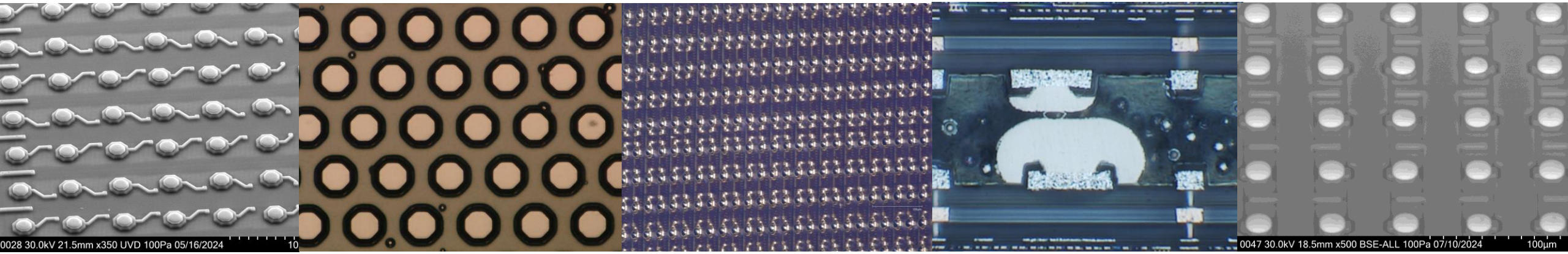
EP-DT
Detector Technologies

EP R&D

In-house plating updates



4th DRD3 week

10–14 Nov. 2025

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3: Universite de Geneve 4: KIT - Karlsruhe Institute of Technology

Introduction

- Hybrid design allows independent optimization of sensor and ASIC
- Standard Sensor and ASIC interconnection:
  - → solder bump bonding
  - → lithography steps required
  - → expensive and complex for single dies, Multi-Project Wafer or small quantities

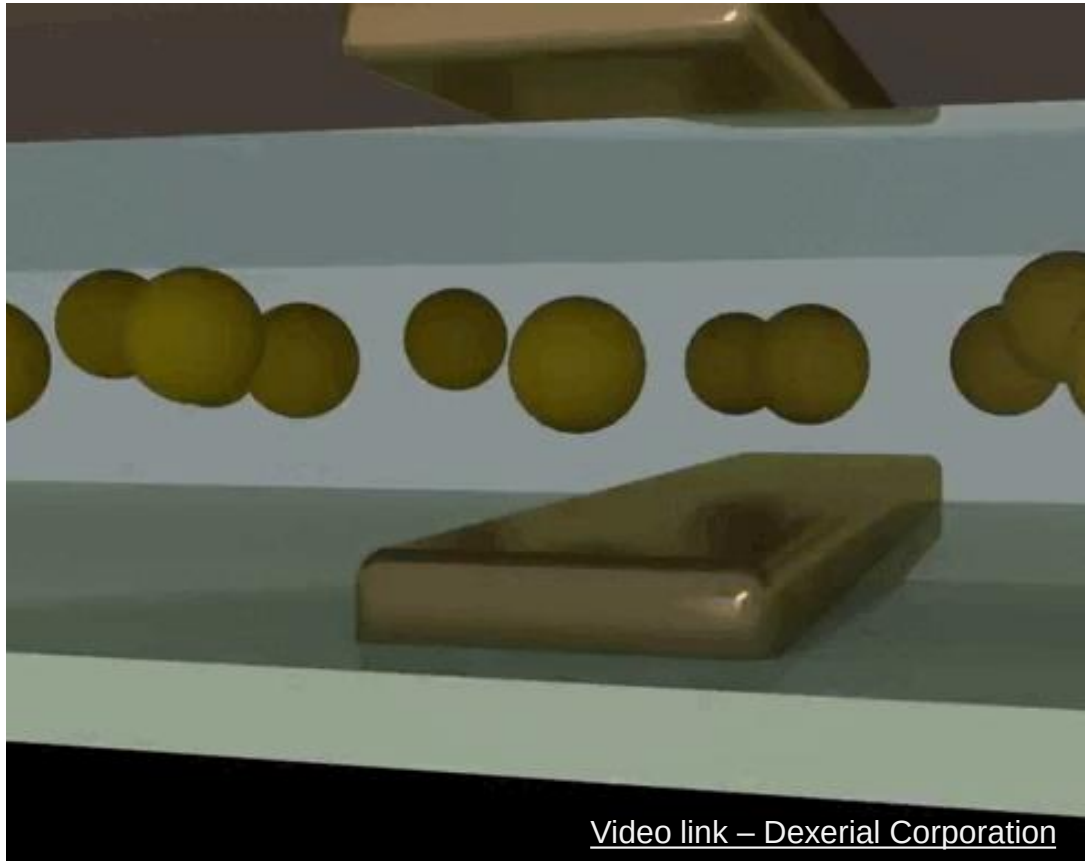
→ Are there alternatives to solder bump bonding that are suitable for single dies?

Development of an in-house module hybridization technique in two main steps:

1. Creation of bumps on the pads of sensor and ASIC with ENIG plating
2. Flip-chip assembly with an anisotropic conductive adhesive between the chips

Advantages:

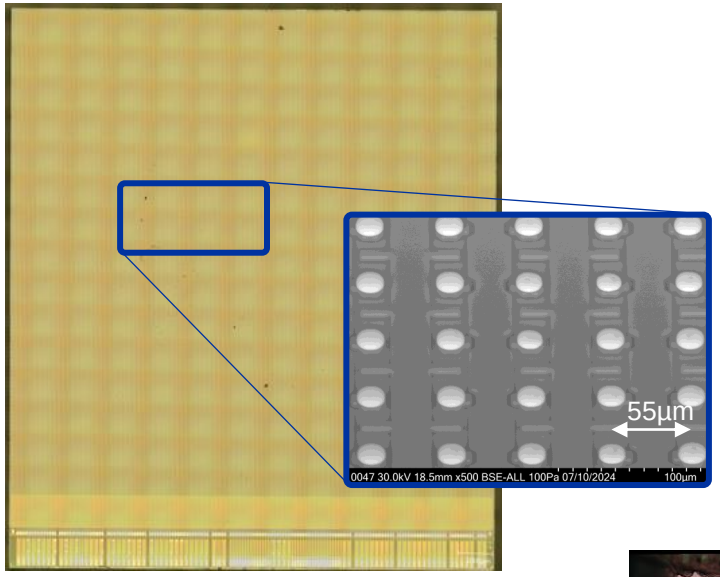
- **Cost-effective**
- **Adaptable** to application
- **Single die** process
- Low temperature process
- Scalable
- Maskless



