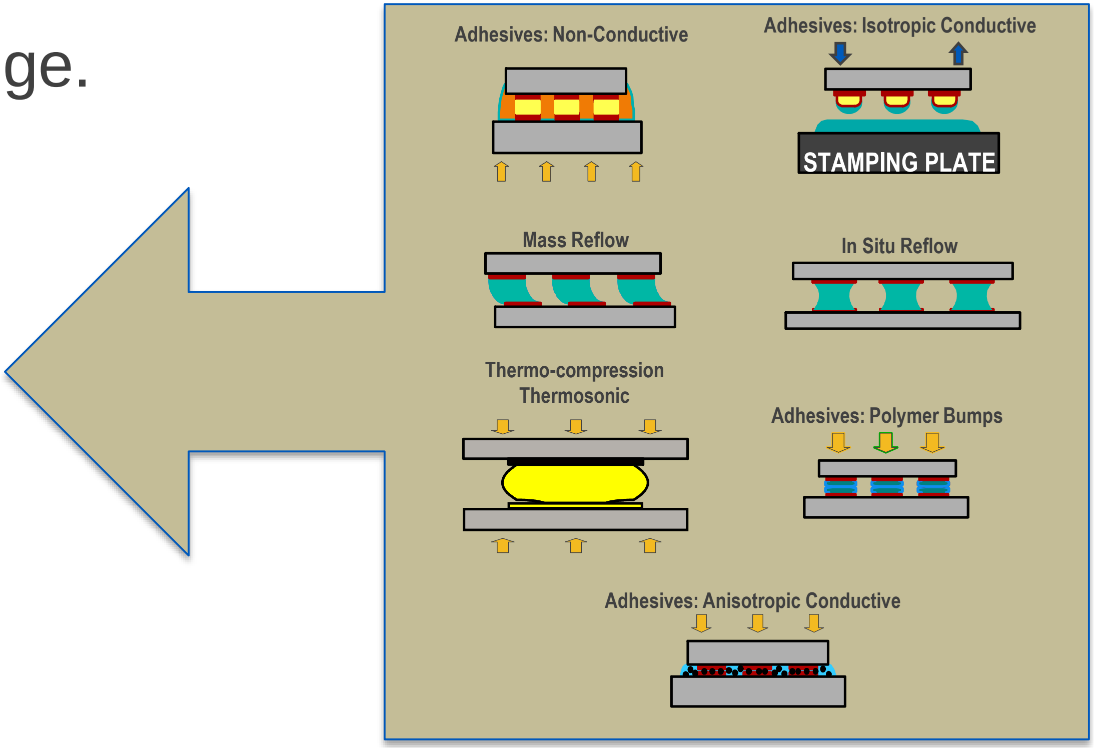
- High accuracy Flip chip equipment
  (± 1µm post bond)

Throughput around
100 UPH @ +/-1µm
(process dependent

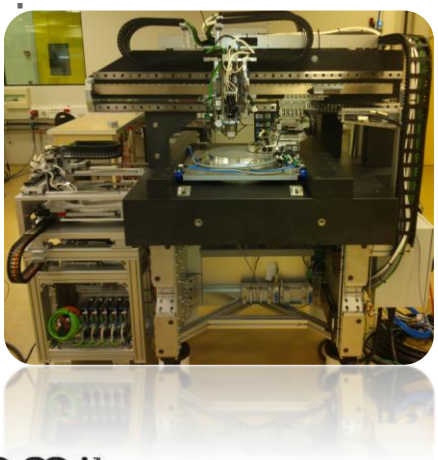
Throughput around
1000 UPH @ +/-1µm
(process dependent)

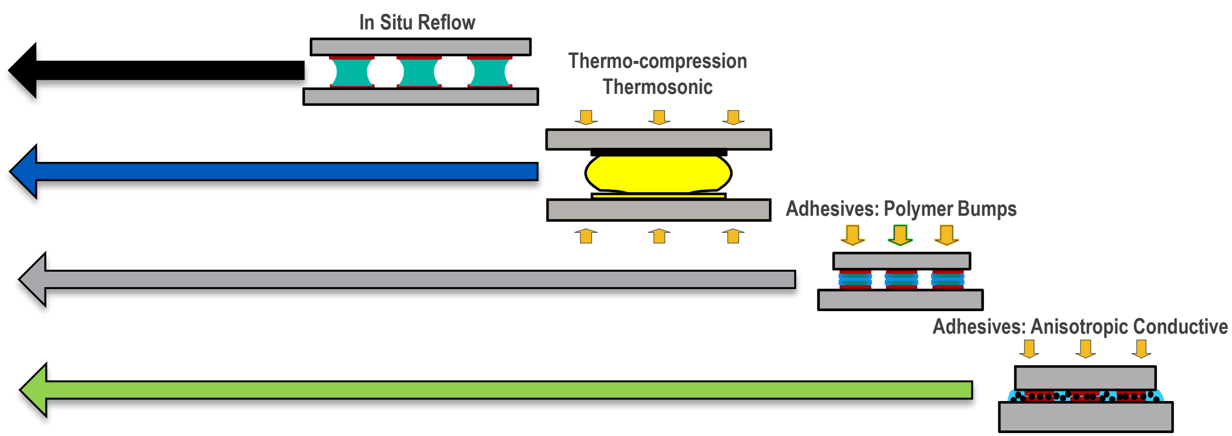
Philosophy change.

