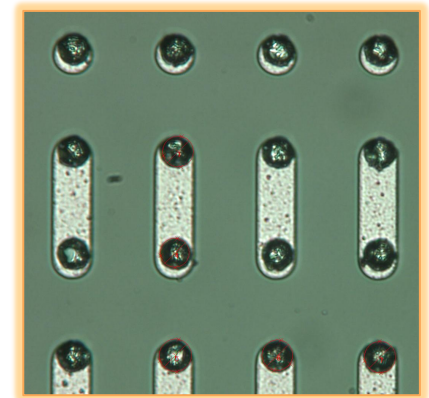




Indium Bump-Bonding developments at INFN for next generation Pixel Detectors



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Introduction

The new 65 nm front-end chip, being developed by RD53 Collaboration, will be compatible with **$50 \times 50 \mu\text{m}^2$ or $25 \times 100 \mu\text{m}^2$ pixel size sensors.**

➤ The smaller pixel sizes imply up to five times the bump density used in the current ATLAS Insertable B-Layer modules and consequently an order of **120 k pixels per chip.**

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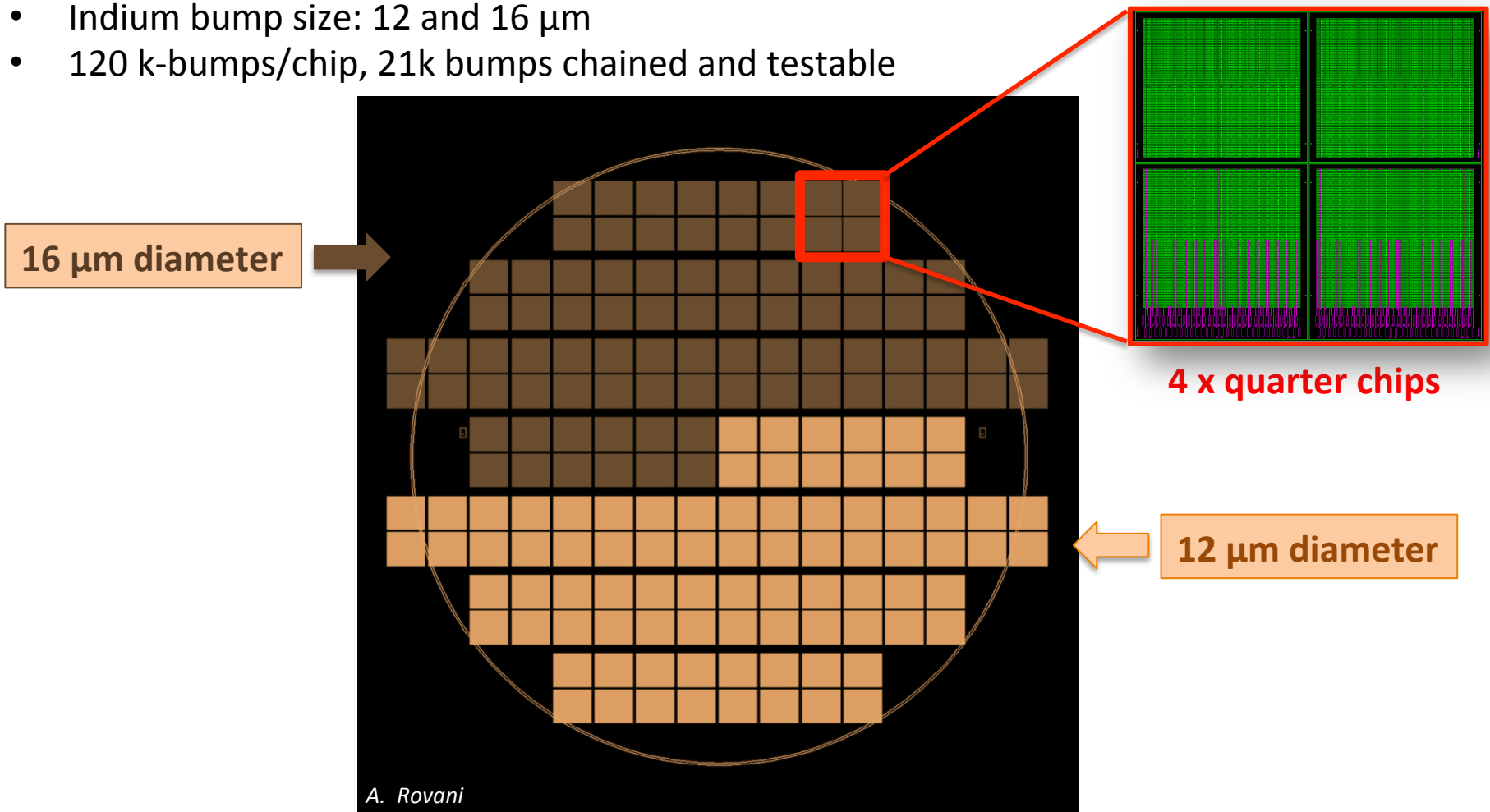
In last months we performed a bump deposition on 12-inch and 6-inch wafers, in the following slides an overview of the activity is reported.