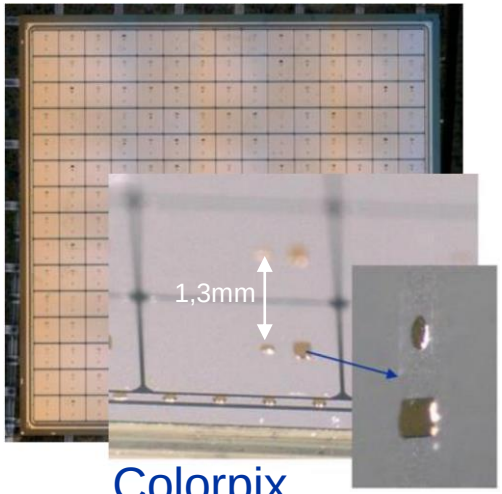
ENIG: Electroless **N**ickel **I**mmersion **G**old
ACA: Anisotropic **C**onductive **A**dhesive

Achieved ENIG plating

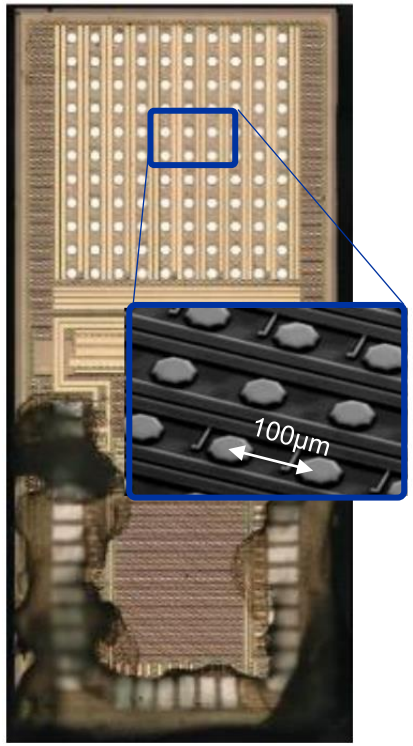
Timepix3



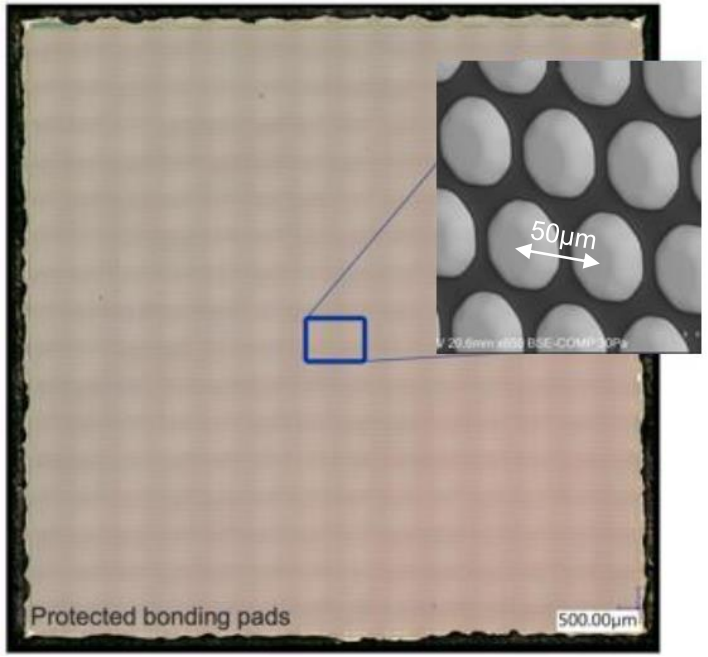
LGAD sensor



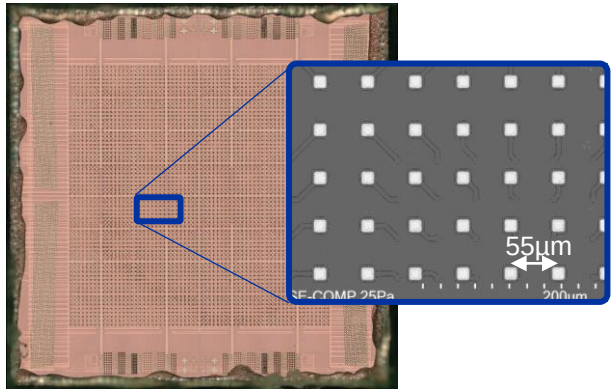
SiGe KEK



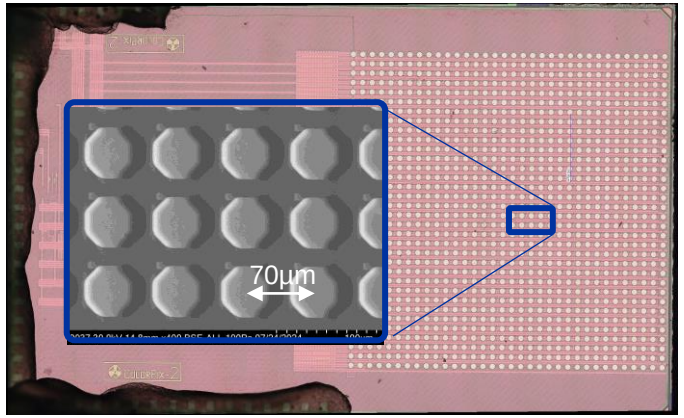
XPOL-III



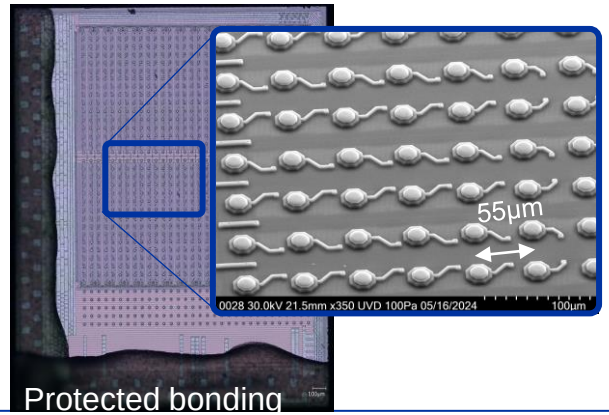
Ignite



Colorpix

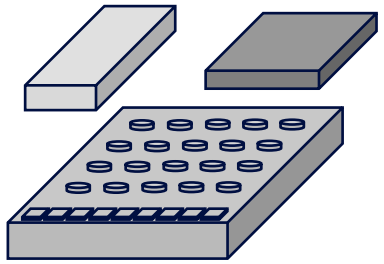


Timespot



Many different chips with different pitch and chip sizes have already been plated