- Options

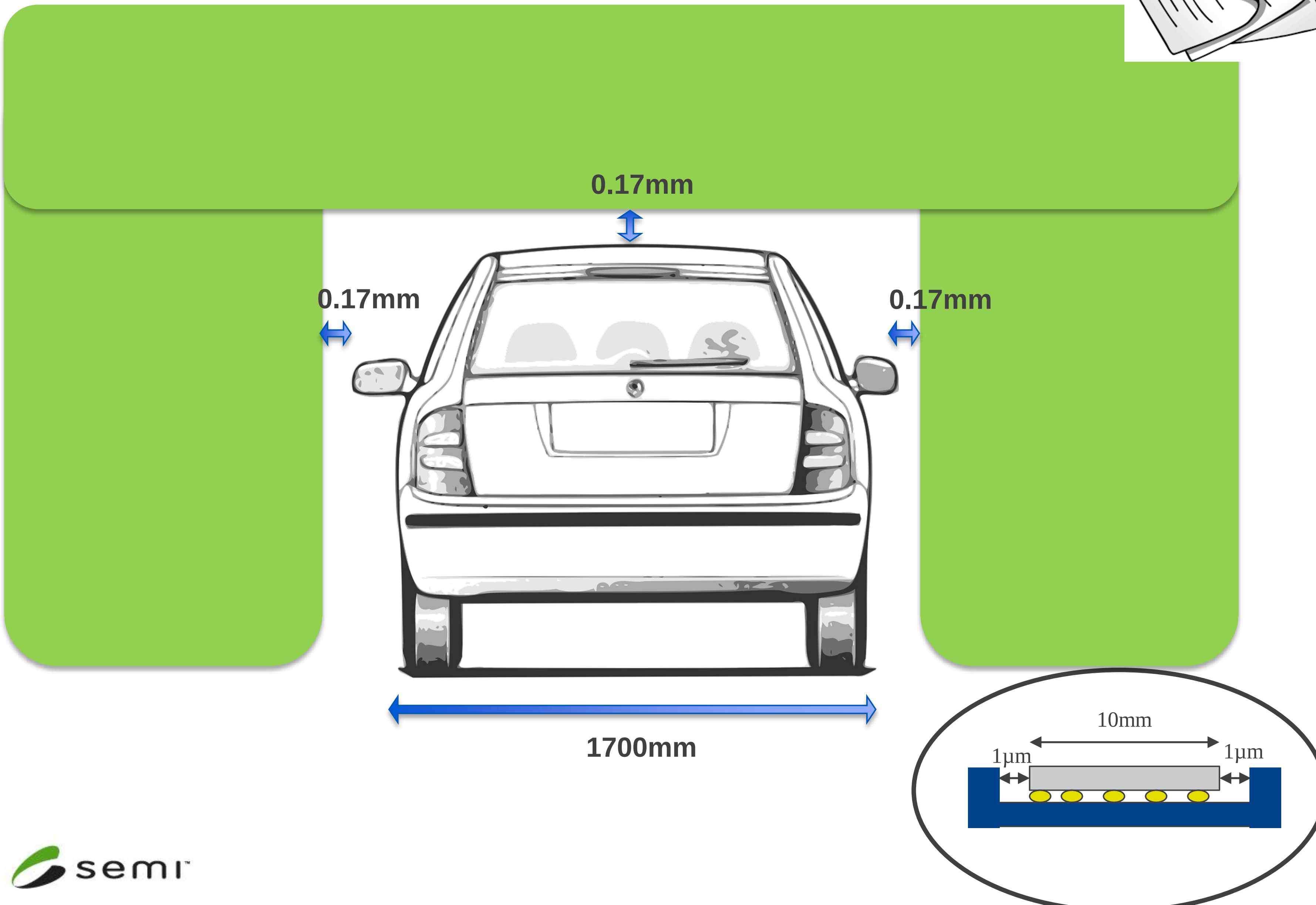


- Configurations





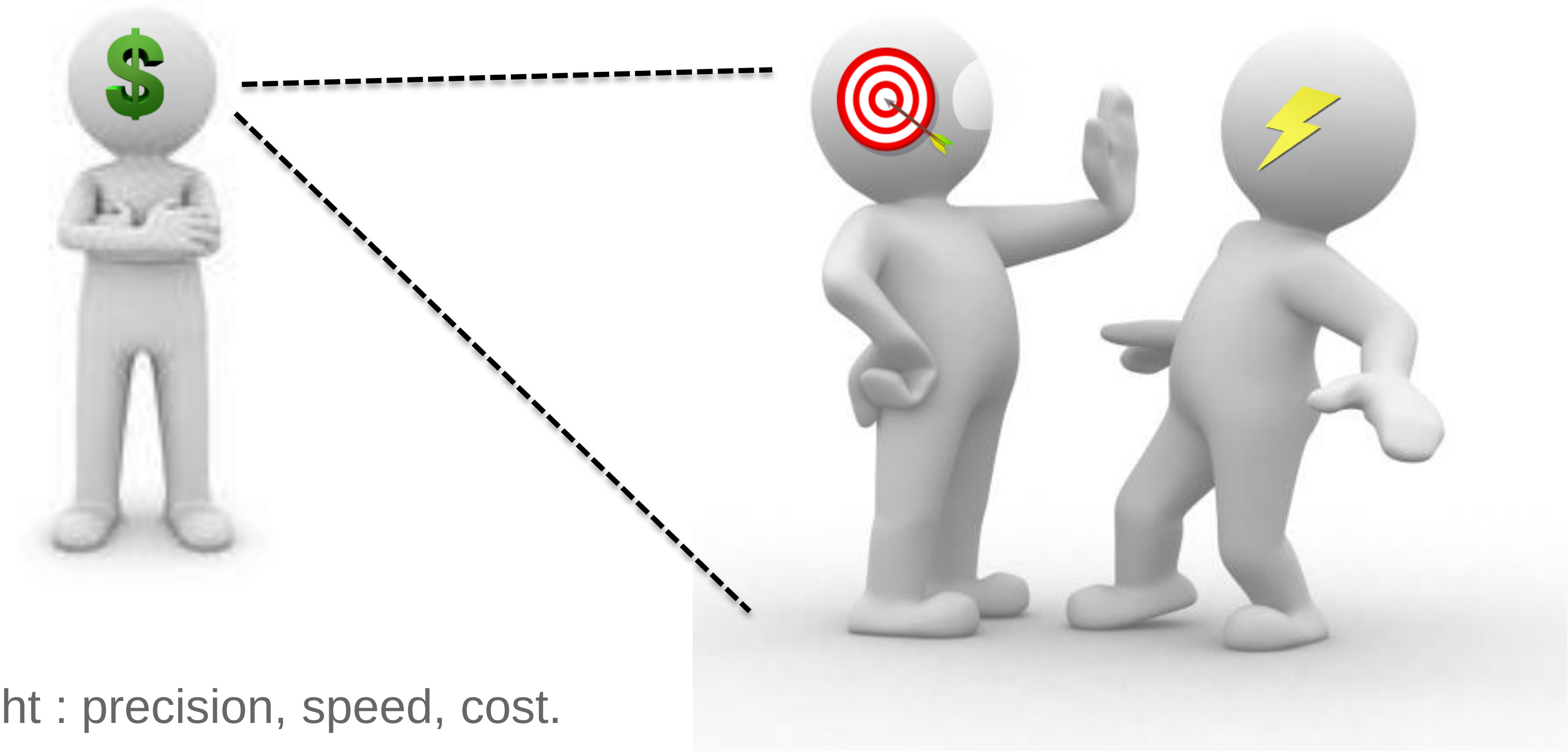
Throughput improvement.



Considerations.

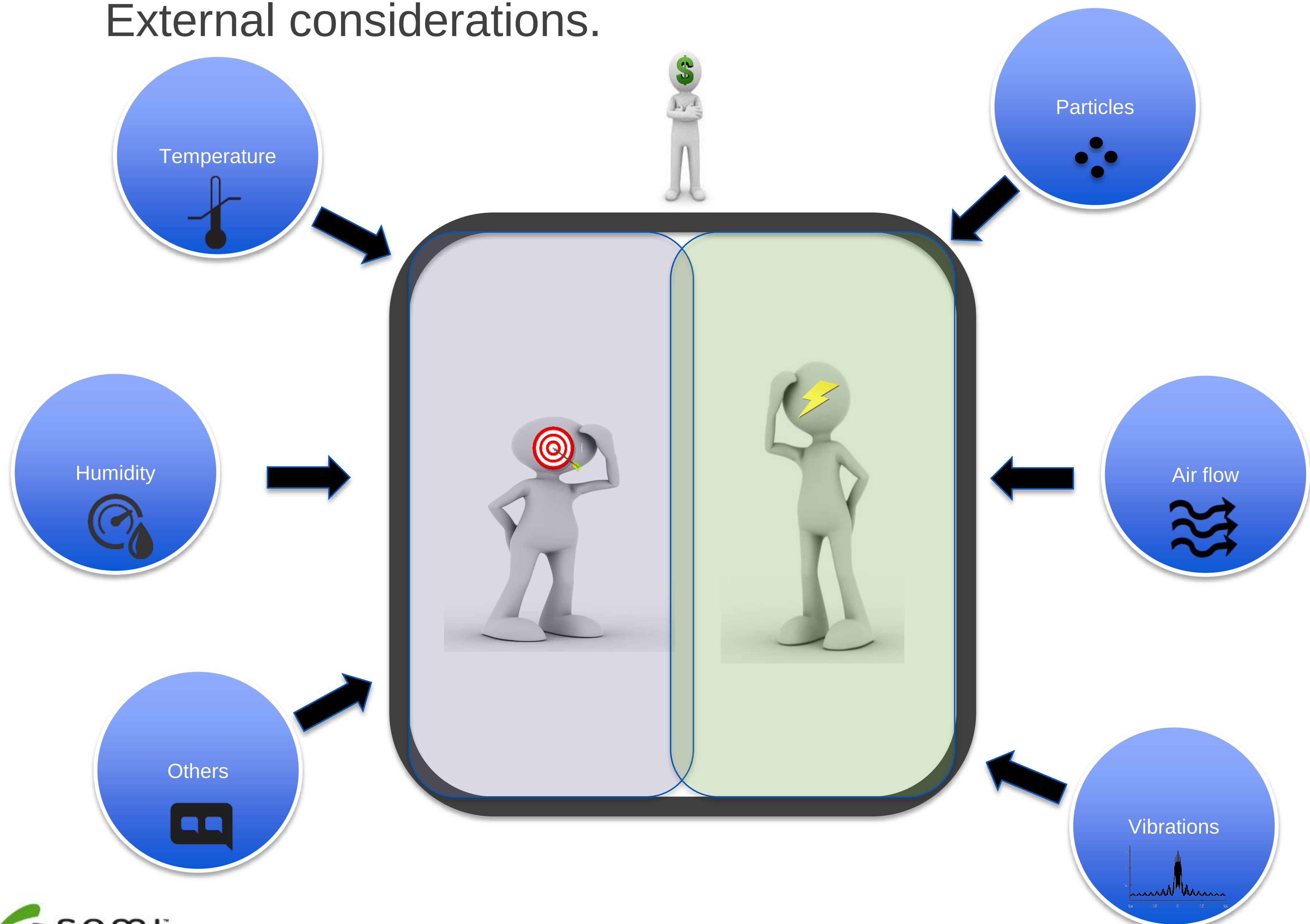
Throughput improvement.

- Mr. Accuracy doesn’t like Mr. Speed.
- Mr. Speed doesn’t like Mr. Accuracy.
- And Mr. Cost has to check all of them……



Fight : precision, speed, cost.

External considerations.



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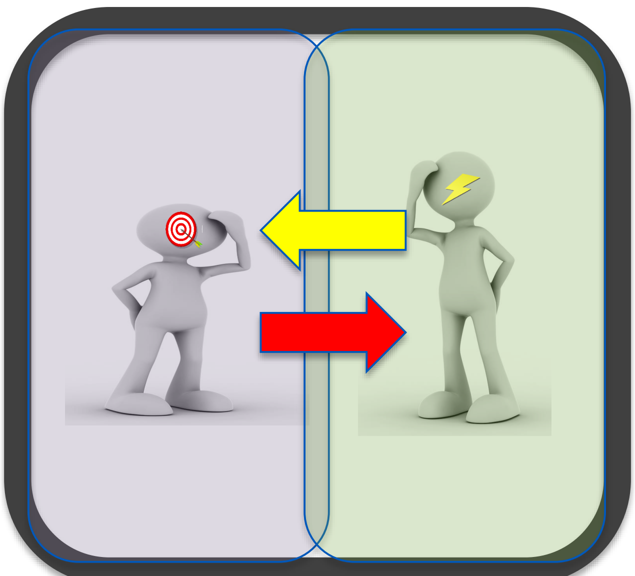
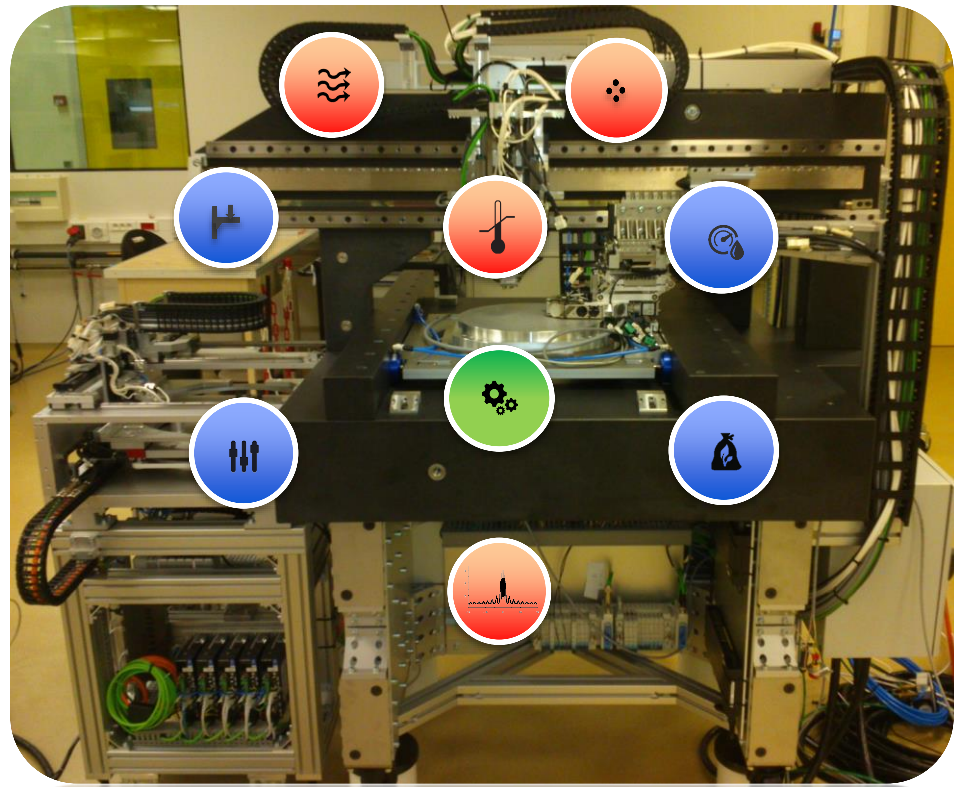
Internal considerations.