High-density Large-surface bump bonding

Dummy wafers produced by FBK with resistive chains:

- 6-inches, 640 μm thick wafers with 30 FE-I4 size dummy chips (or 4 x quarter chips)
- Metal pad: 18 and 20 μm
- Passivation open: 10 and 12 μm
- Indium bump size: 12 and 16 μm
- 120 k-bumps/chip, 21k bumps chained and testable

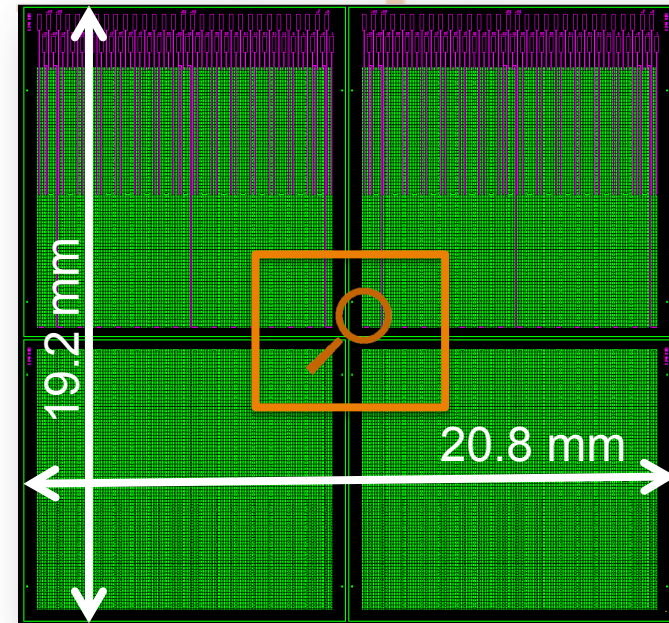
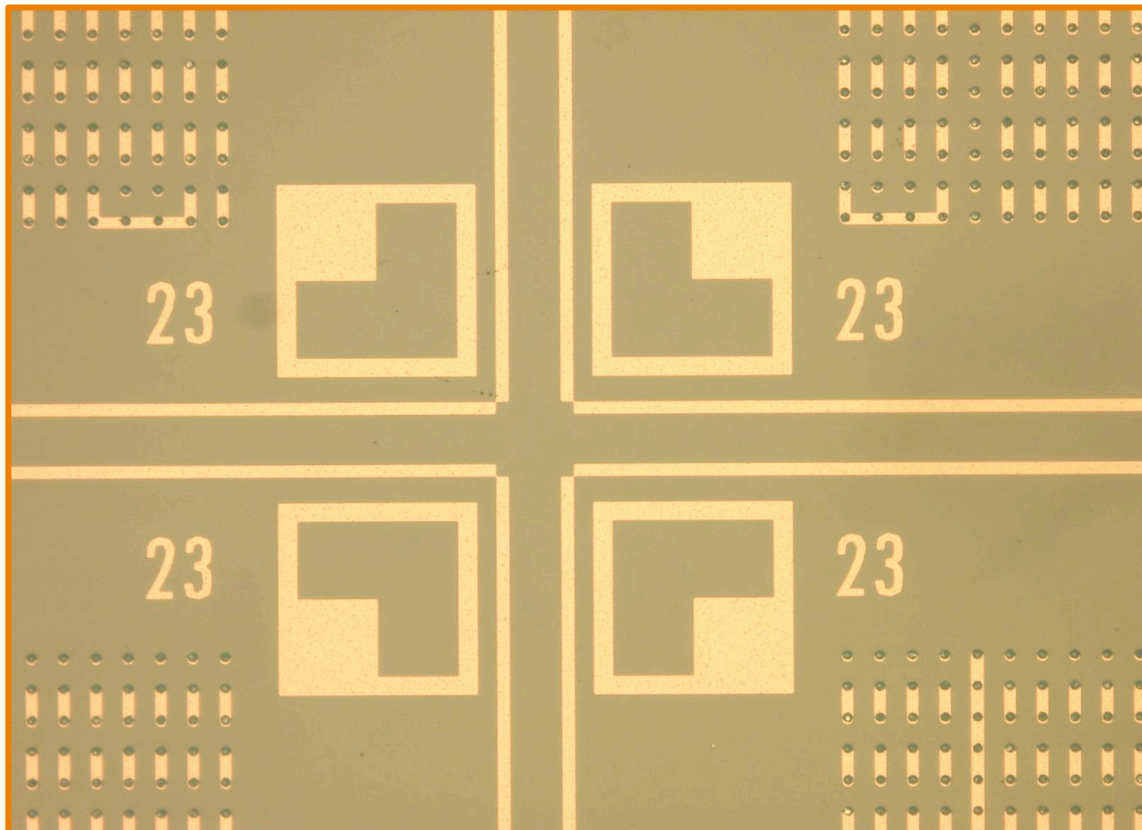
↘ FE-I4 chip



