



# Bump Bonding



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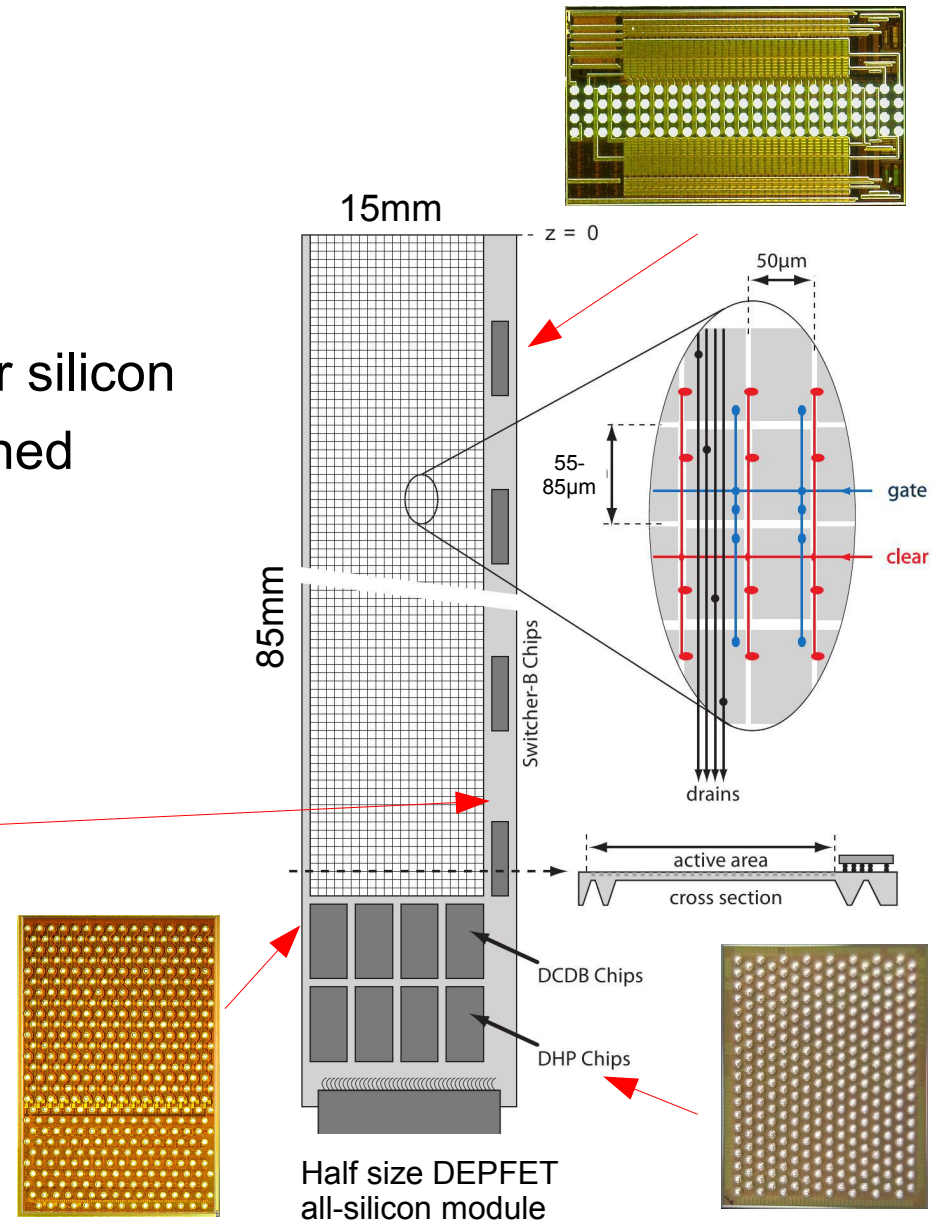
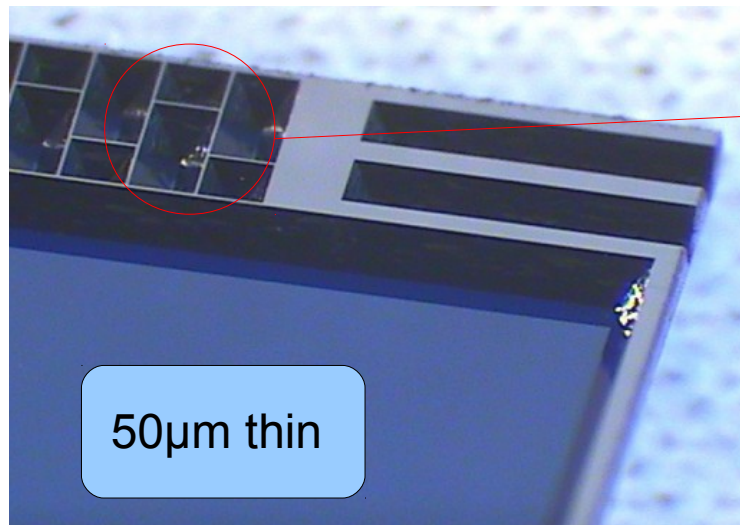
6th Annual Workshop of the Helmholtz Alliance

Hamburg

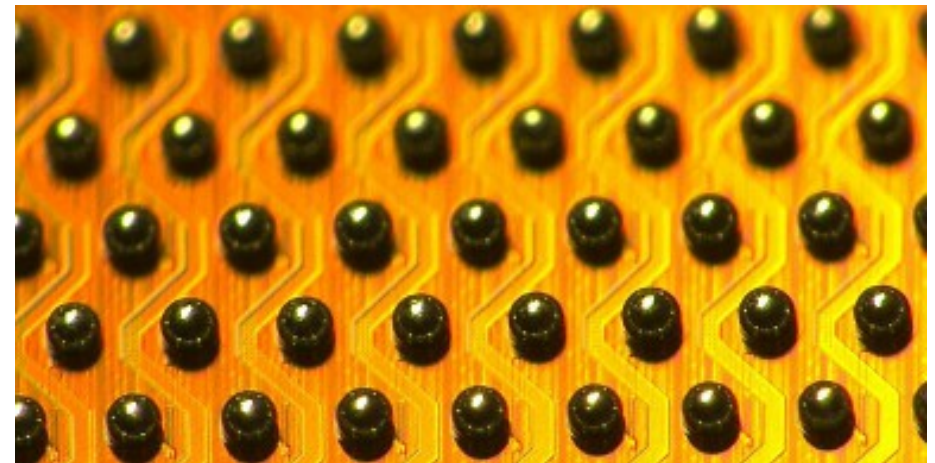
04.12.2012

# DEPFET all-silicon module

- DEPFET pixel detector
  - Belle tracker upgrade
  - ILC vertex detector
- self-supporting all-silicon module
  - no interposers: flip-chip onto detector silicon
  - thinning down to 50 $\mu$ m, partially thinned support frame
  - low material budget: 0.18% X0