Internal & external considerations.

- Both have to live together.





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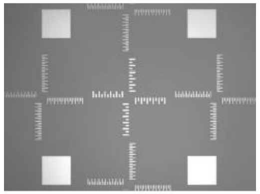
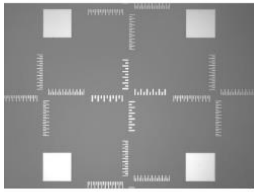
Thermal drift example.

Temperature effects.

- Cycle at 21°C : **± 0.4µm**

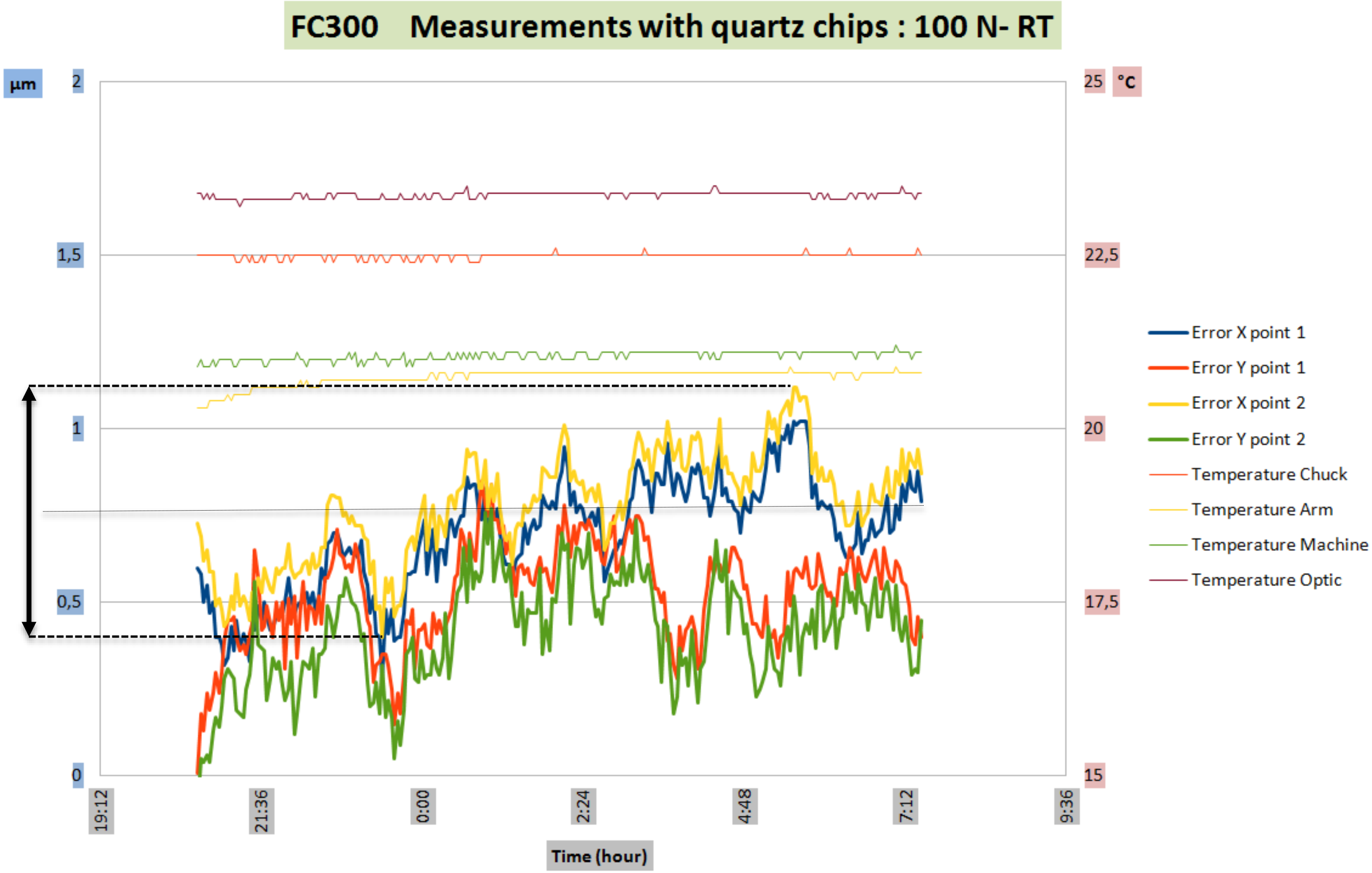


Chip (Top)

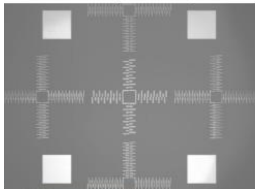


Substrate (Bottom)

0.8µm



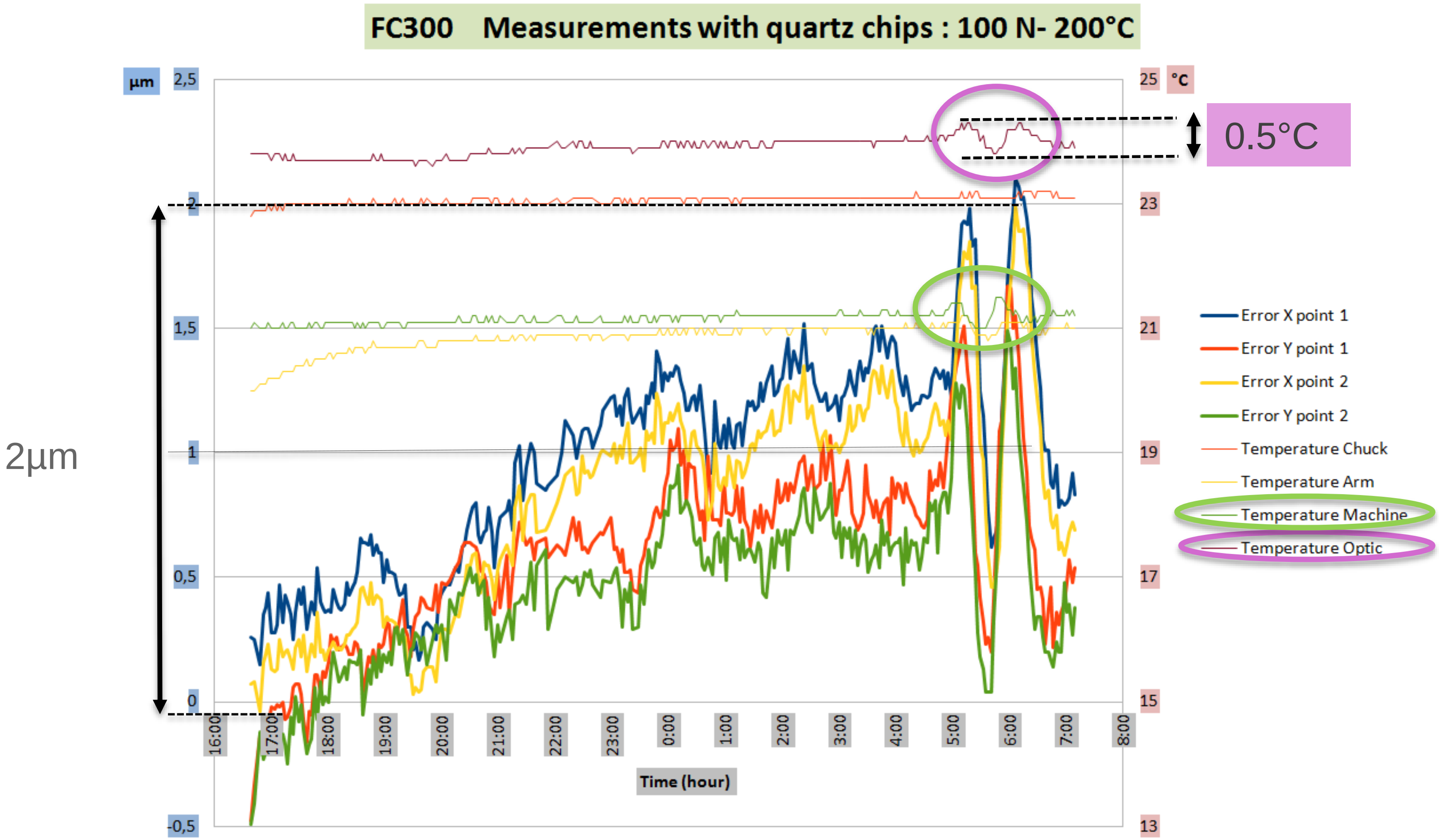
Both (Mixed)



11 hours overnight

Temperature effects (without any compensation).