Process flow ENIG plating

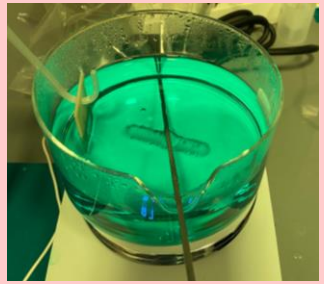


ASICs / Sensors

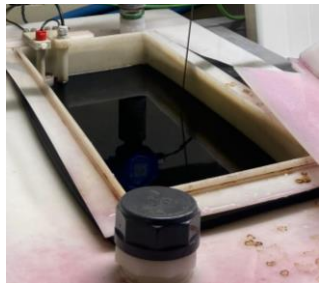
Pretreatment

Focus for today

Ni-deposition



Immersion Gold

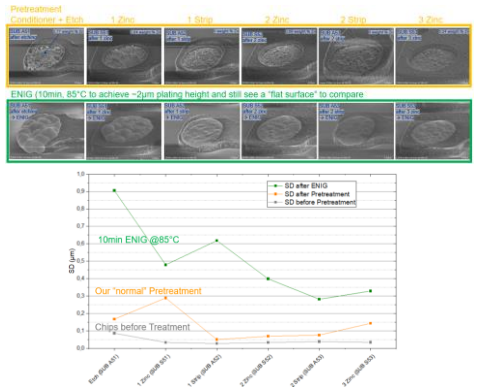


Analysis

- Microscope
- SEM
- Bump height analysis

- Pad size
- Passivation Opening
- Pitch
- Matrix size
- Passivation

→ Affect Bump geometry

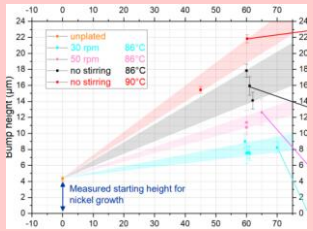


→ Affect Bump uniformity

More details

The deposition rate is similar for different chips

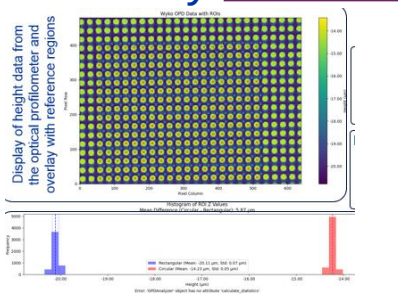
More details



→ Detailed investigation

Not investigated yet

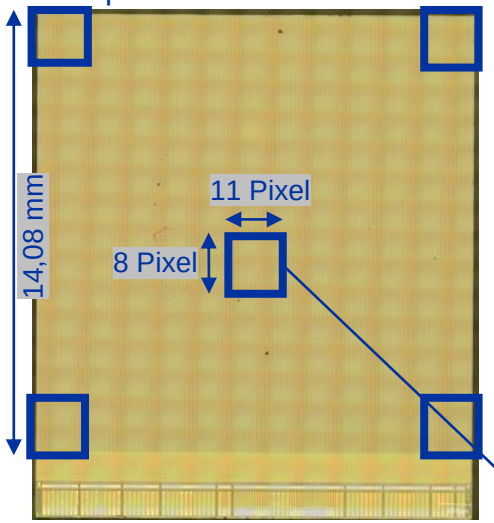
- Development of a software for determination of bump height and uniformity More details



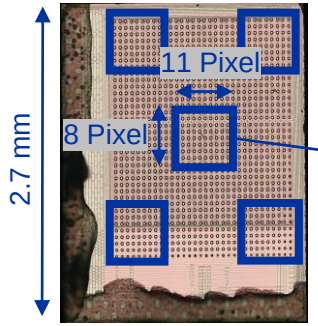
Analysis of the height and uniformity of ENIG bumps

1 Select Areas on Chip

Timepix3 with measured areas



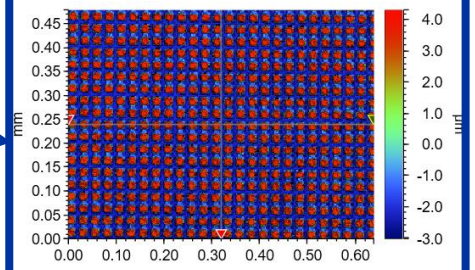
Timespot with measured areas



2 Optical profilometer measurement

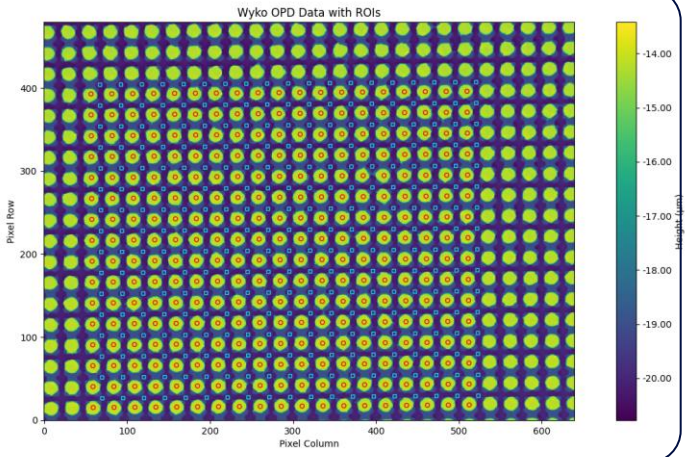
Bruker Contour
@ CampusBiotech

Height data per area

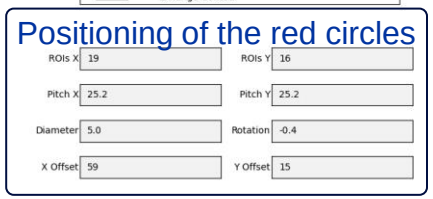


3 Calculation of heights for statistical comparison with custom-developed software

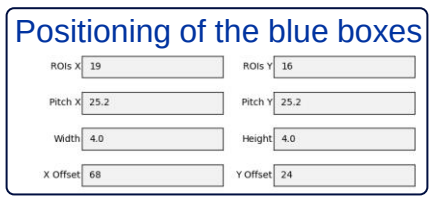
Display of height data from the optical profilometer and overlay with reference regions