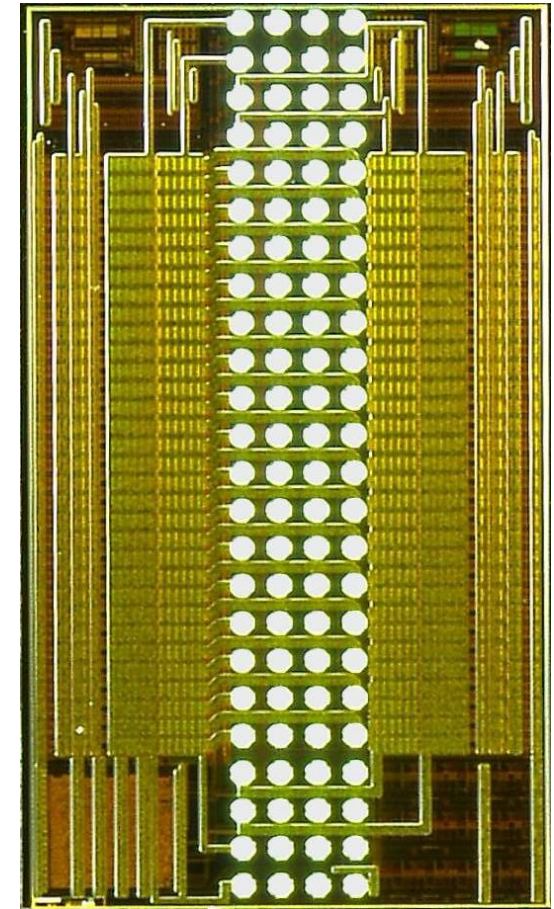


- Multi-Project Wafer (MPW) Chip Submissions
  - many designs on a single wafer layout -> production cost sharing
  - no access to wafers
  - single chips are delivered
  - limited set of technology options
- DEPFET ASIC bumping
  - DCDB, DHP: MPW bumping available
  - SwitcherB: no MPW bumping



100 $\mu$ m bumps of DCDB read-out chip

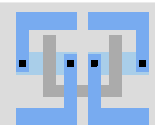
- Bumping technology for SwitcherB required
  - easy-to-use, low infrastructure requirements
  - gold stud thermocompression already available
  - but: high forces on thinned balcony problematic
  - solder bumps: low force
  - solder allows to rework and repair DEPFET modules
- Solder bumping technology
  - most processes optimized for wafer level bumping: screen printing, electroplating
  - many processing steps, mask sets required
  - single chip processing possible, but complicated
  - solder jetting technology is preferred



SwitcherB without bumps

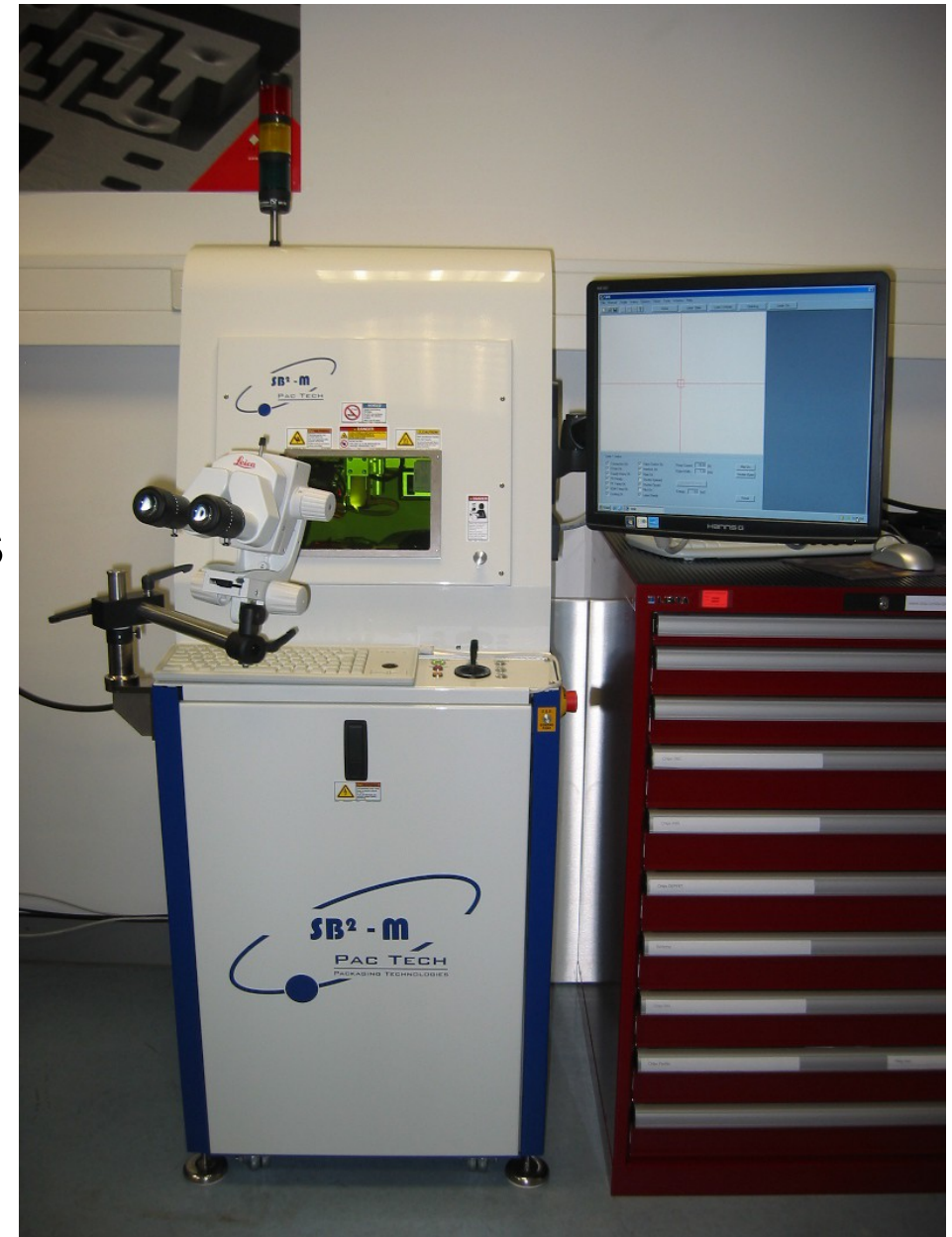
# Under Bump Metallization

- Solderable surface required
  - Al-pads for wire bonding are not solder wettable
  - MPW submissions have Al-pads
- Under Bump Metallization (UBM)
  - provides solder wettable surface
- Industry standard
  - multi layers of metal: adhesion, diffusion barrier, wettable, oxidation barrier
  - evaporation or sputtering in vacuum or wet-chemical plating
  - complicated process, masks required
- Simple UBM process
  - gold studs
  - bonder already available
  - no masks required
  - flexible