- Cycle at 200°C (perturbation): **± 1µm**



11 hours overnight

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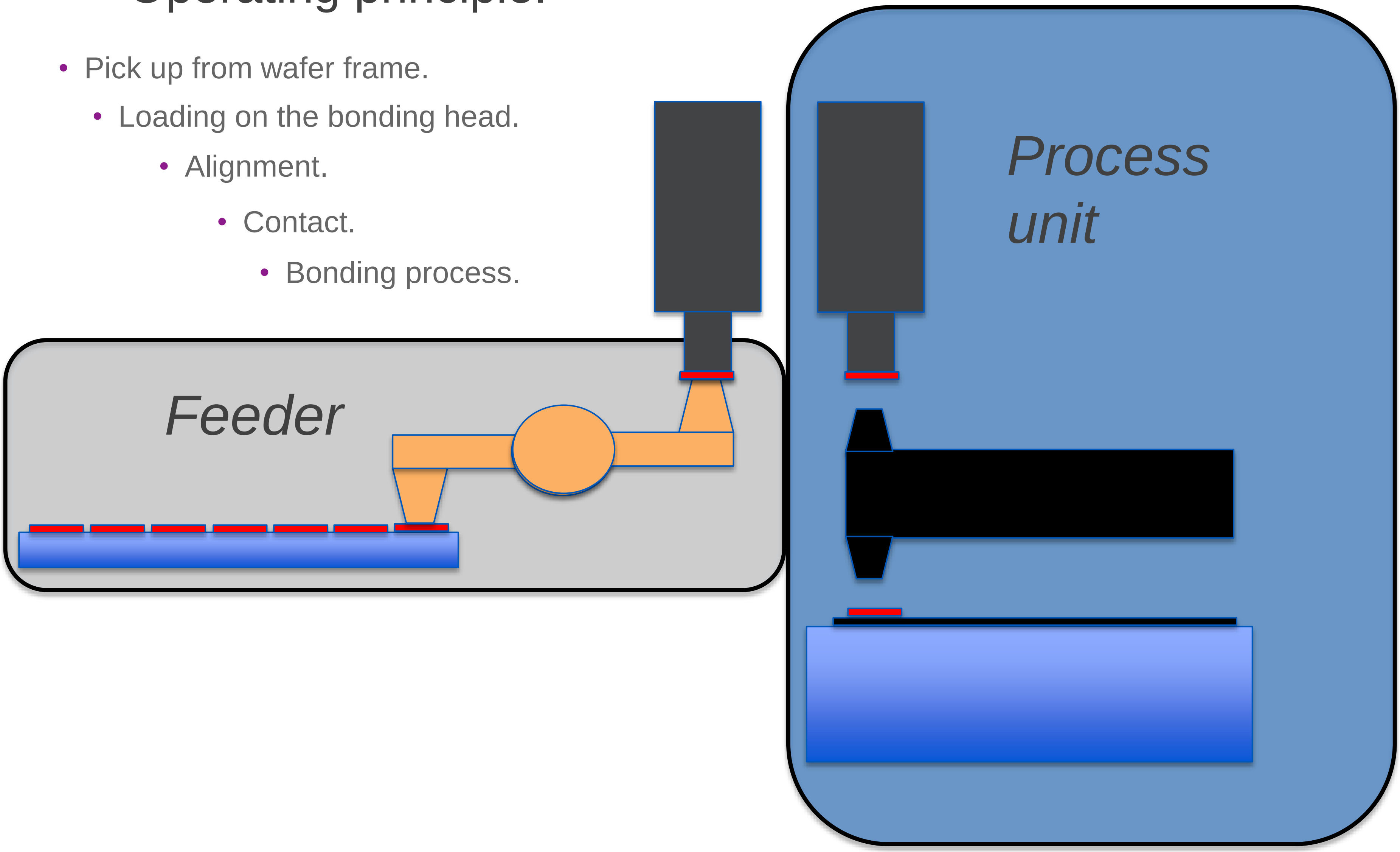
New Equipment Development.

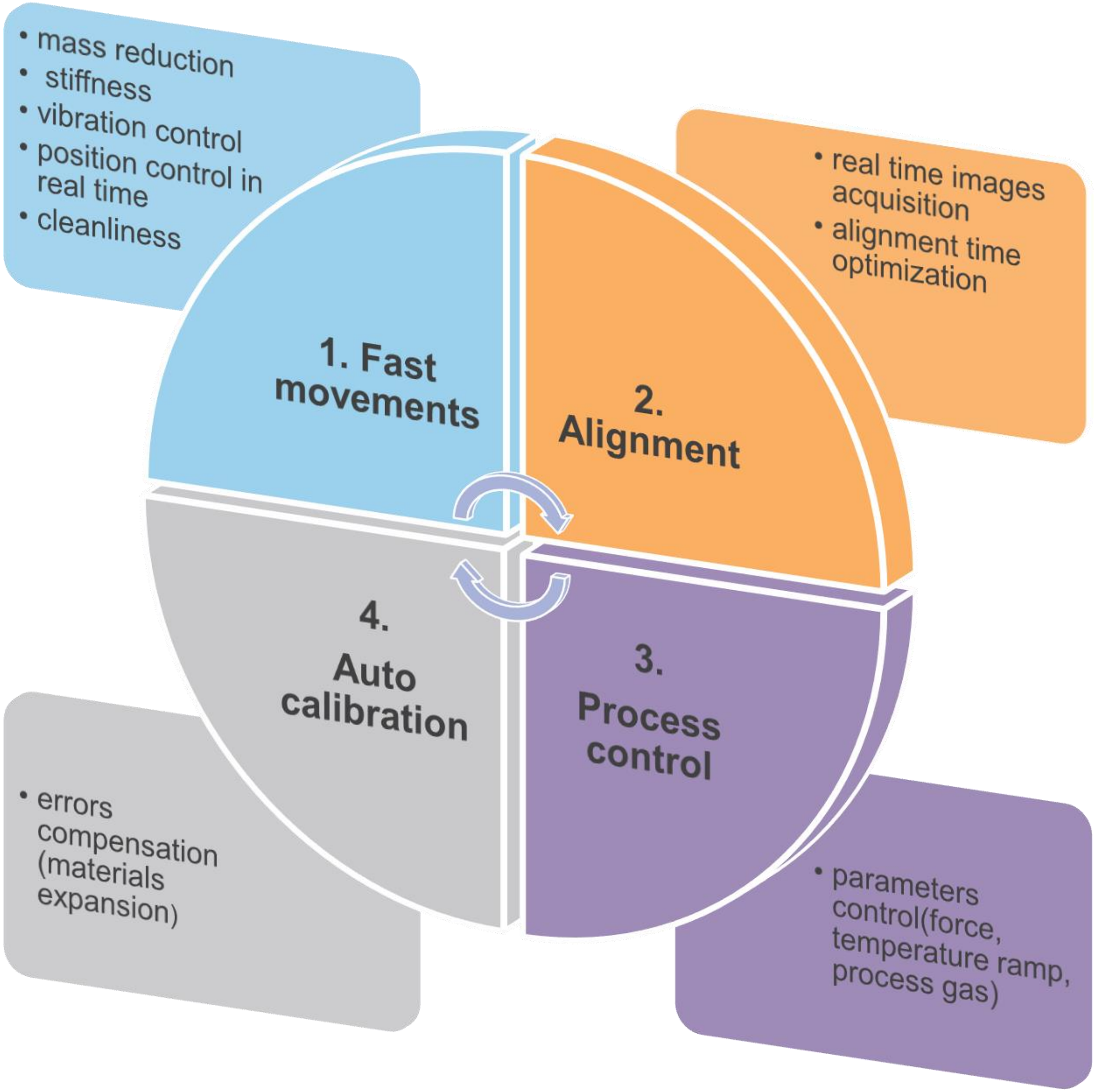
High accuracy, high throughput.

Operating principle.

- Pick up from wafer frame.
  - Loading on the bonding head.
    - Alignment.
      - Contact.
        - Bonding process.

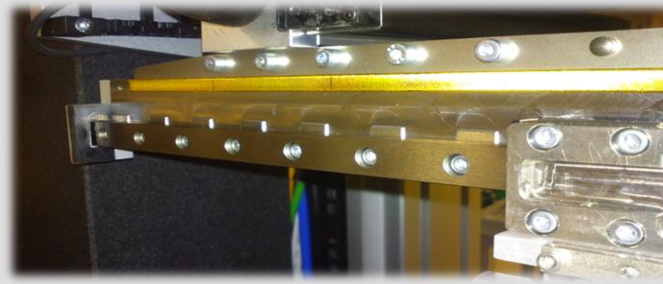


Keys points.


• mass reduction
• stiffness
• vibration control
• position control in real time
• cleanliness
1. Fast movements
• real time images acquisition
• alignment time optimization
2. Alignment
3. Process control
• parameters control(force, temperature ramp, process gas)
4. Auto calibration
• errors compensation (materials expansion)

Guiding systems.

- Traditional linear motion guide



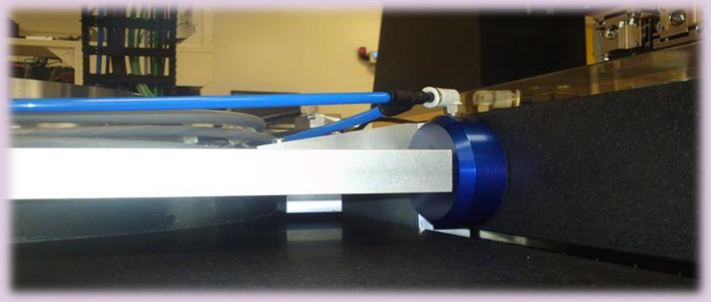
- Stiffness
- Standard parts

- Dust generation
- Not good enough for very high accuracy movement

- Total air bearing guide

- Low dust generation
- No friction
- Good for very high accuracy movement

- Limited Stiffness
- Need special design

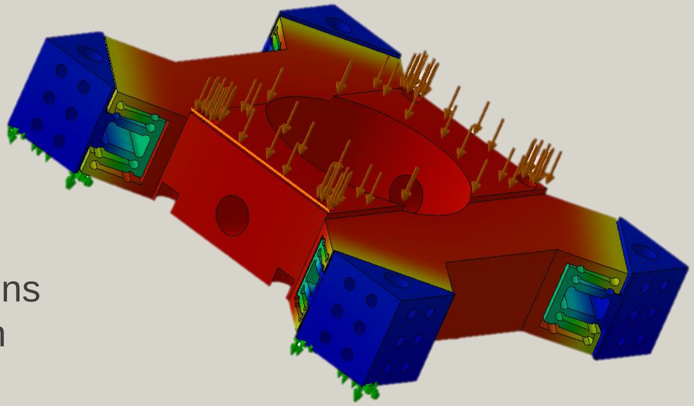


Guiding systems.

- Flexure guiding stage

- Very accurate and repeatable
- Possible to get a good stiffness

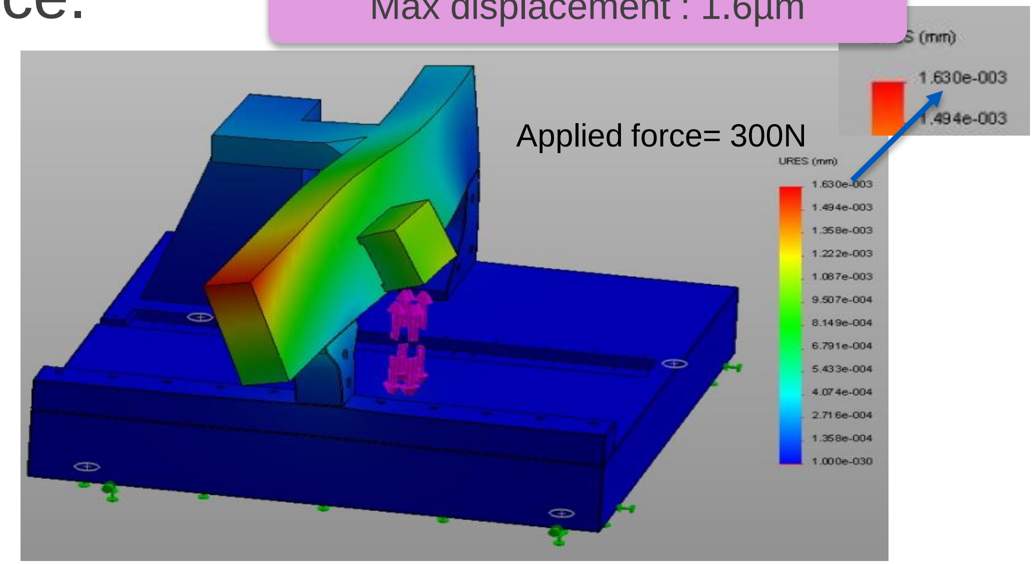
- Limited stroke
- Very sensitive with temperature variations
- Need special design



Design, Material choice.