High-density Large-surface bump bonding

Dummy chip with resistive chains

- FE-I4 size
 - With flip-chip possibility for the tiles
- 120k-bumps: **21k-bumps tested**
(124 chains of 172 bumps per chip, uniformly distributed over the chip)

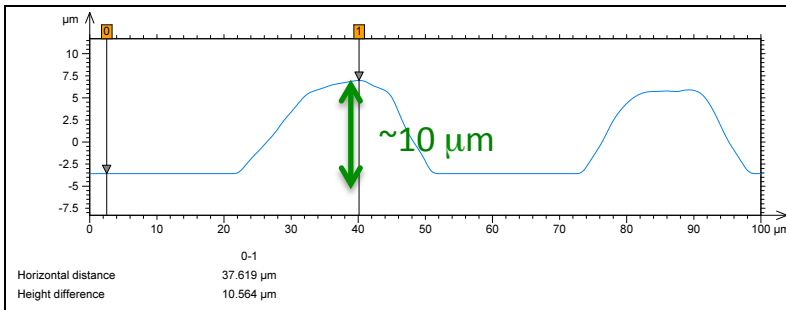
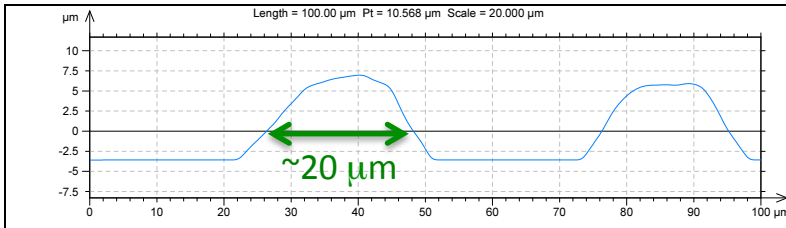


Here a picture of the bump deposition before flip-chip

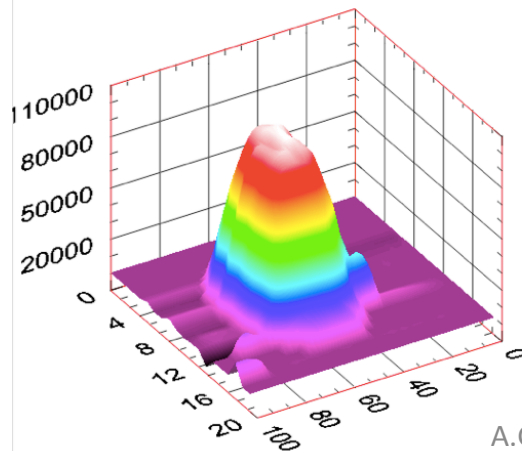
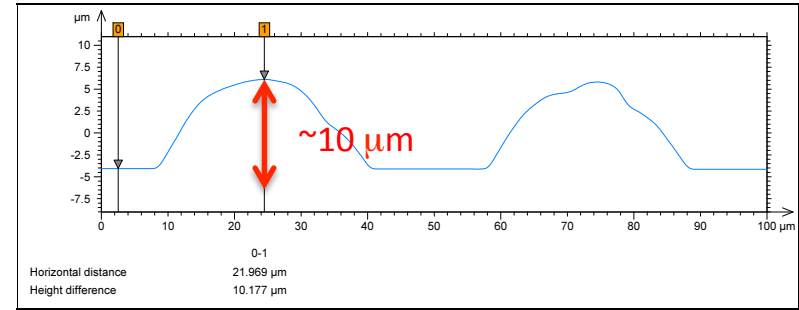
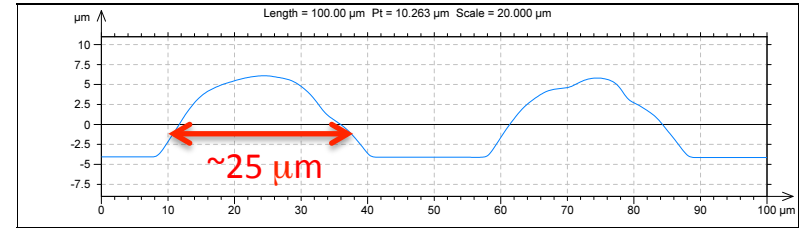
High-density Large-surface bump bonding