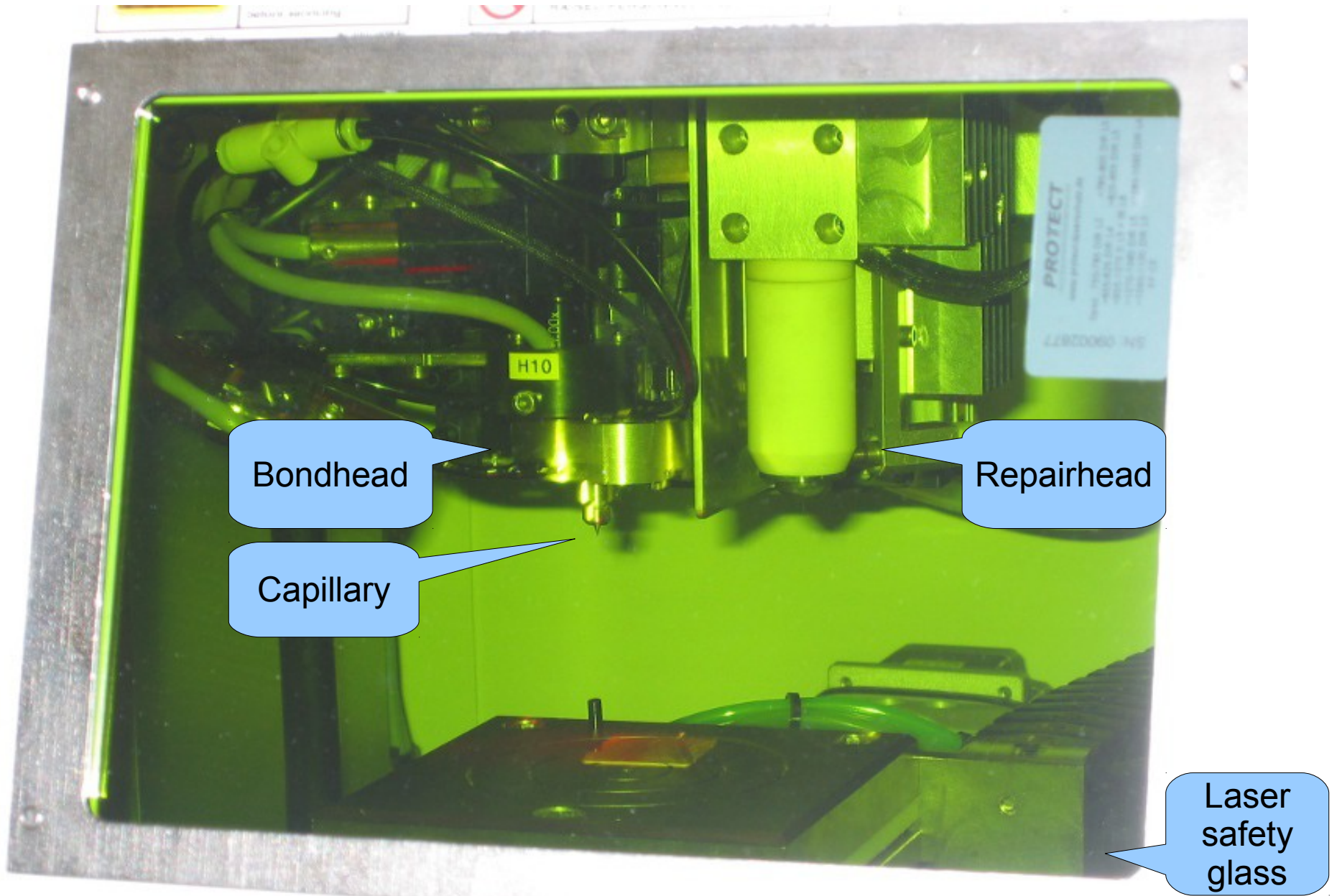


# PacTech SB2-M

- Deposit single solder balls
- 60 $\mu$ m solder balls SnAgCu
  - 40 $\mu$ m...760 $\mu$ m possible
  - Max. 5 balls/sec
- Melts ball with 20W IR laser
  - Laser enclosed in housing
- Low infrastructure requirements
  - pressured air
  - nitrogen