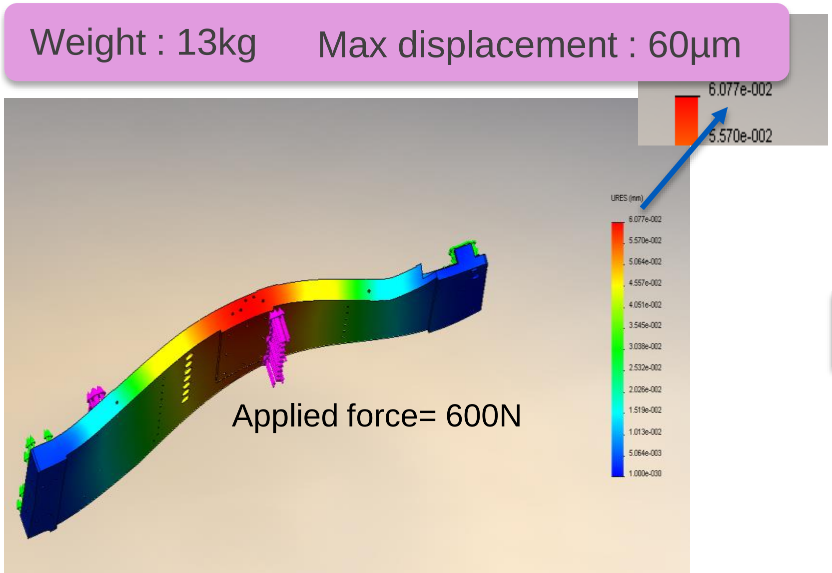
- Strong effort on the design
- FEA analysis to predict and improve
- Stiffness improvement (material & design)

Max displacement : 1.6µm



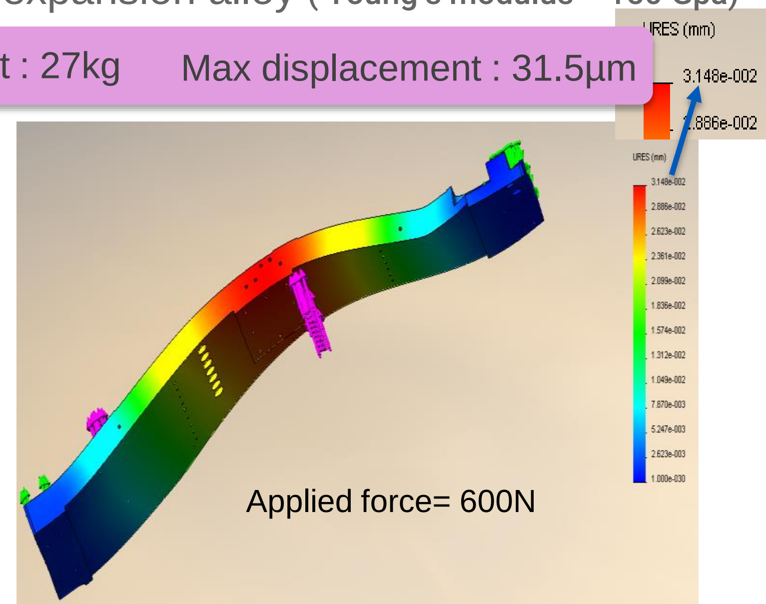
- Aluminum plate (Young's modulus = 69 Gpa)

Weight : 13kg Max displacement : 60µm



- Low expansion alloy (**Young's modulus = 150 Gpa**)

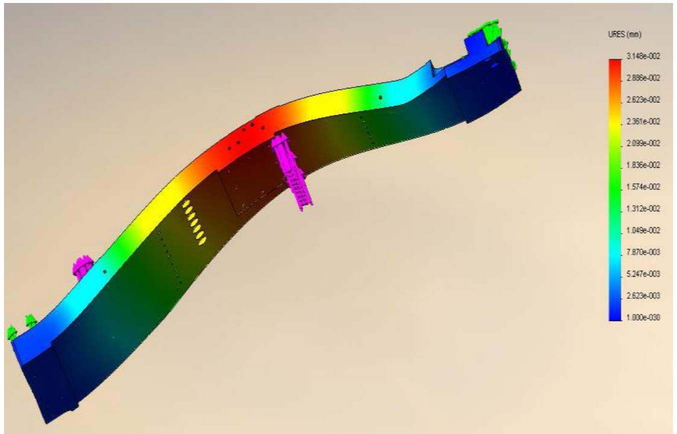
Weight : 27kg Max displacement : 31.5µm

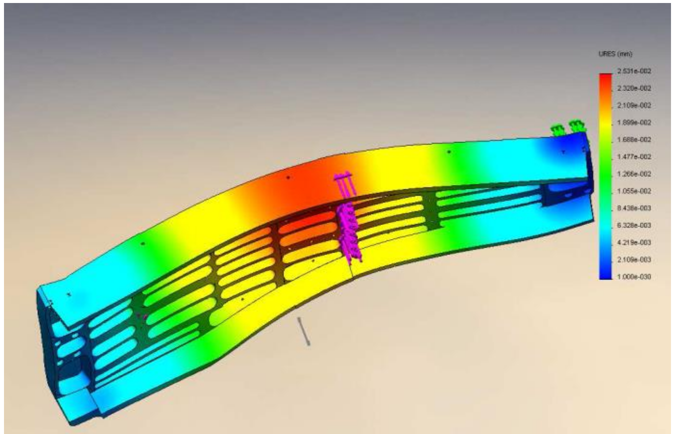


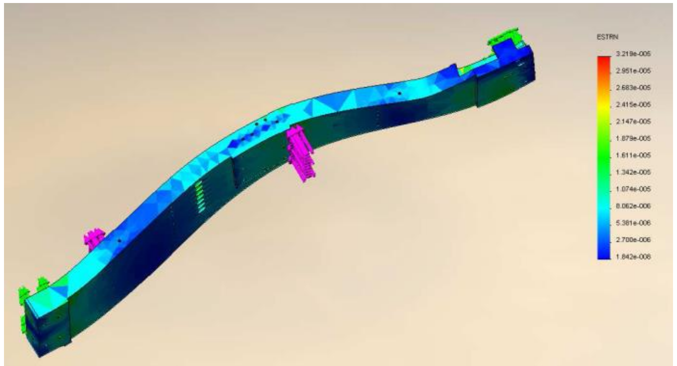
Design, Material choice.

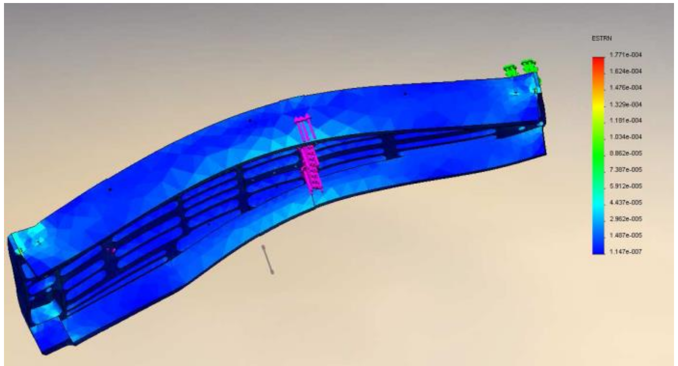
- Low expansion alloy **(Young's modulus = 150 Gpa)**

Weight : 27kg	Max displacement : 31,5µm	Weight : 17kg	Max displacement : 25µm

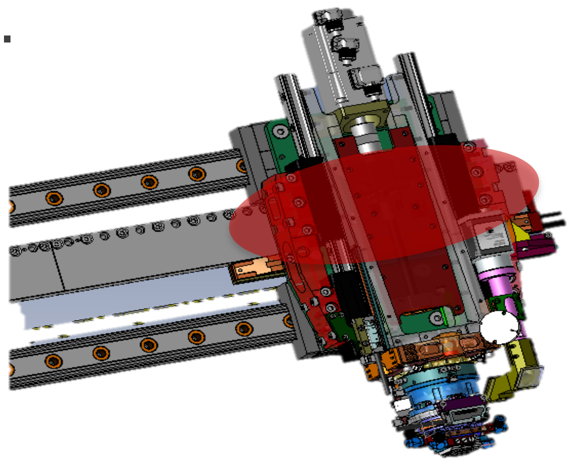




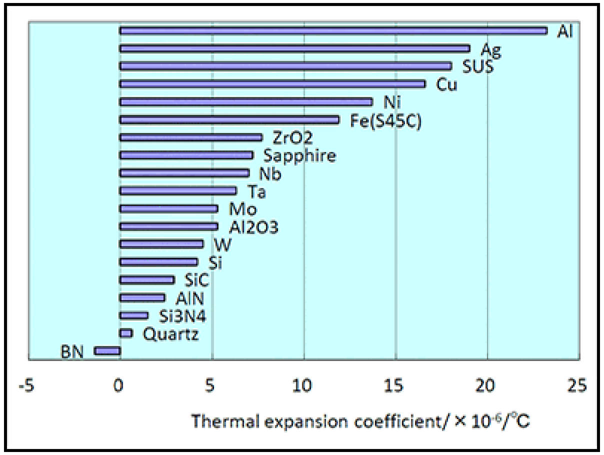


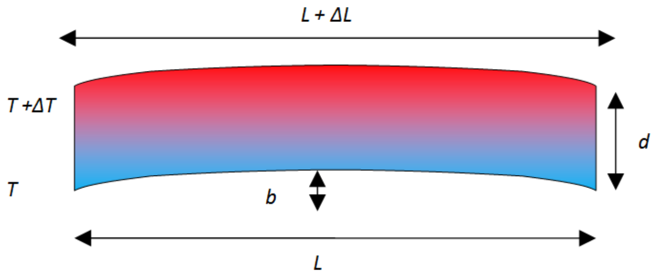


Material choice, Heat management.