Preliminary measurements of bumps dimension before the flip-chip, done in Genova using a profilometer

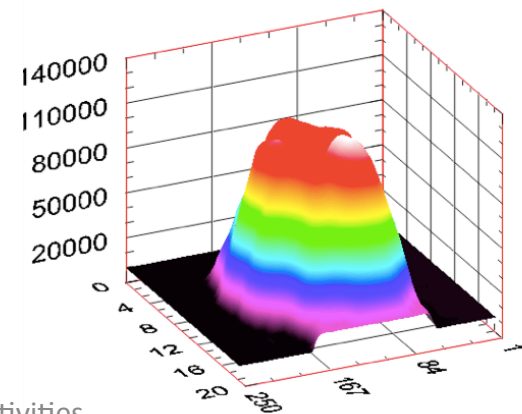
12 μm \varnothing bump



16 μm \varnothing bump

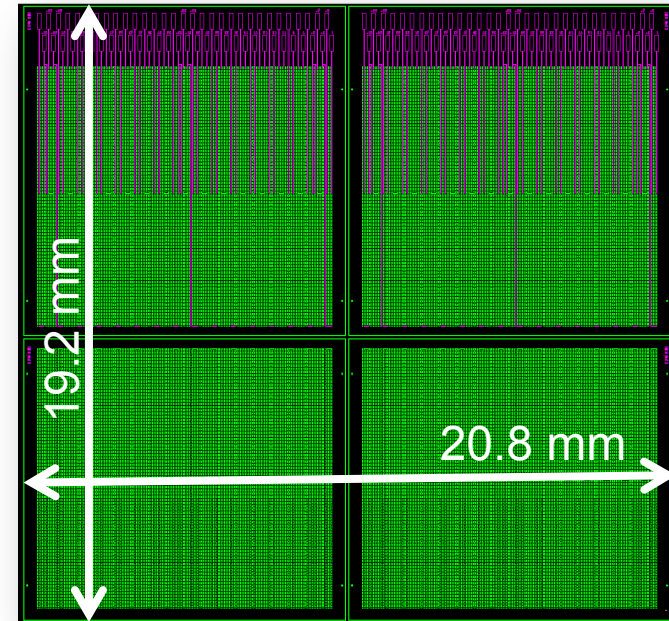
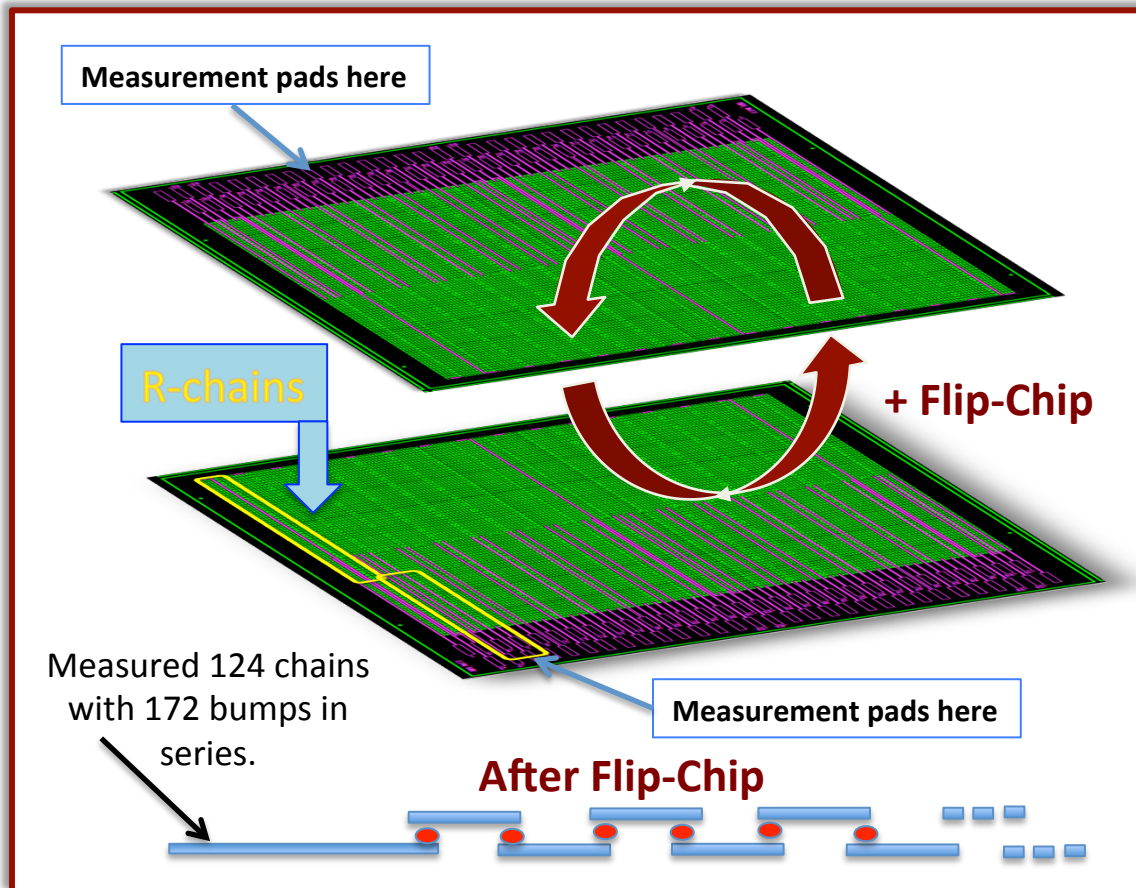