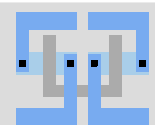
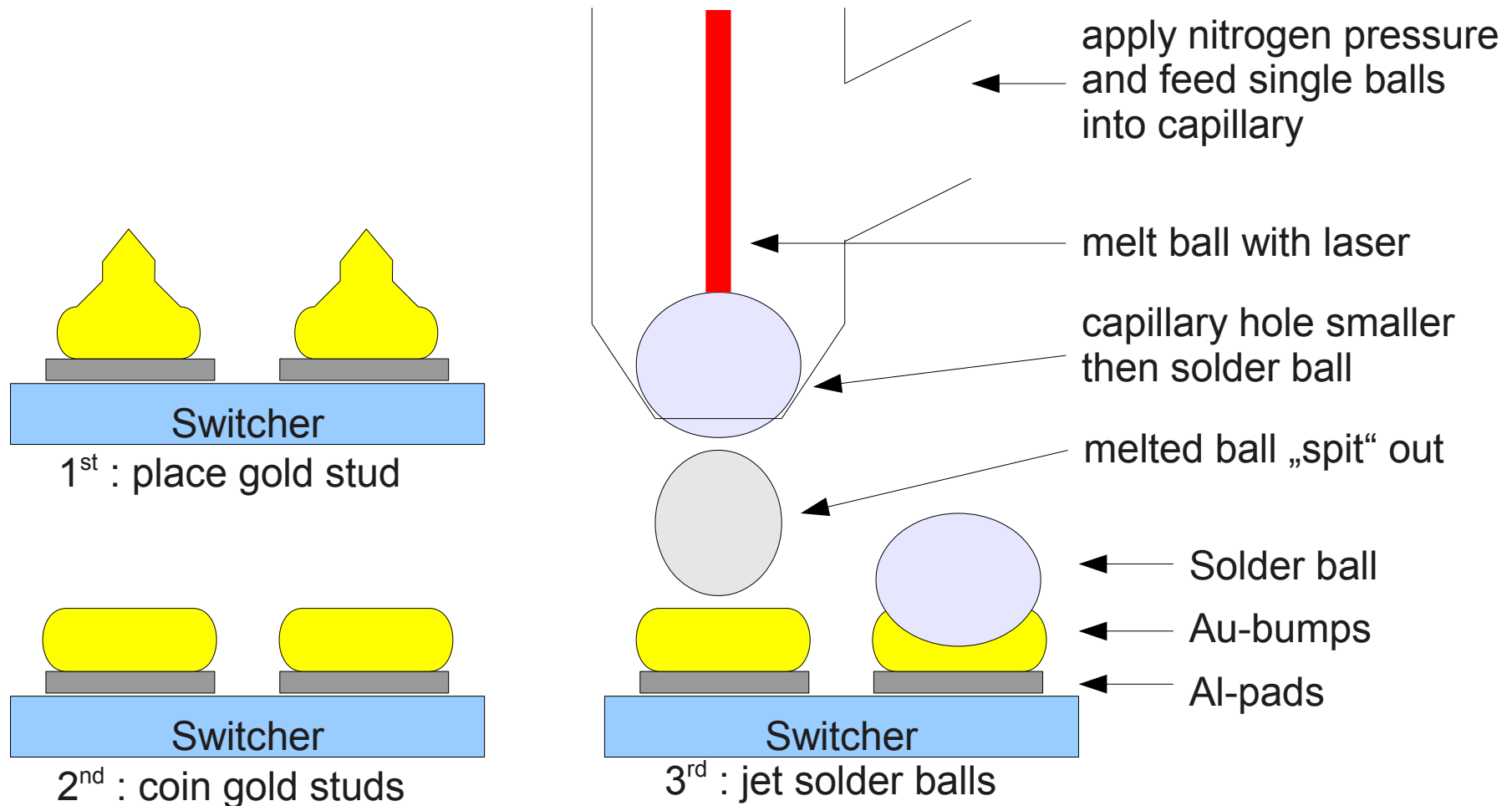


# Bond- and Repairhead



# Single Chip Solder Bumping

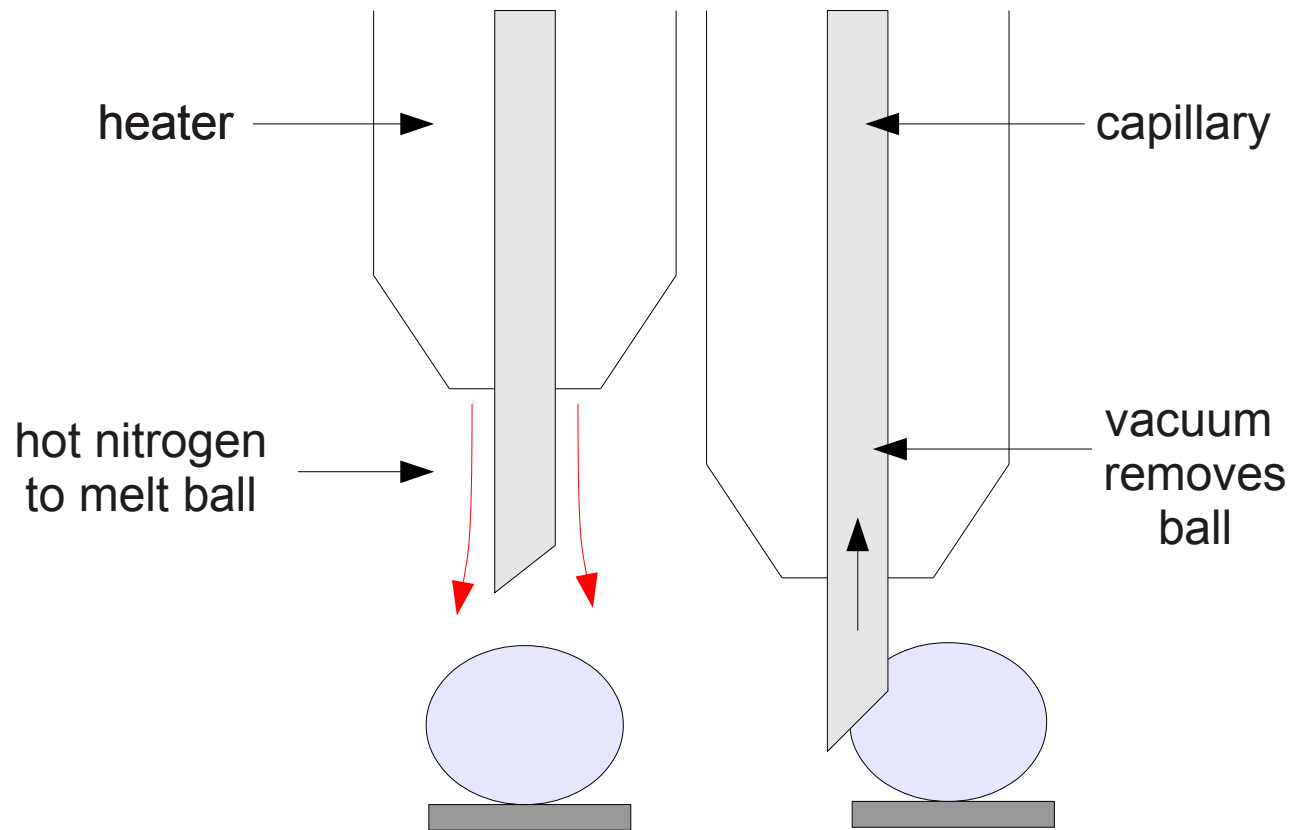
- use coined gold studs as an under bump metallization
- place solder bumps on top using PacTech solder jetting technology