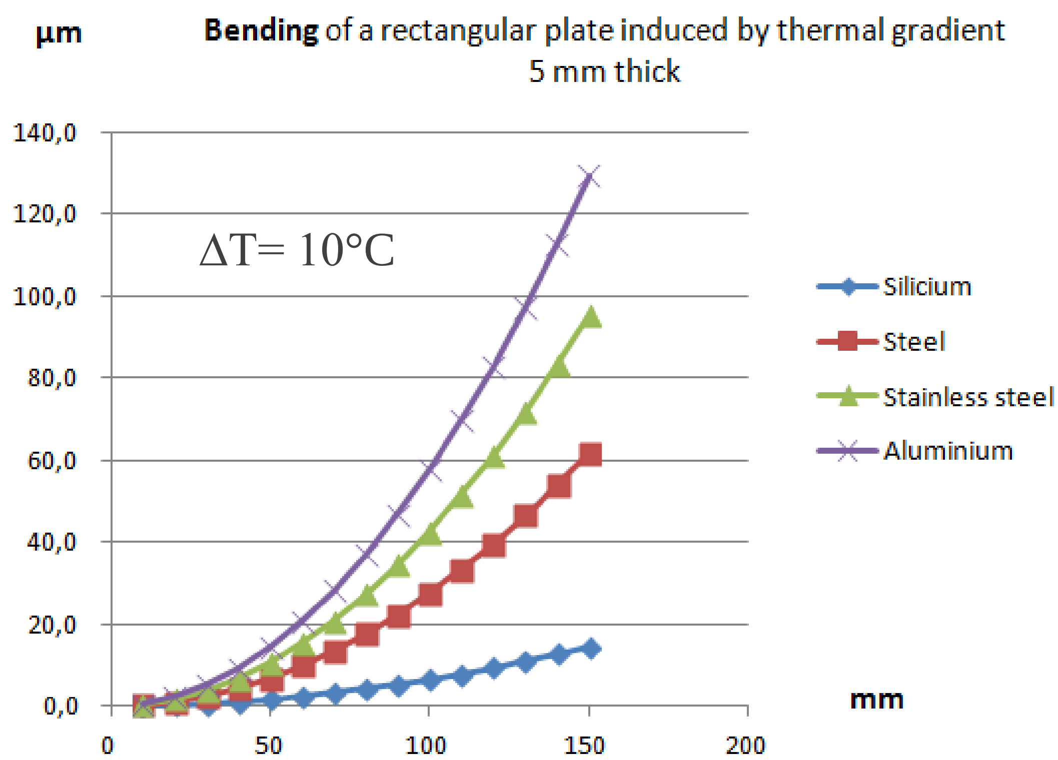


- Thermal expansion (ΔL=α . L_0 . ΔT)





$$b = \frac{\alpha \,.\, L^2 \,.\, \Delta T}{8.\, d}$$



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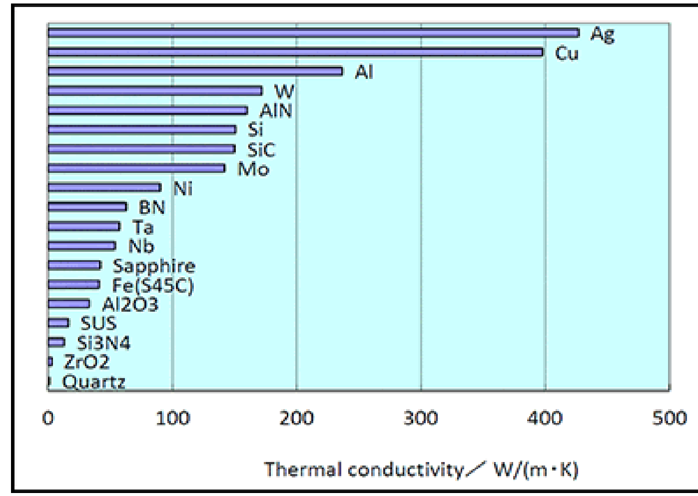
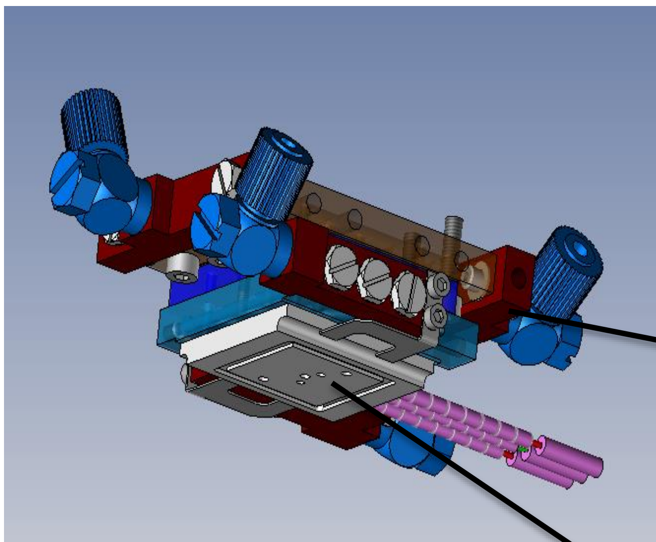
Material choice, Heat management.

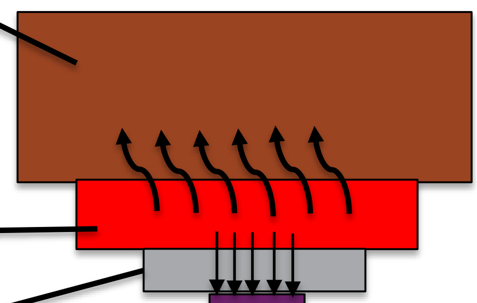
- Thermal conductivity (W.m^{-1}.K^{-1}),
- Heat dissipation





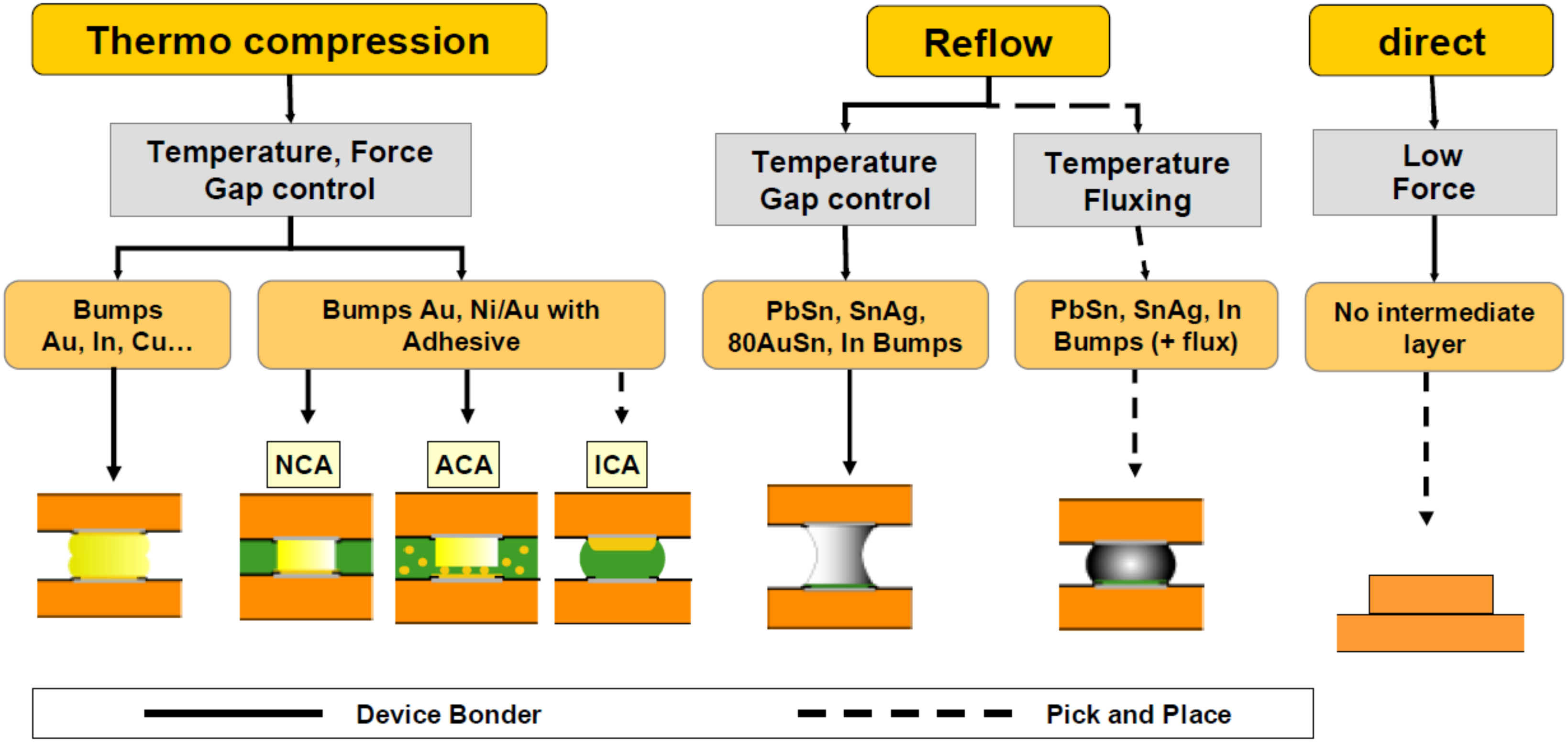
Heater

(TC bonding heater).



- Conduction
- Convection
- Radiation

Process impact.



Improvements examples.

Bonding arm.