3D bump profile



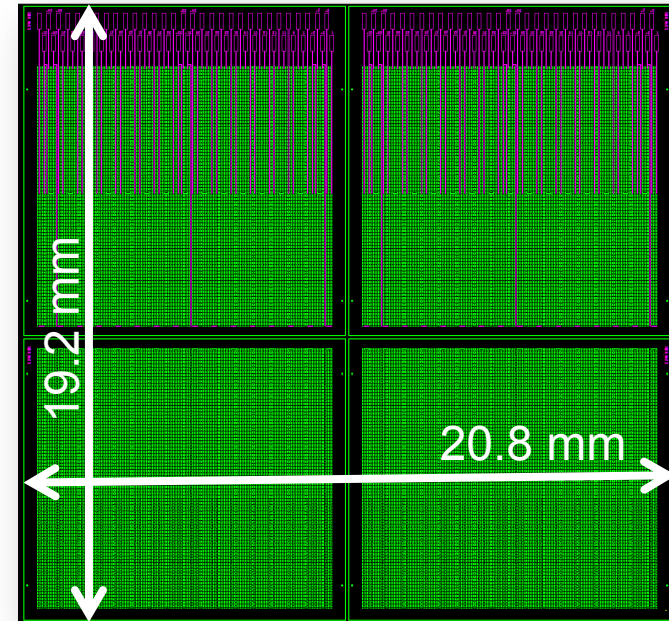
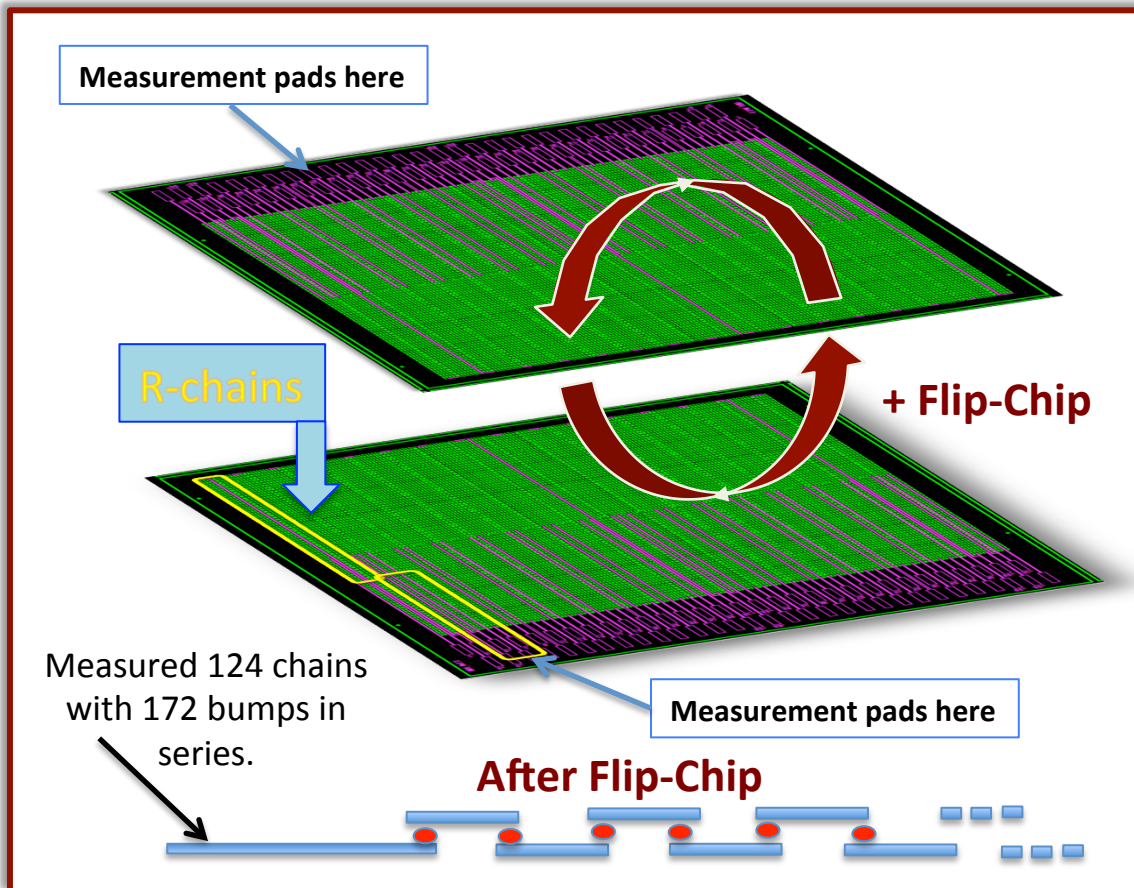
High-density Large-surface bump bonding