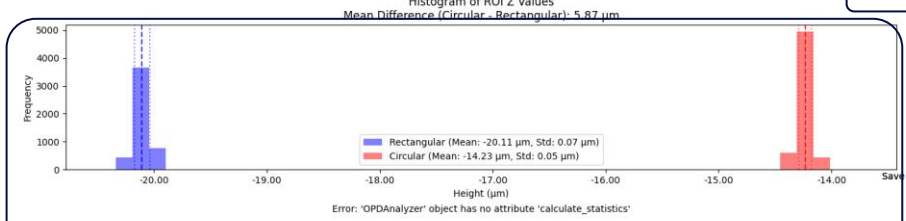


Positioning of the red circles

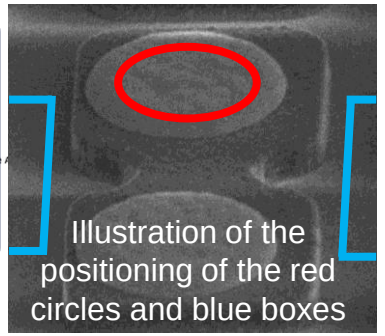


Positioning of the blue boxes



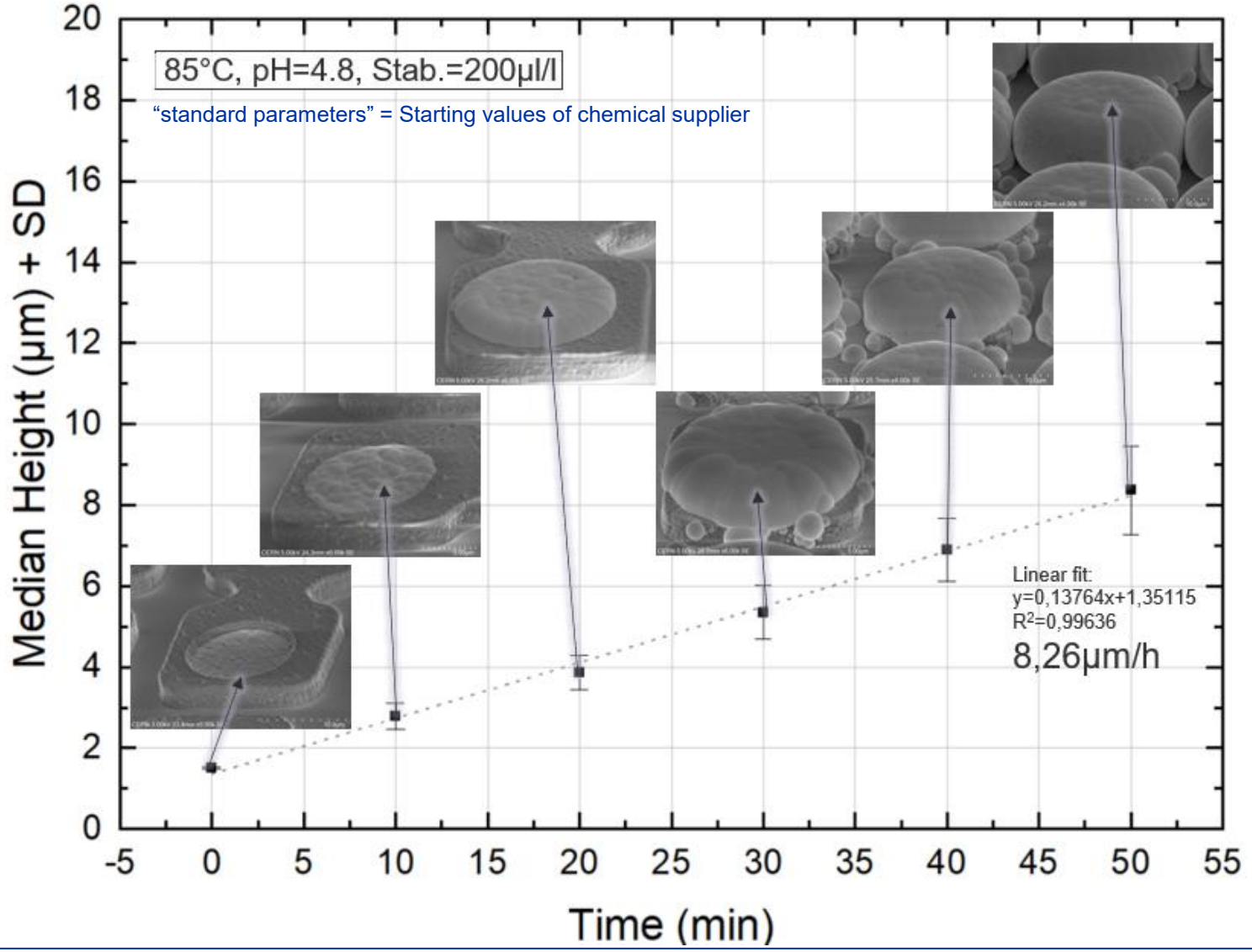


Representation of the height values from the reference regions in a histogram

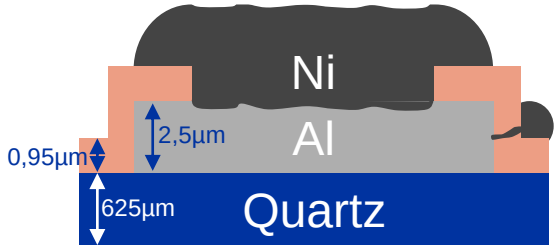


→ Determination of the median value and standard deviation of the bump height as a measure for height and uniformity

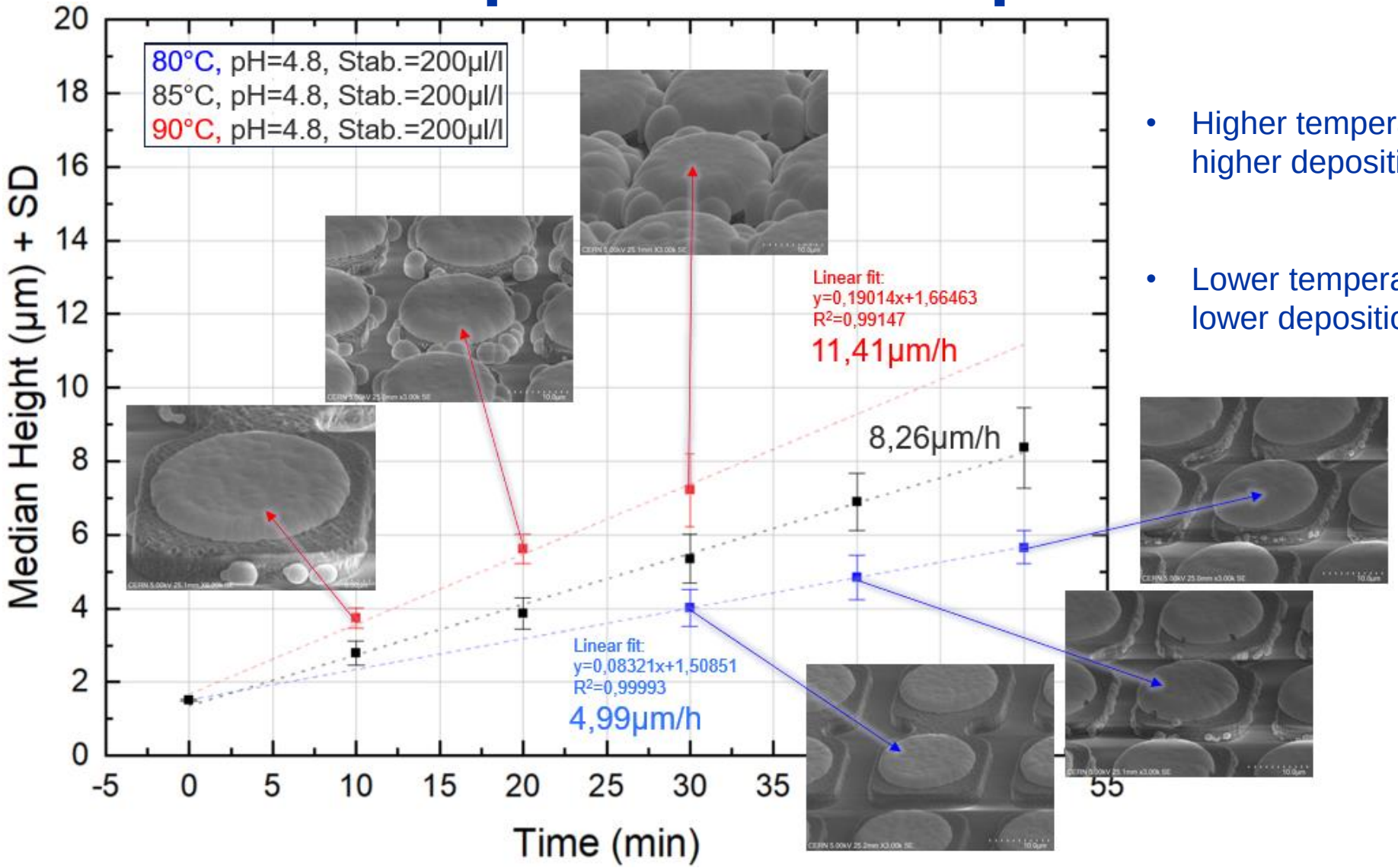
Nickel deposition with “standard parameters”