Force
from 1N to 4000N

Moving mass: 40kg

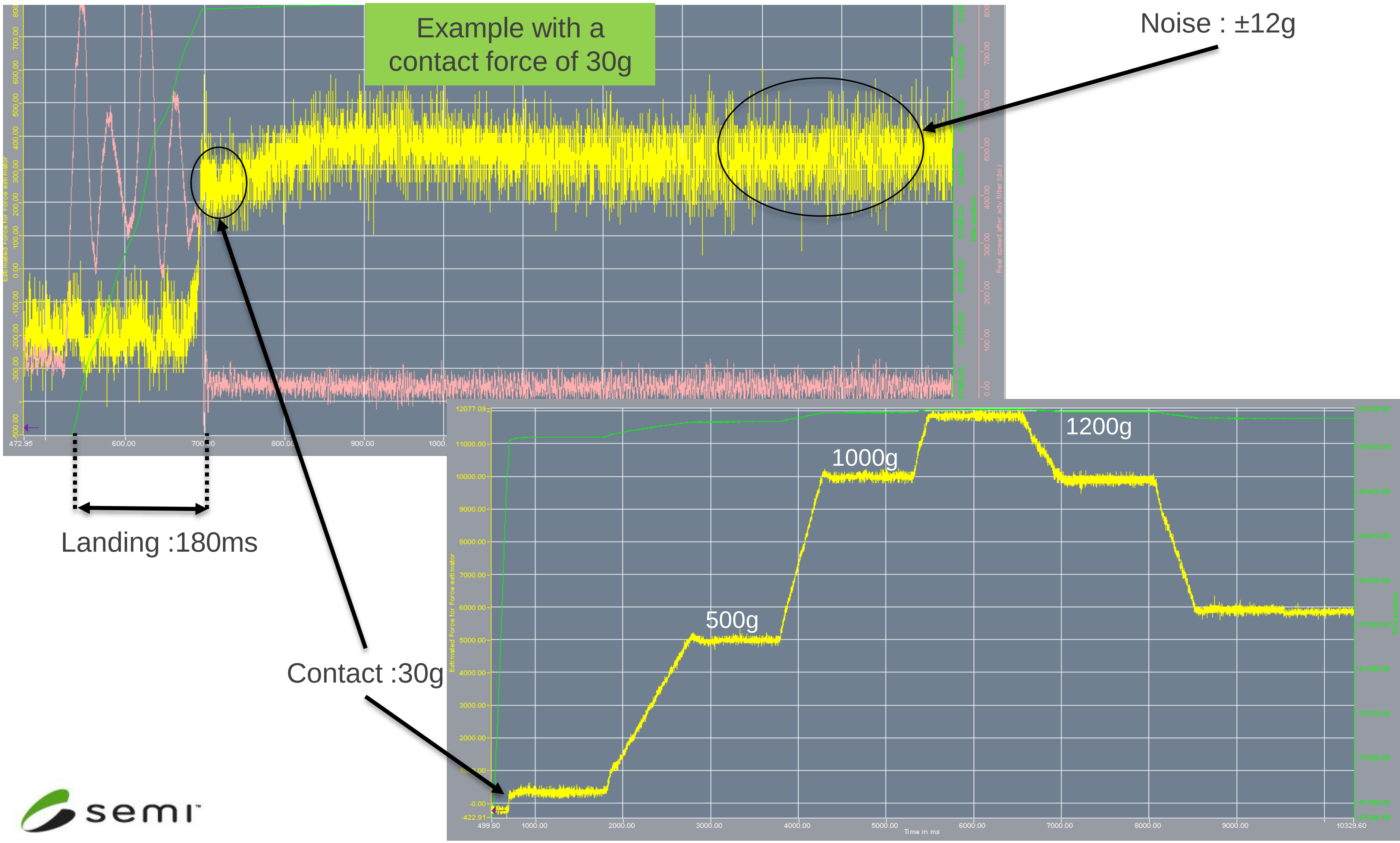
Same scale

Force
from 0.3N to 300N

Moving mass: 3,3kg

Bonding arm.

- Force control.

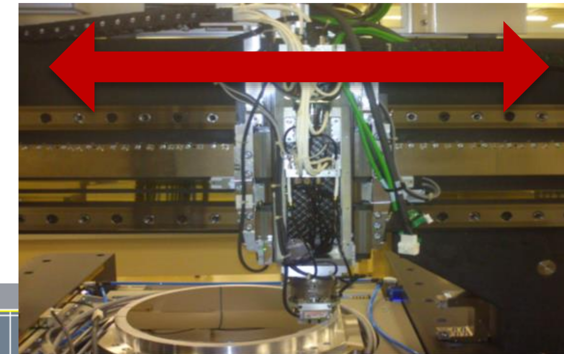


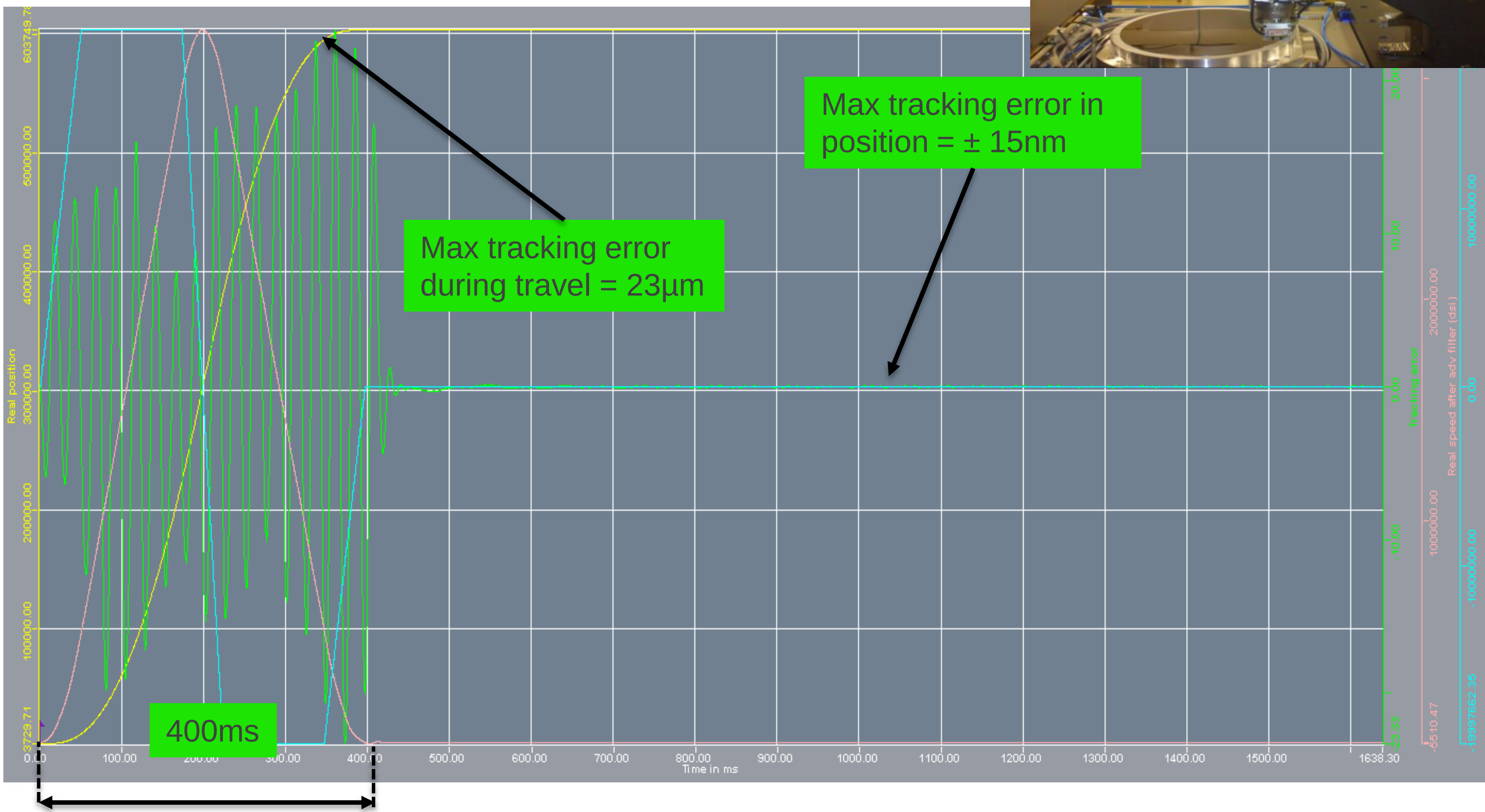
Bonding head.

- Movement control.

Bonding head, X movement :

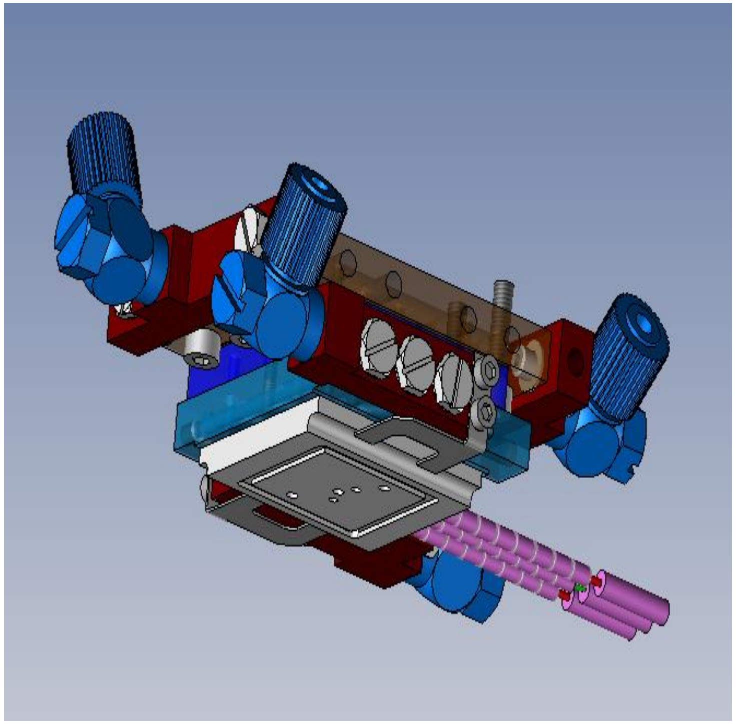
- Moving mass = 12kg
- Movement stroke = 1m

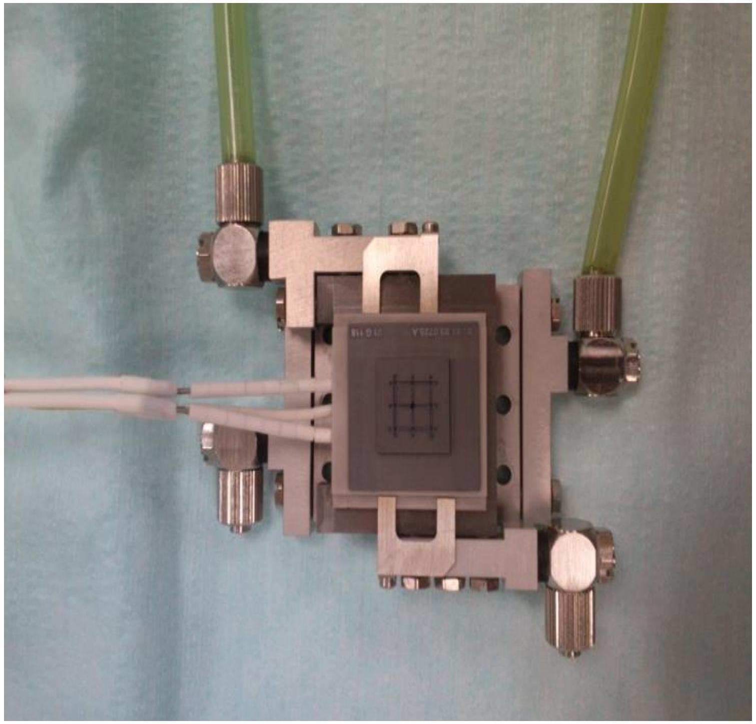




Heater (TC bonding heater).