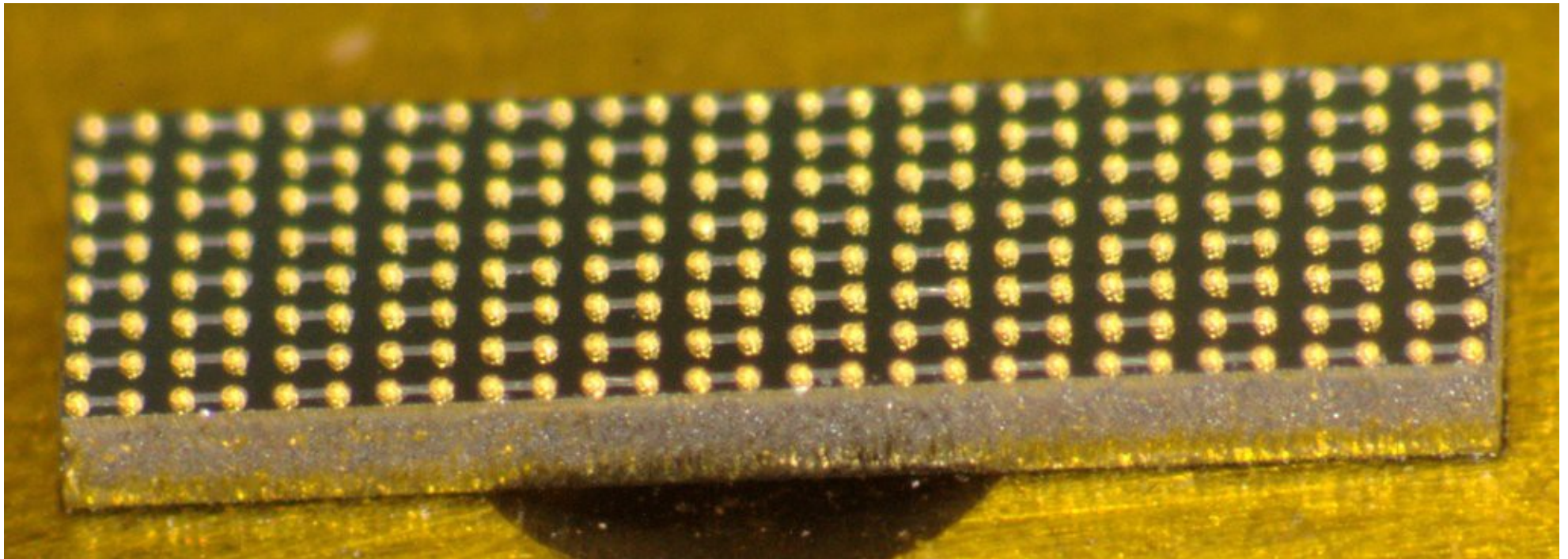
# Solder Removal

- Repair head allows selective removal of solder



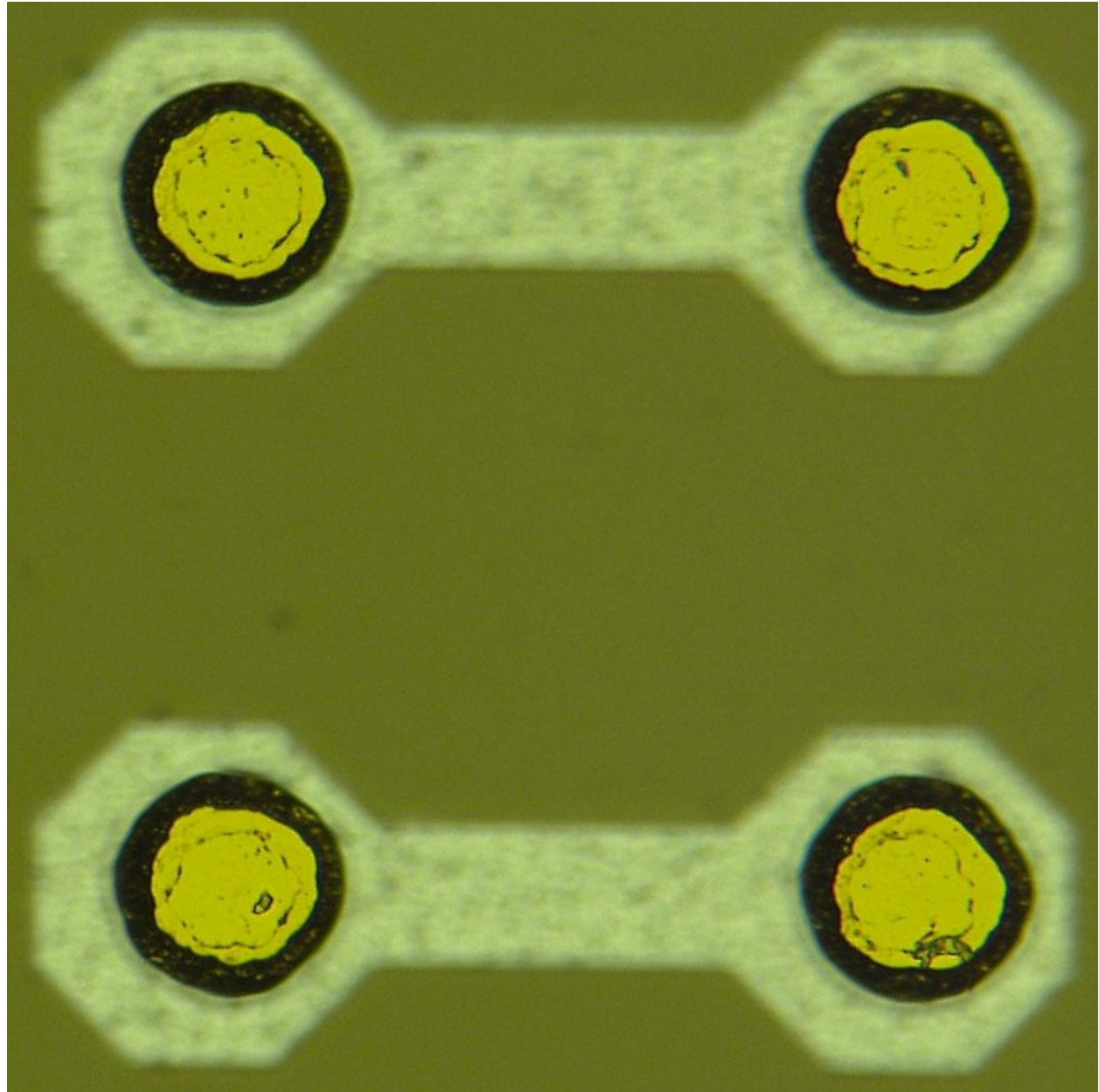
# Gold Stud Bumping

- place gold studs on chip and substrate
- coin studs on chip to remove tail on top and create a flat surface
  - using flip-chip machine and big piece of silicon