- DC samples with 400x400 matrix and 25µm pitch
- Nickel growth at a constant speed
- Nickel growth is isotropic, resulting in a corresponding bump shape depending on the pad geometry
- “Overplating” presumably due to pinholes in the passivation

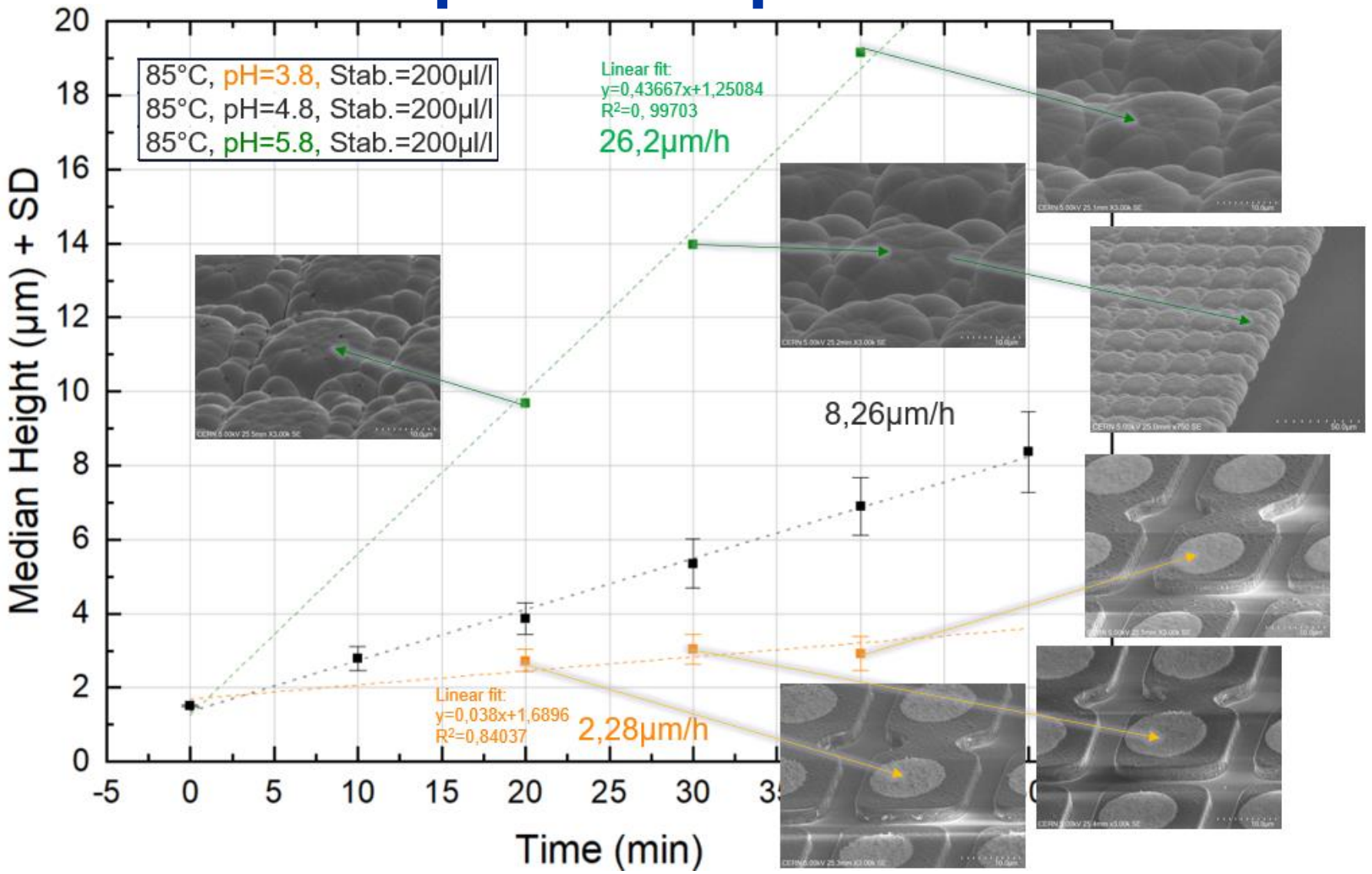


Influence of temperature on deposition-rate



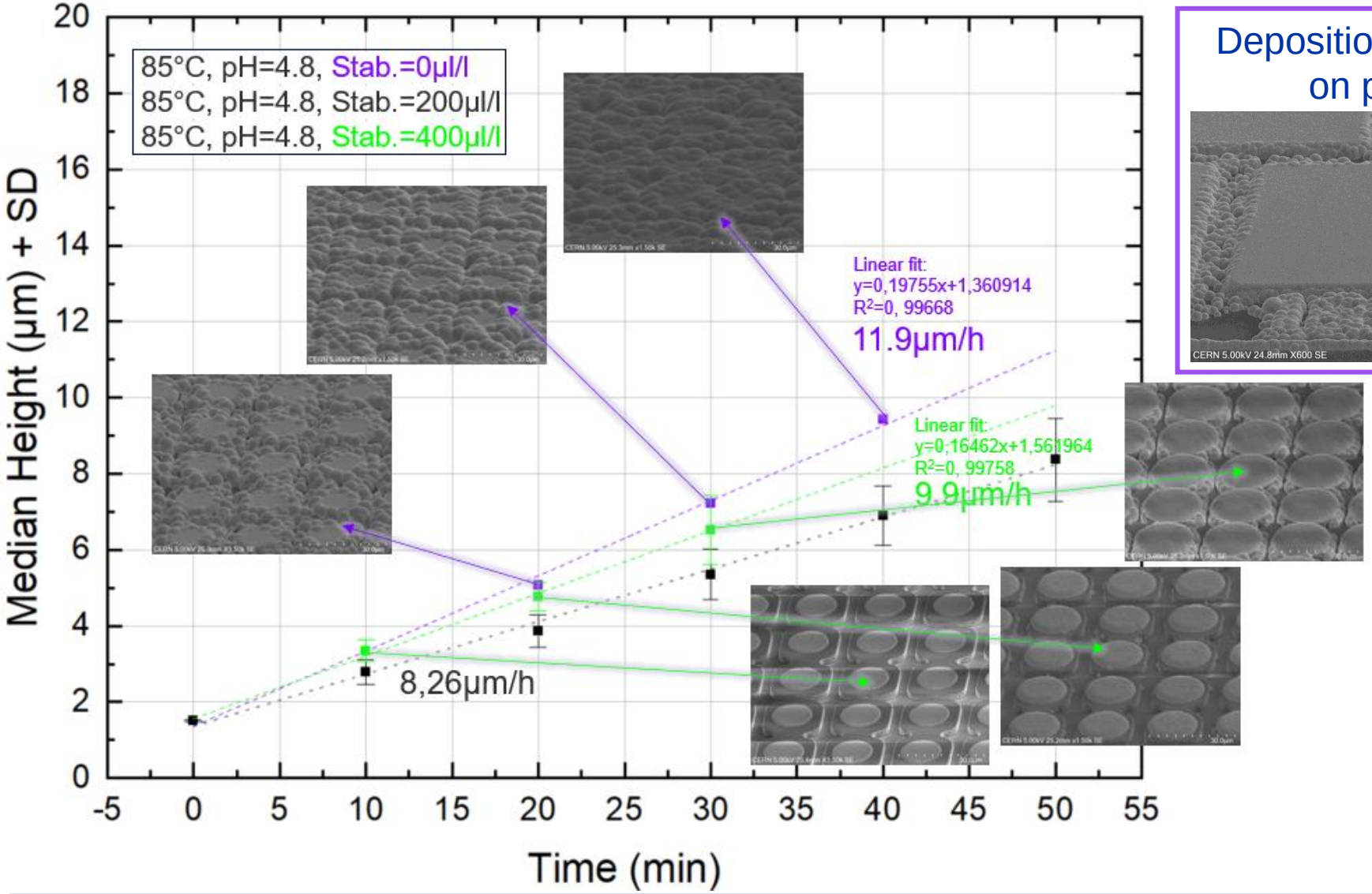
- Higher temperature leads to a higher deposition rate
- Lower temperature leads to a lower deposition rate