- Example with a 26x26mm heater in real conditions.





Heater (TC bonding heater).

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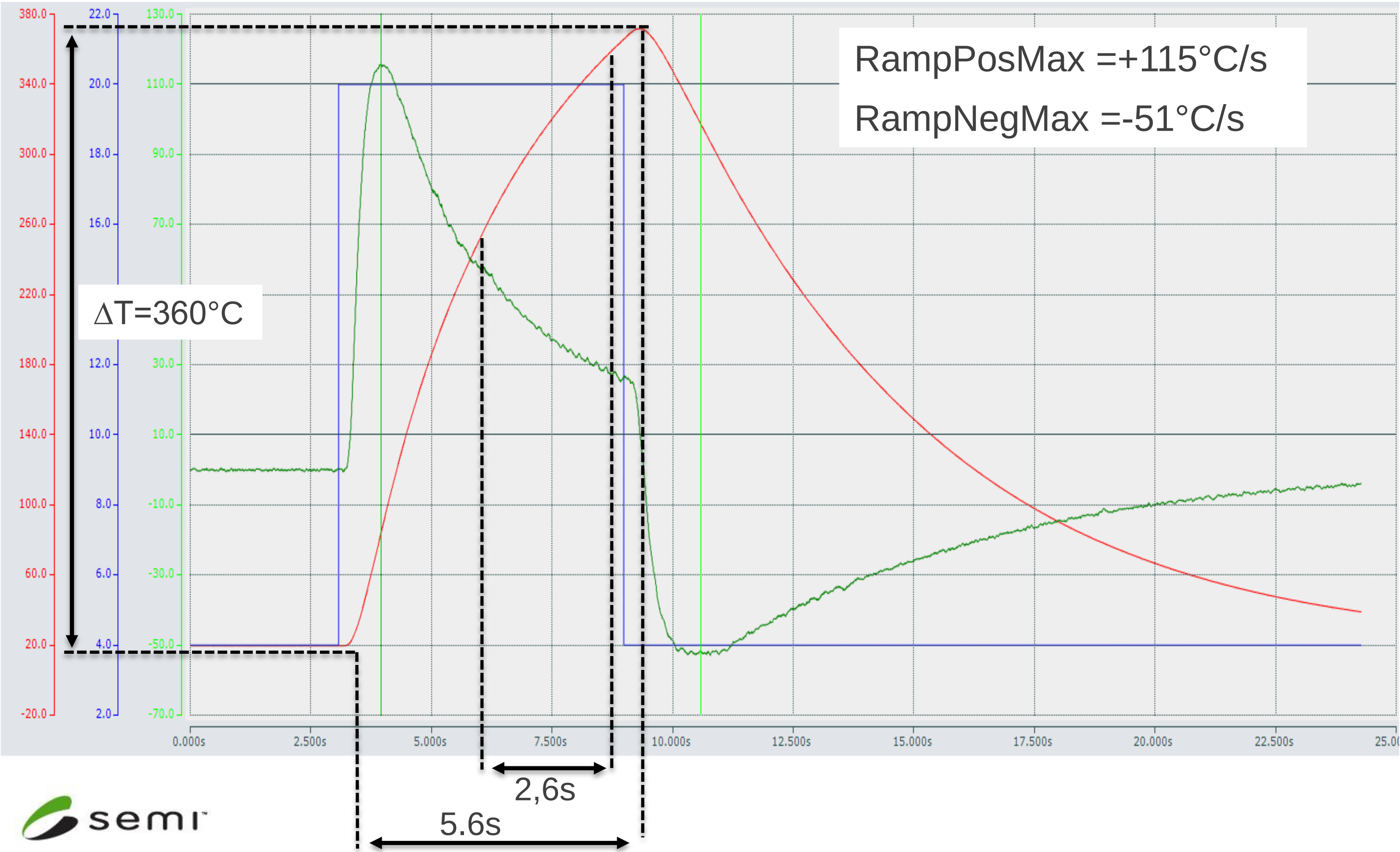

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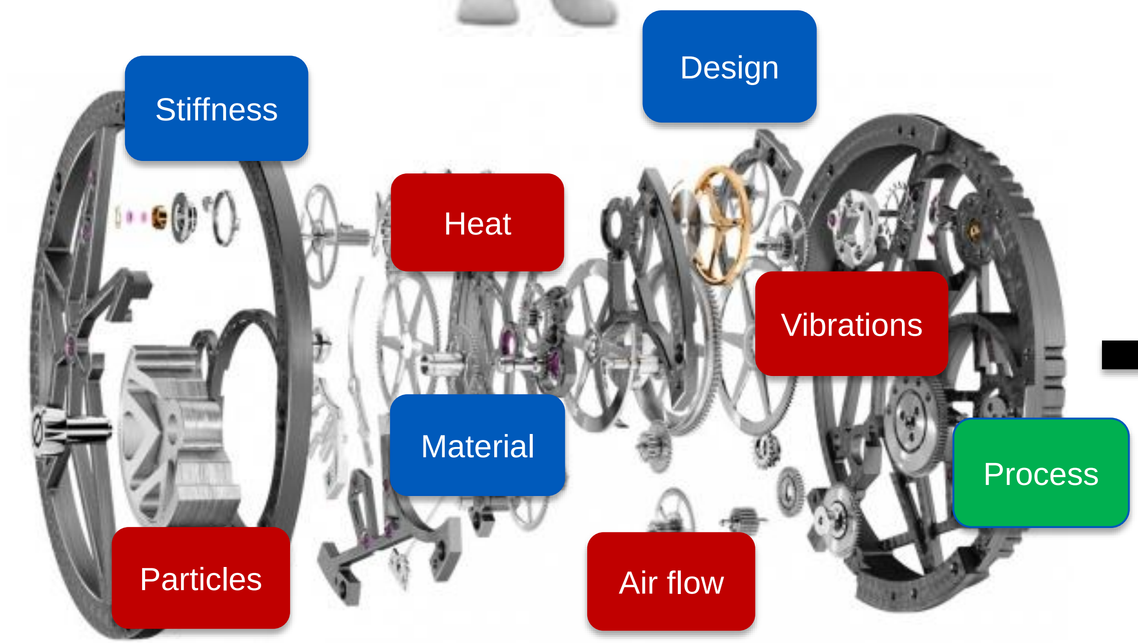
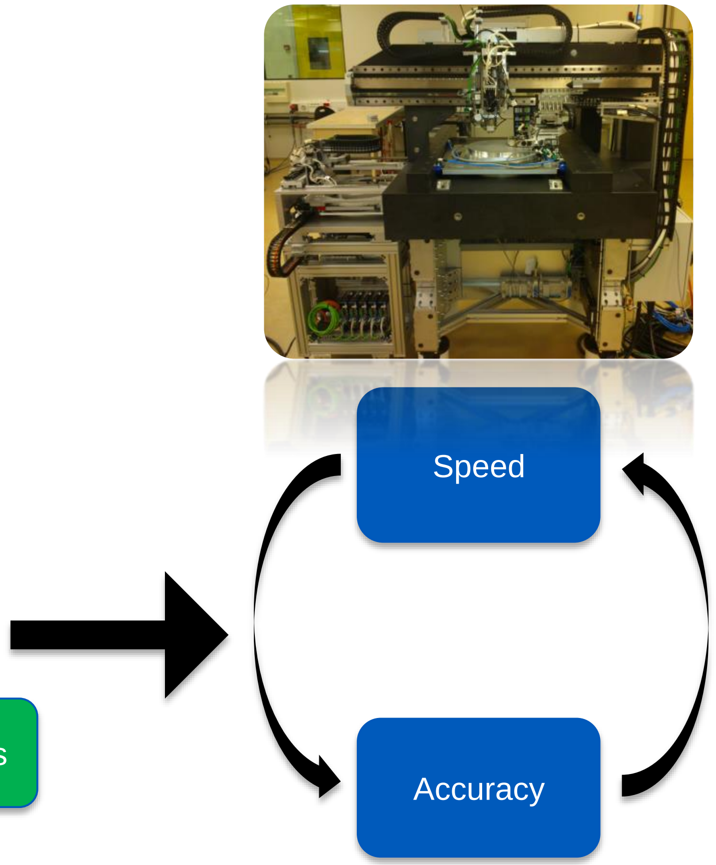
In summary.

Accurate and rigorous on every details.

- Need to understand, to measure, to test, to qualify…





Next step: Collaboration.

Collaboration.

Saint-Jeoire, France January, 2016

SET – Smart Equipment Technology, the leading supplier in high accuracy Die-To-Die and Die-To-Wafer bonders, today announced its participation in the 3D integration consortium of IRT Nanoelec, which is headed by CEA-Leti. SET is thus joining Leti, STMicroelectronics and Mentor Graphics to develop advanced 3D Die-To-Wafers stacking technologies, using direct Copper-To-Copper bonding.

2016 **innovation**

THANK YOU FOR YOUR ATTENTION

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