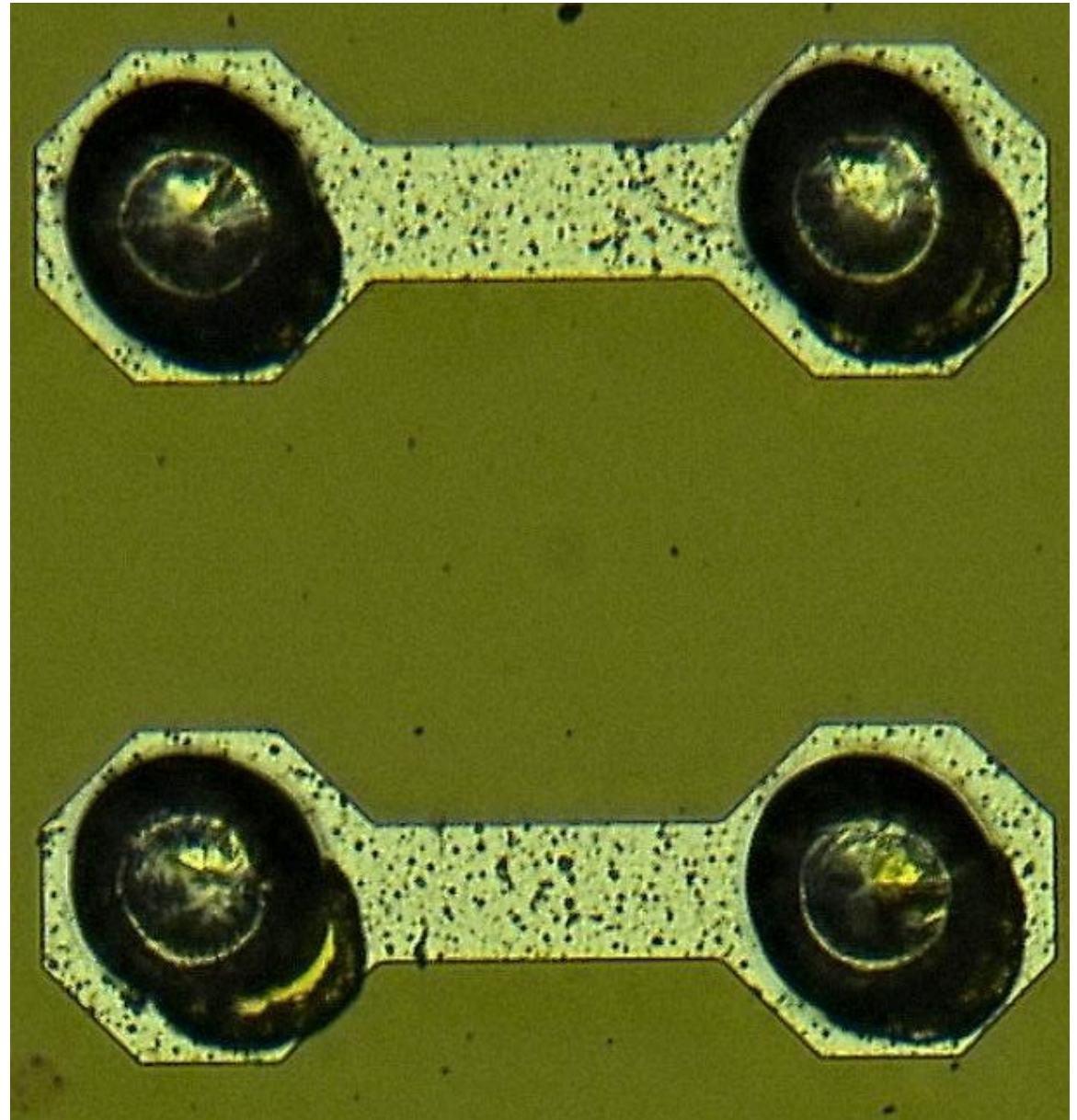
# Gold Stud Dimensions

- 58 $\mu\text{m}$  bump diameter
- 42 $\mu\text{m}$  flat diameter

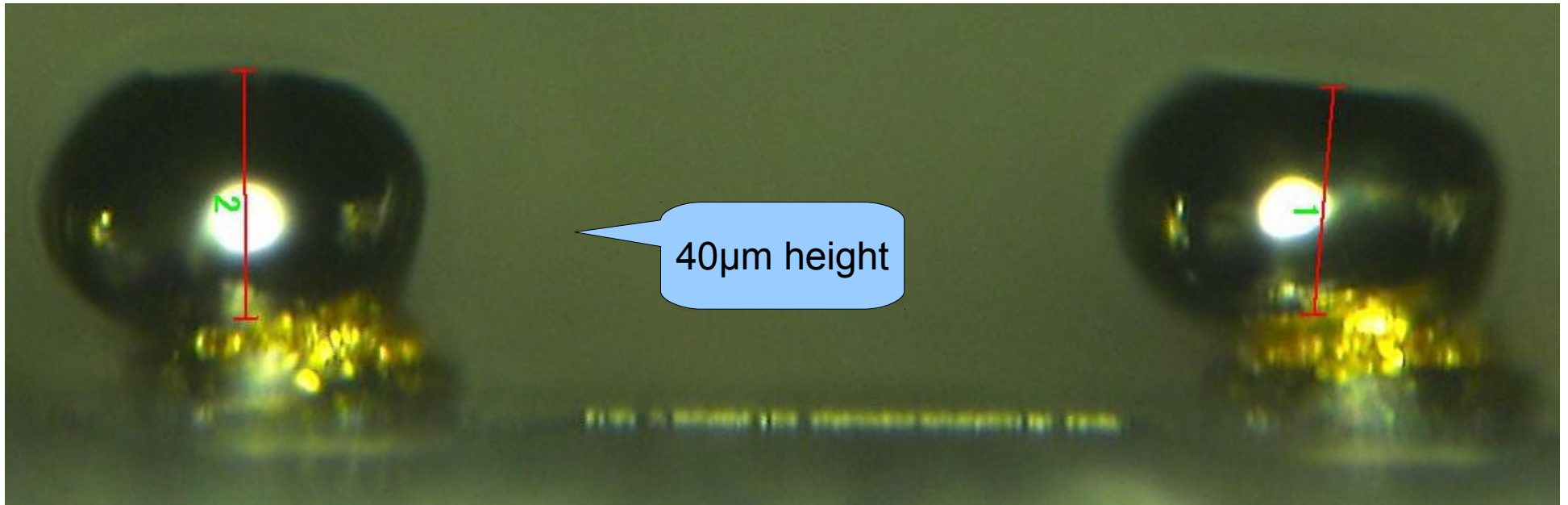