Influence of pH on deposition-rate

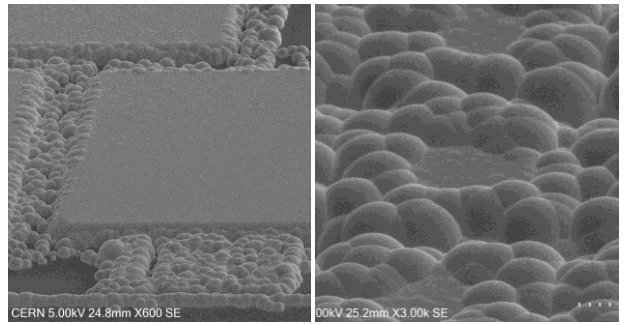


- Higher pH leads to a higher deposition rate
  (Since the bumps were connected, the software could not be used here, instead measurements were taken manually at the edge)
- Lower pH leads to a lower deposition rate
- The influence on the deposition rate of pH ± 1 is significantly greater than that of ± 5°C

Influence of stabilizer on deposition-rate



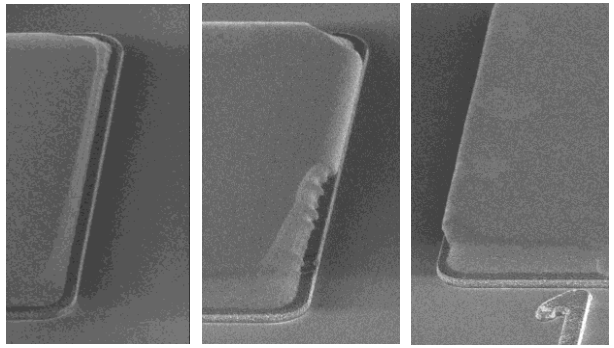
Deposition seems to start on passivation