Should flip one quad-chip on top of the other leaving the measuring pads free for measurement under needles (i.e. flip one chip over the other rotated by 180° and superimpose the bump pattern).



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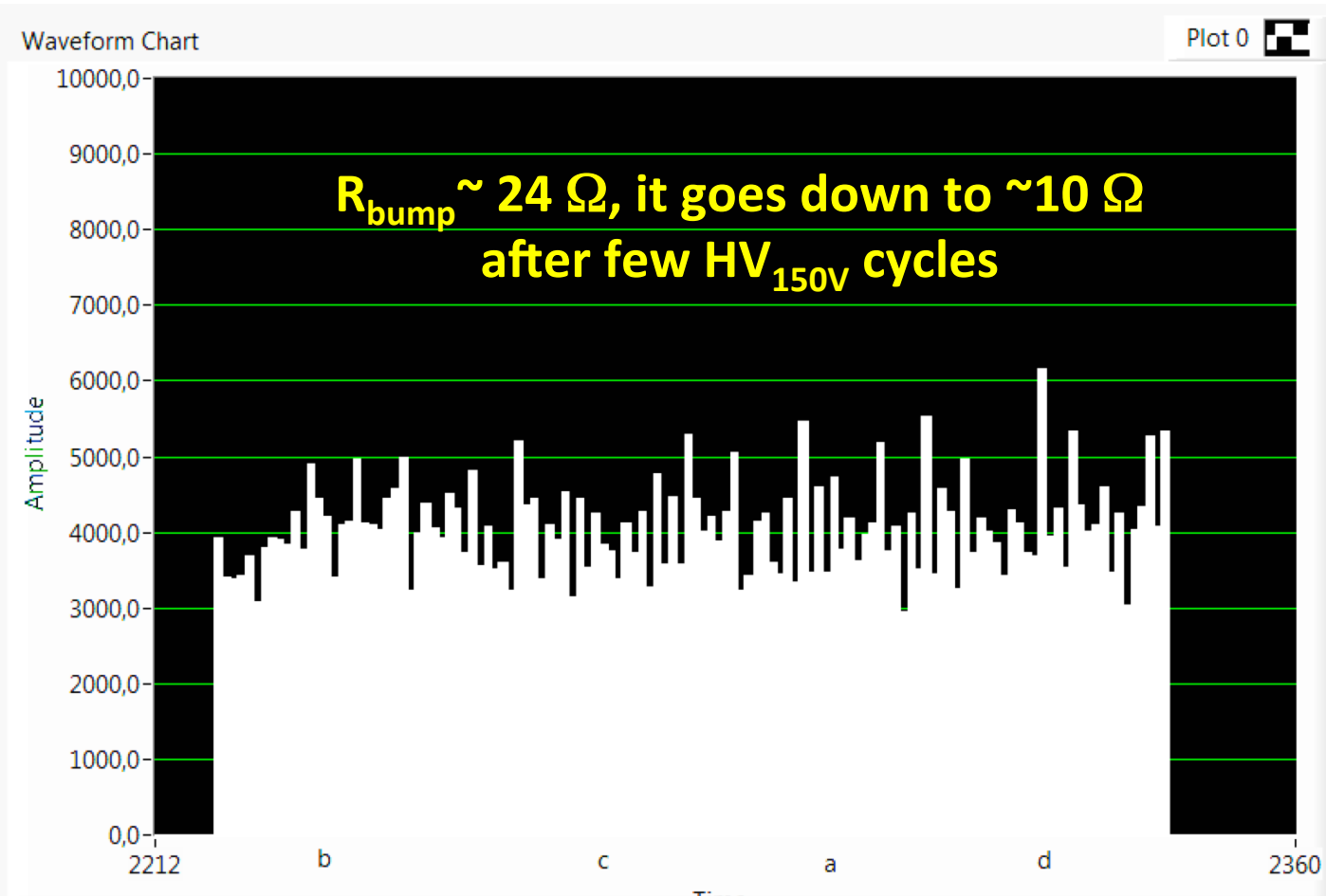