# Solder Bumping

- Ball diameter:  $67\mu\text{m}$

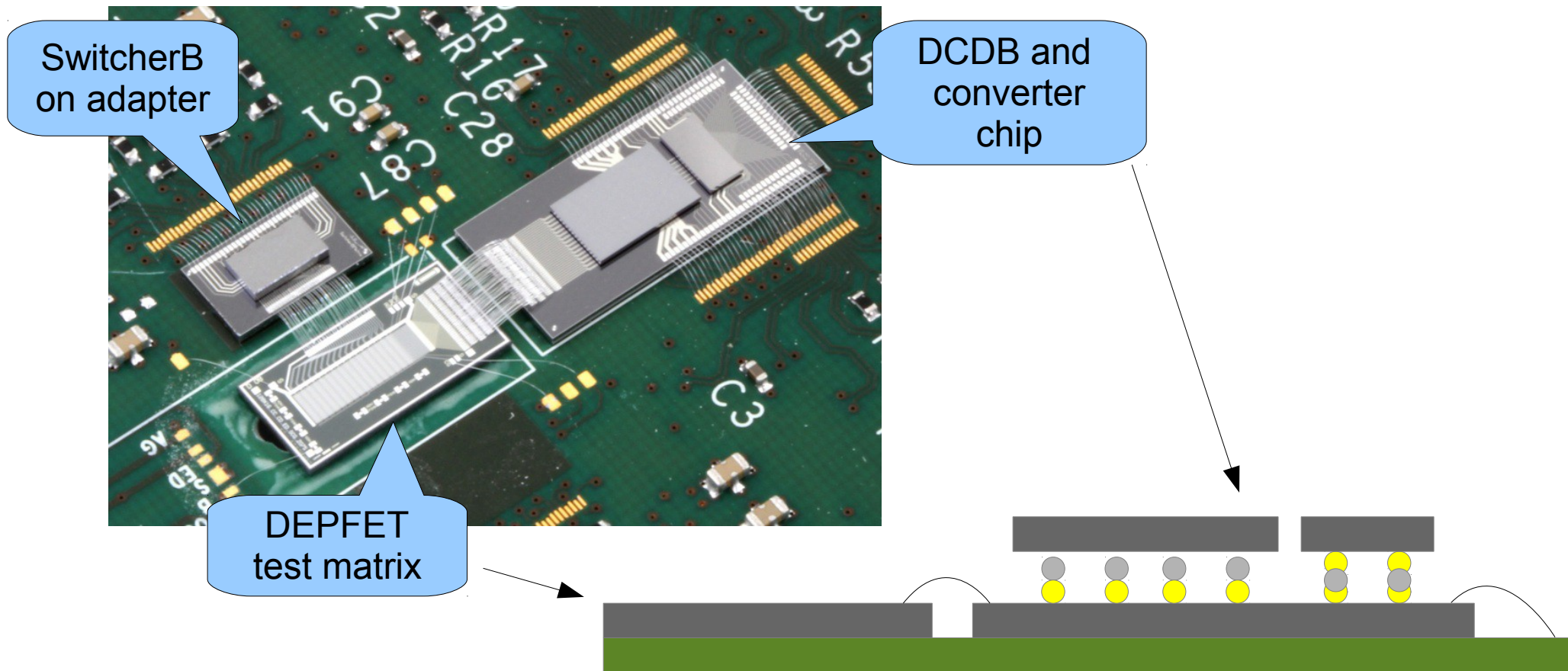


# Solder Ball Side View



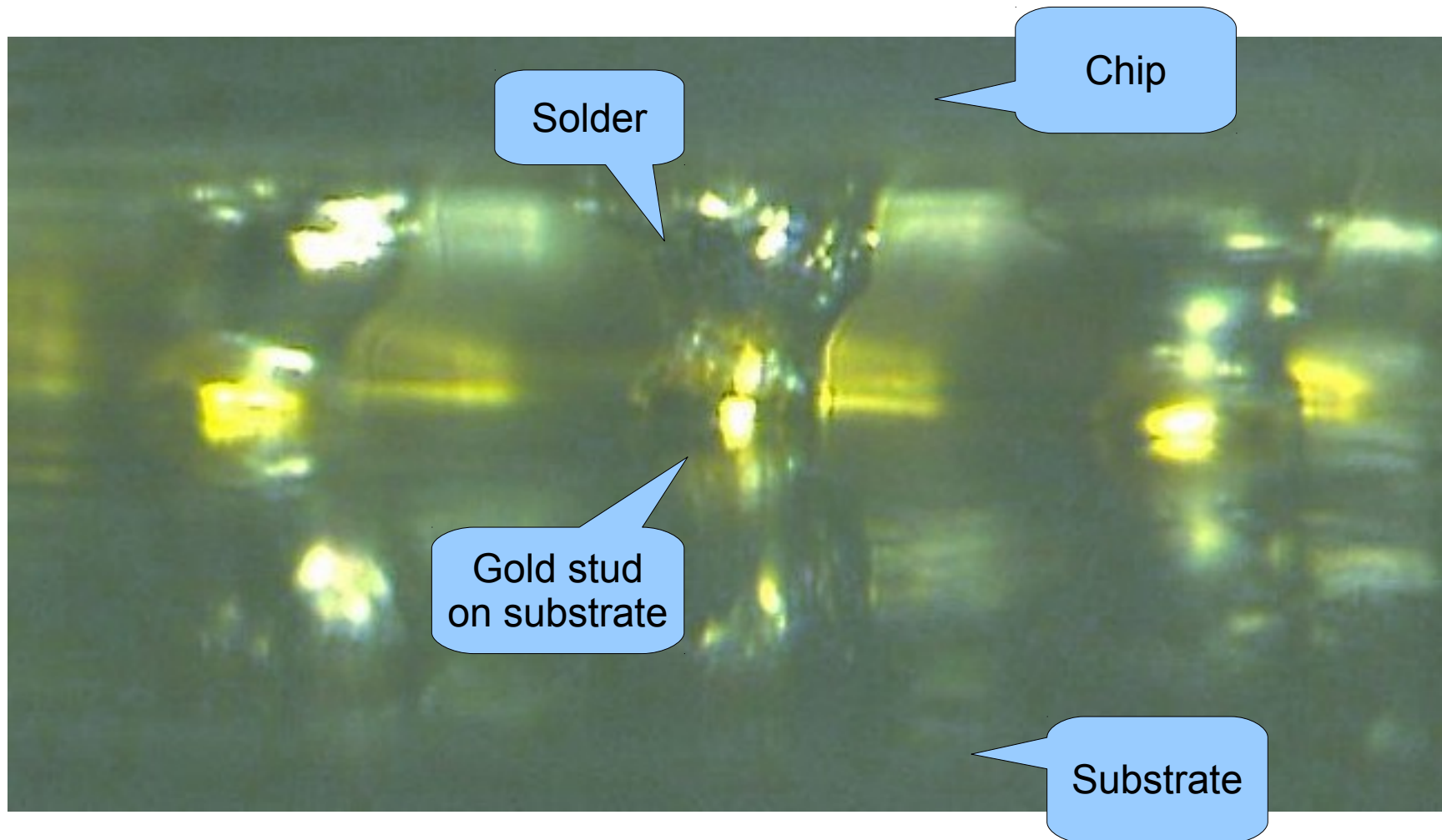
# Wire Bond Adapters for DEPFET Test Systems