Growth through Pinhole

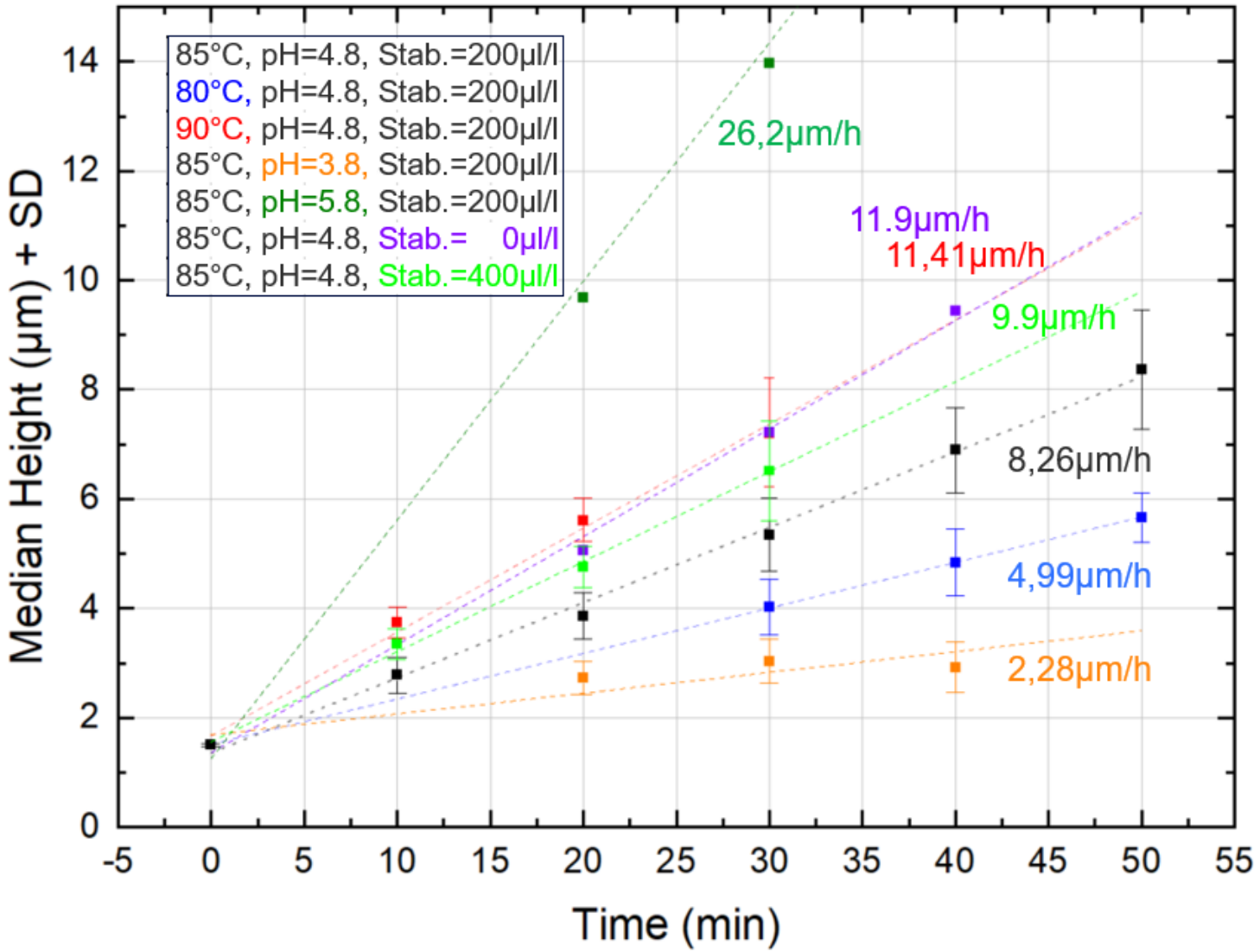
Growth on passivation

Deposition seems to stop randomly



→ 200 µl/l gives best results

Influence of parameters on deposition-rate

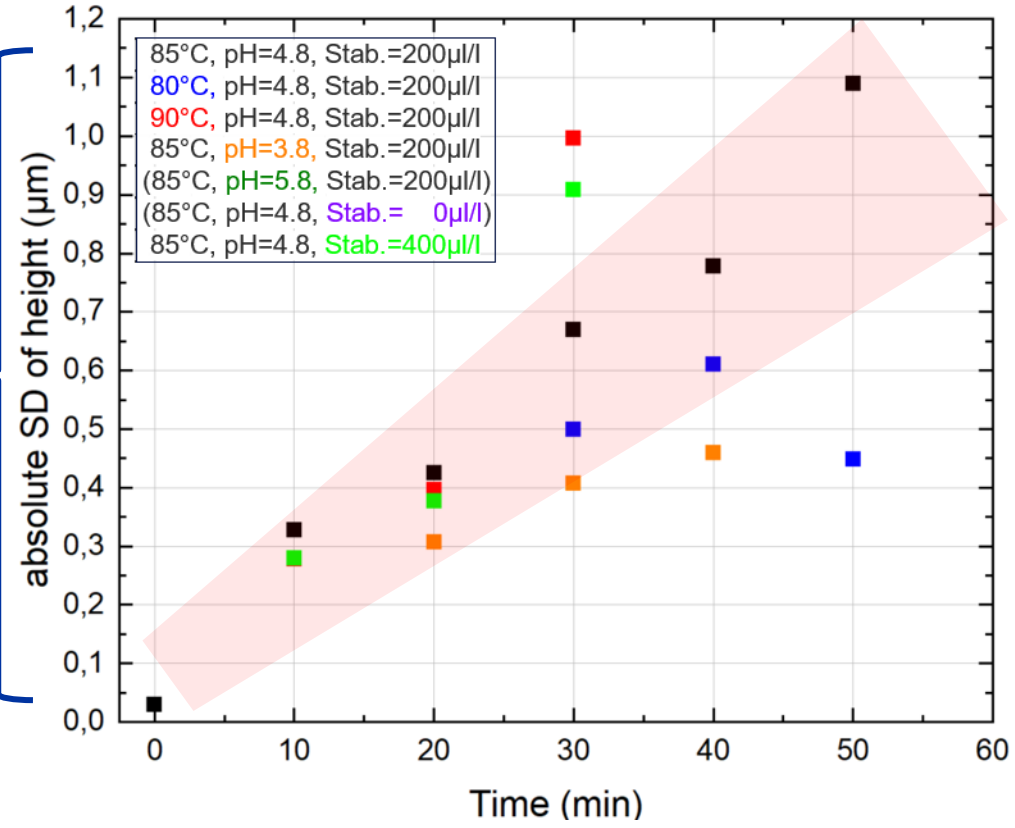


- Parameters such as temperature, pH and stabilizer concentration have a direct influence on plating
- Temperature and pH can be increased to achieve a higher deposition rate
- The stabilizer concentration should be around 200µl/l to stabilize the plating but not stop it

→ Examination of the uniformity of all samples to find a possible correlation between the parameters and uniformity

Correlation between plating parameters and uniformity?

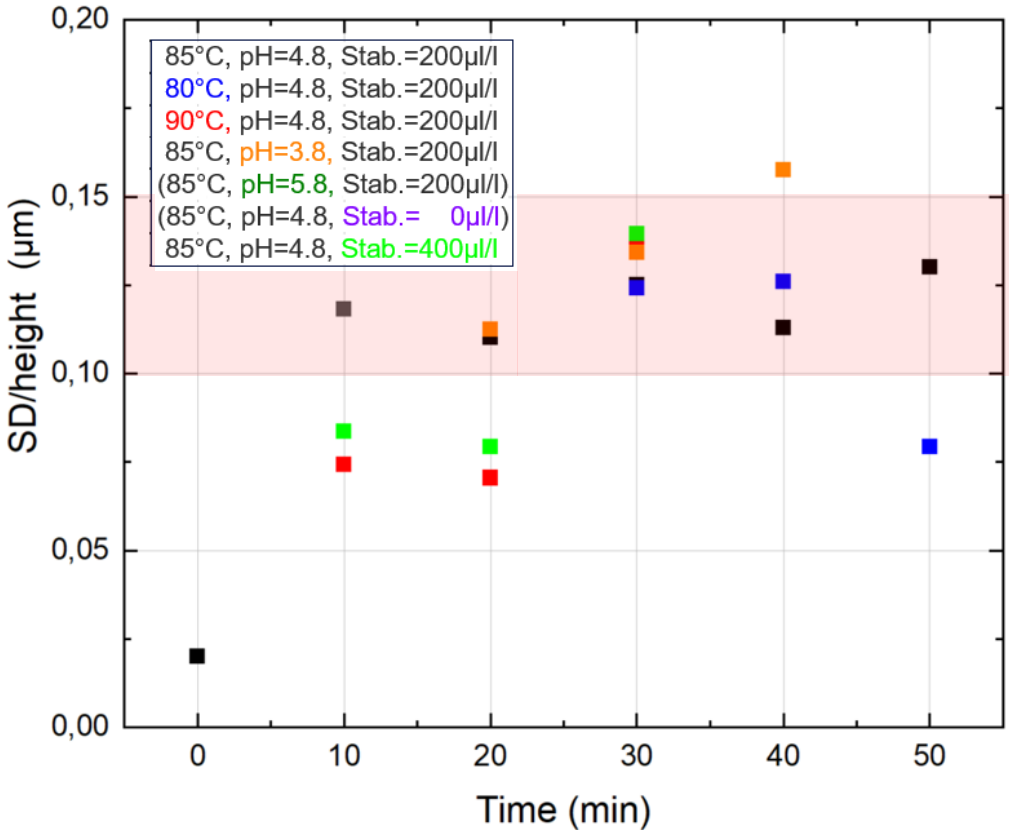
Graphic showing absolute uniformity



SD below 1,1µm

Absolute SD increases with plating time or plating height.