**No “open” amongst
64 k bumps
(3 devices tested)**

**No indications of
shorts bumps**

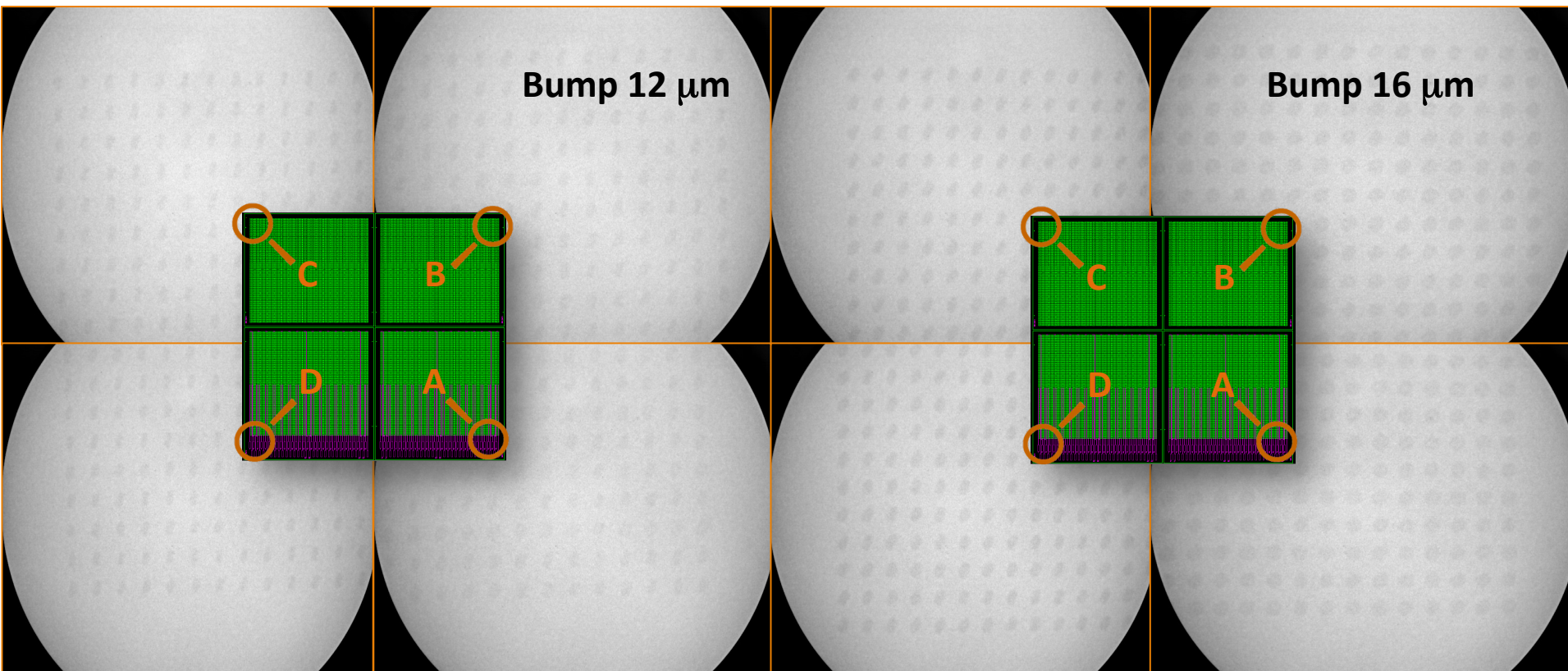
High-density Large-surface bump bonding

Measure 124 chains with 172 bumps in series. Must apply 150 V ($I_{\max} = 100 \mu\text{A}$) to break the initial indium oxide before R-measurement.



High-density Large-surface bump bonding

The flipped chips have been also checked with X-ray @ 120 keV
and both bumps type at 12 and 16 μm look ok!



High-density Large-surface bump bonding

On 12" wafer deposition of only bumps (without resistive chains)

- Wafer has been visually analyzed and bumps height measured with a profilometer
 - Preliminary results on bump height ($\sim 10 \mu\text{m}$), uniformity good ($\sim 1 \mu\text{m}$)
 - problems during the lift-off due to not uniform bump deposition \rightarrow bump density is final, but only "spots" have been deposited on the wafer
- Next step is to repeat the same deposition and tests done for 6" wafers on 12" wafers with resistive chains

Conclusions

- ✓ **Very promising results in the first tests from resistive chains of high density bump bonding on 6" wafers:**
 - ✓ No "open" amongst 64k bumps (3 chips)
 - ✓ No indications of shorts
 - ✓ Still flip-chip planarity and matching space accuracy to be improved

From the results obtained, Selex seems to confirm its abilities in good quality bump deposition also at high densities

Concerning 12" wafers more tests are needed:

- ✓ At the moment is ongoing a new design of the resistive chains layout on 12".
 - ✓ Resistive chain QA with 12" Si wafers not doable at FBK (investigation ongoing with other producers).