- Flip-chip only read-out and steering chip
- Wire bond only DEPFET test matrix
- Need wire bond adapters for test systems
  - gold studs as under bump metallization



# Flipped Side View

- Solder balls compensate ball placement error



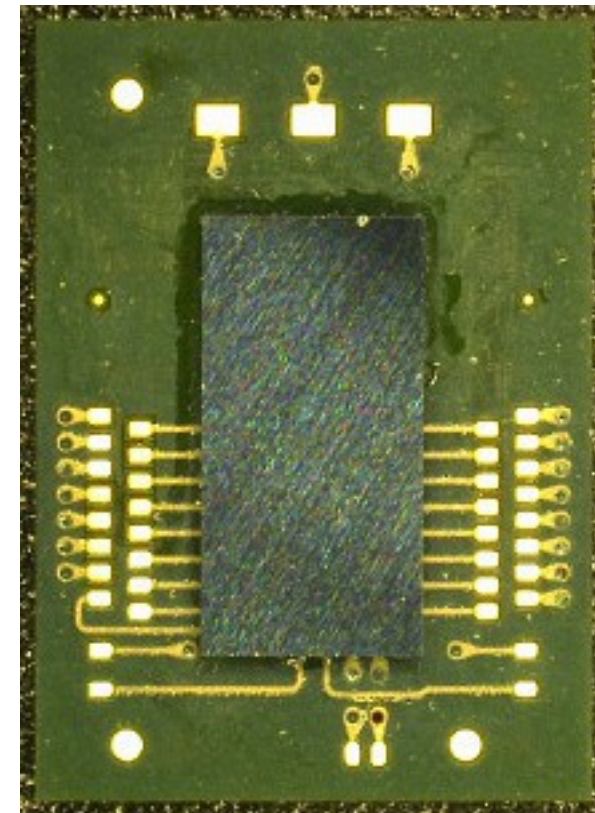
# Solder Bumping at XNAP

- X-ray diffraction and imaging with avalanche photodiodes
- Detector is sensitive to pressure
  - solder bumping used for test assemblies

Read-out chip with  
solder-on-gold

Ceramic or PCB  
interposer

Avalanche  
photodiode

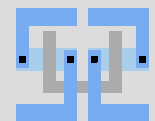


Top view: read-out  
chip on interposer



# Summary

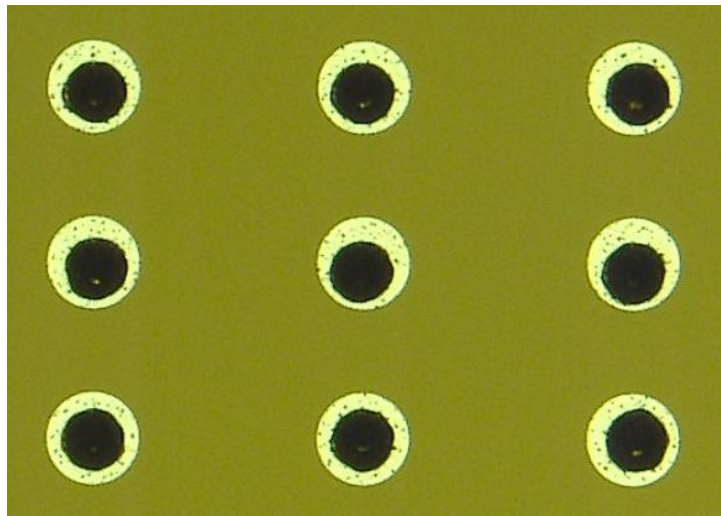
- Solder baller offers a flexible solution for single chip bumping
- PacTech machine partially funded by Helmholtz Alliance
- Suitable UBM is required. Can use gold studs.
- Successfully used in Belle-II prototyping (Switcher chips) and for XNAP (APD array prototype)
- Other small scale application are welcome



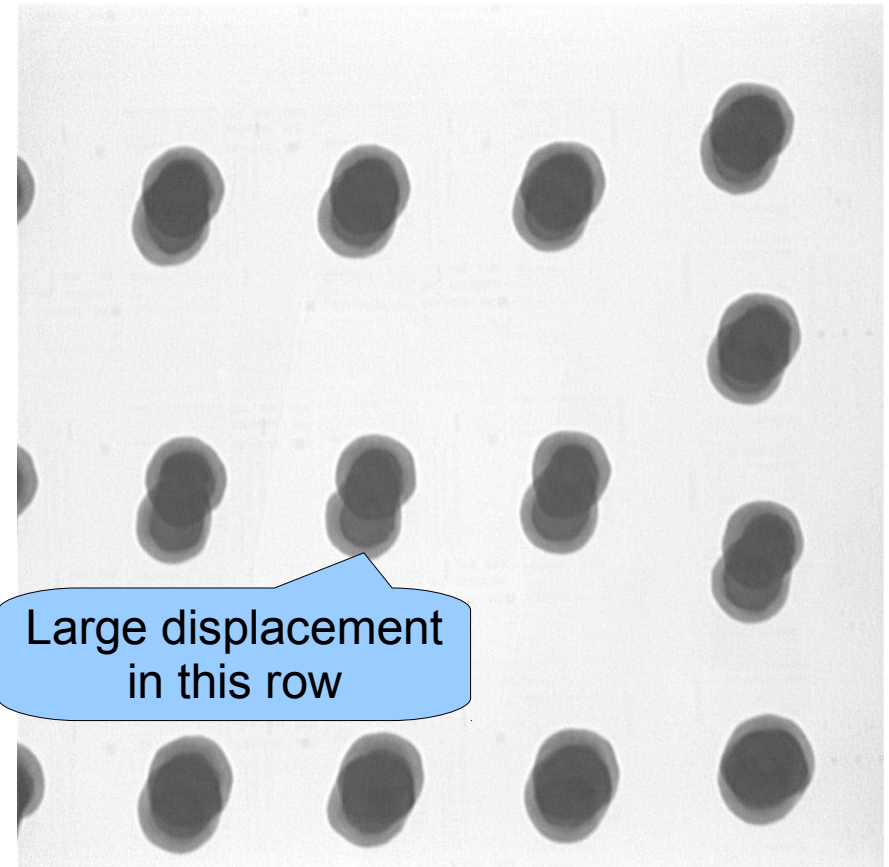
Thank you!

# Gold Stud Misalignment

- Gold stud placement error of bonder
  - unconnected bumps



Photograph of gold studs  
on substrate



X-ray image of flipped assembly