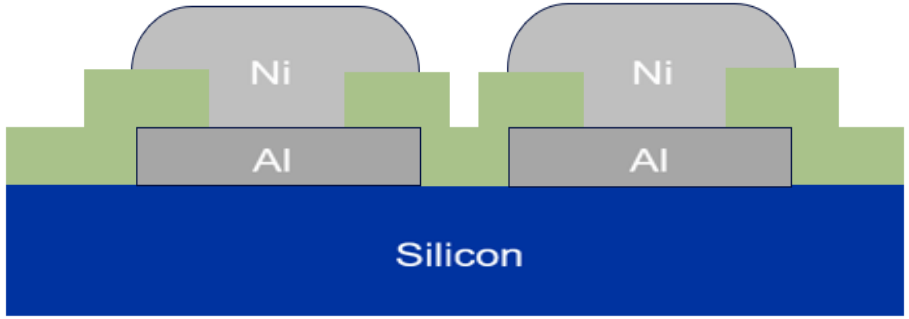
Graphic showing uniformity in relation to height

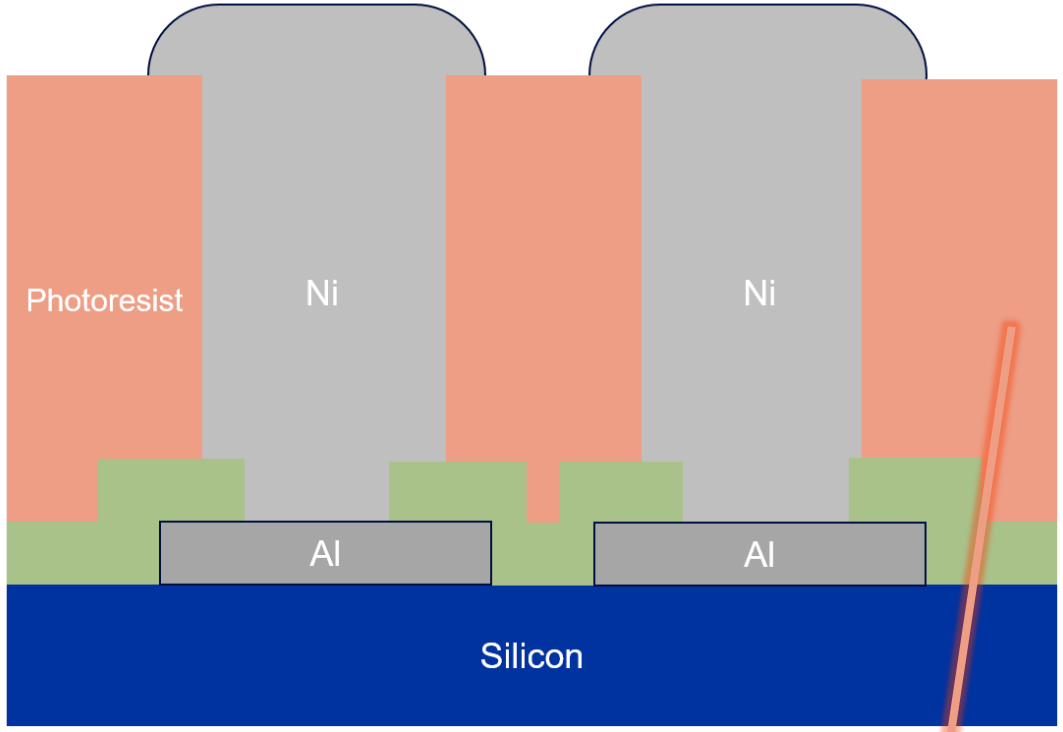


SD in range of 7-16% of height for all samples

SD linked to plating height
Tendency for lower SD at high deposition rate?

Future ideas:

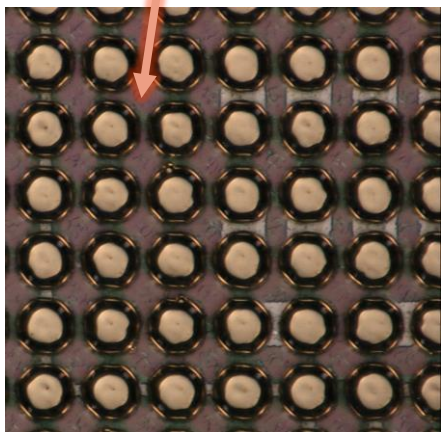




- Achievable bump height limited by pitch and surface layout
  → need to avoid shorts between pixels

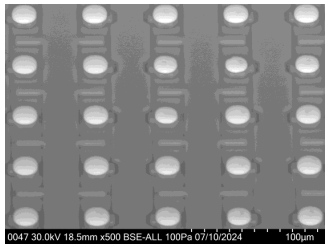
- A photoresist could be used to create pillar or mushroom-like bumps.

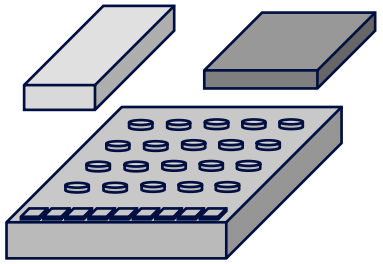
- First test already demonstrated, but suitable PR must be found.



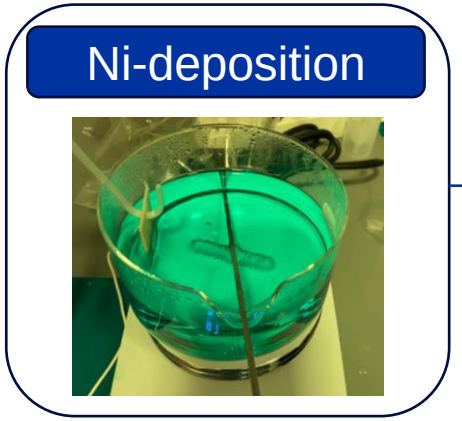
Summary

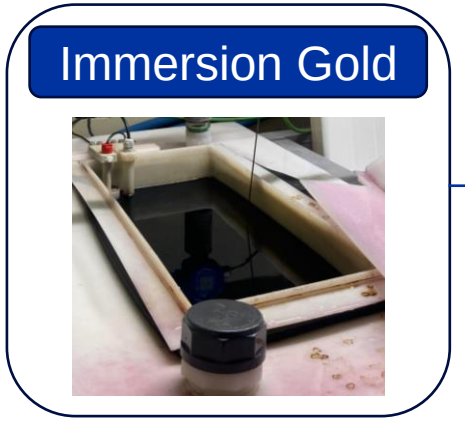
- We can grow nickel bumps on different chips.
  These nickel bumps can be used as UBM or for our in-house hybridization.

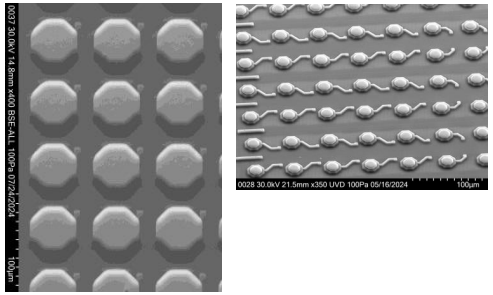




ASICs / Sensors







ENIG UBM / Bump

- The maximum achievable height is linked to the chip geometries.
- We can adjust the deposited height of the nickel bumps.
- The nickel bumps have a good uniformity of approximately 7-16% of their height across the entire pixel matrix.
- Faster growth of nickel bumps leads to slightly better uniformity.