Conclusions

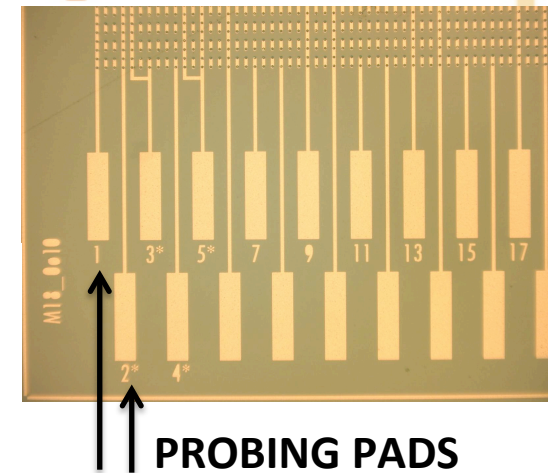
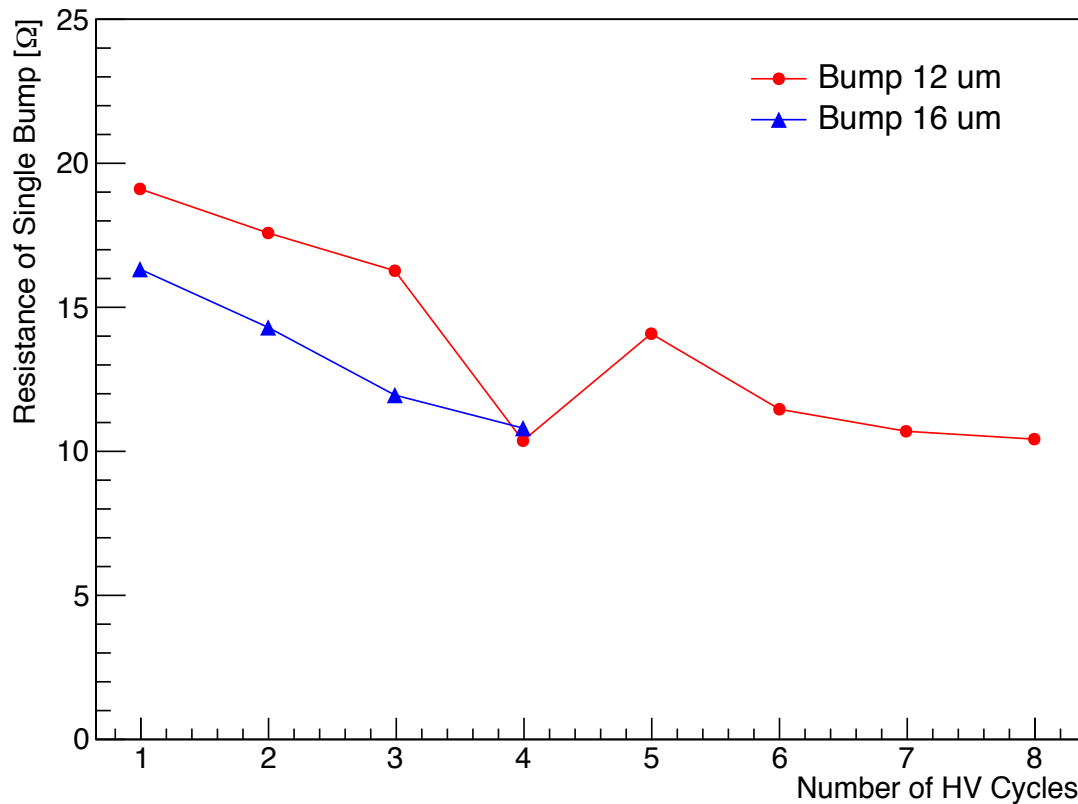


A decorative horizontal band of colorful pixels, transitioning from green and blue on the left to yellow and orange on the right, with the word "Spare" overlaid in the center.

Spare

Flip-Chip Results with $50 \times 50 \mu\text{m}^2$ pitch bumps on $2 \times 2 \text{ cm}^2$ chips

Measure 124 chains with 172 bumps in series.
Must apply 150 V ($I_{\text{max}} = 100 \mu\text{A}$) to break the native Indium oxide before R-measurement.



$R_{\text{bump}} \sim 20/17 \Omega$, it goes down to $\sim 10 \Omega$ after few HV_{150V} cycles