

Packaging Technologies at DESY

Flip-Chip Mounting

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DTS-ST3 Topical Meeting, 17 March 2022

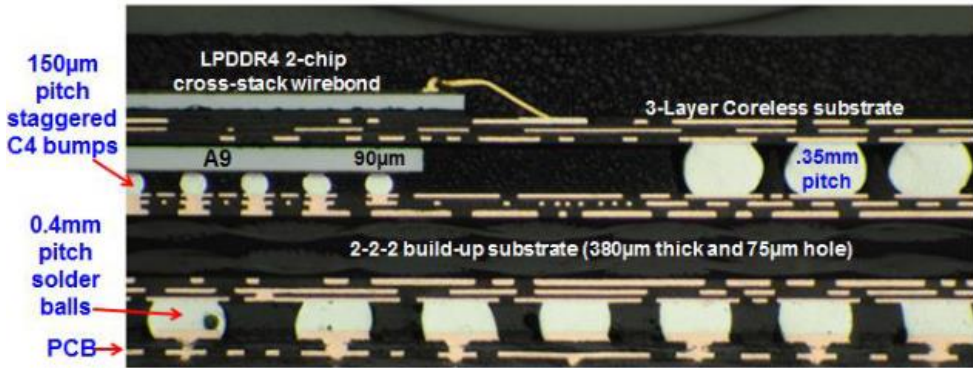
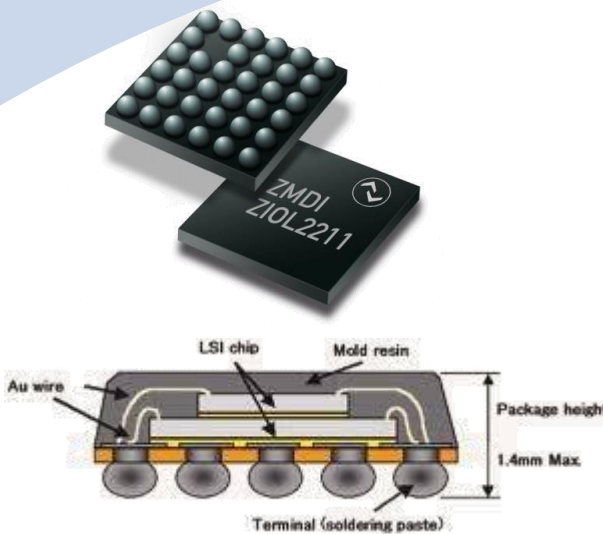
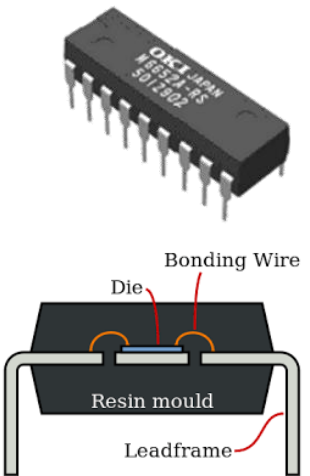
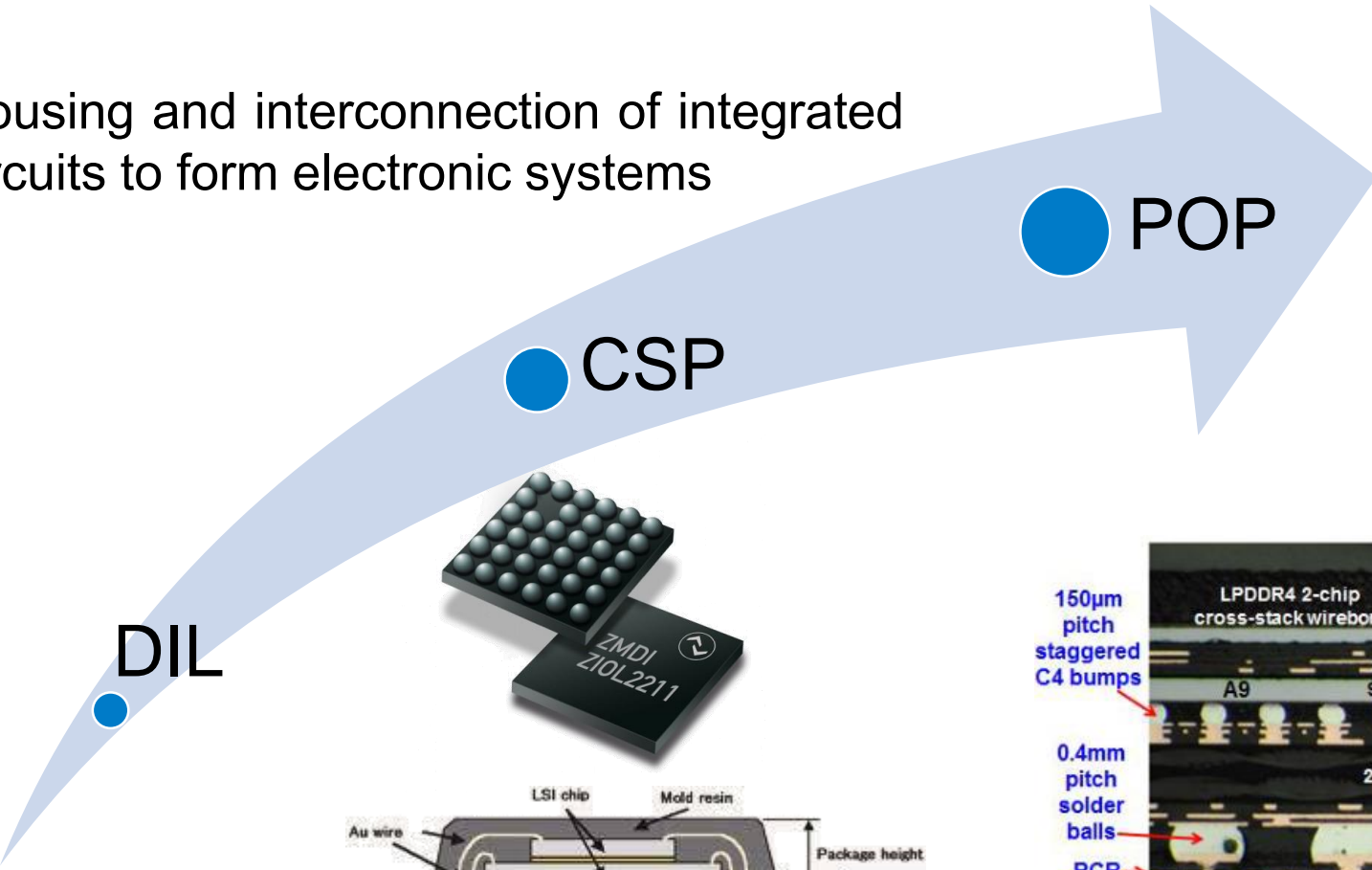
HELMHOLTZ



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Definition

Packaging: Housing and interconnection of integrated circuits to form electronic systems


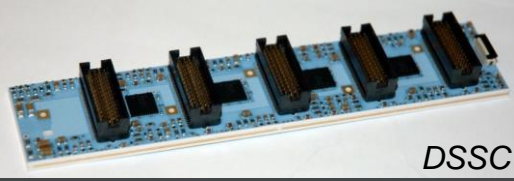

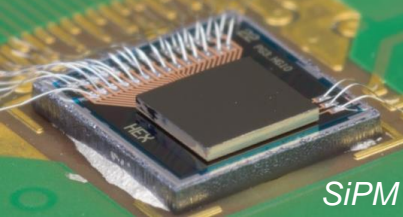
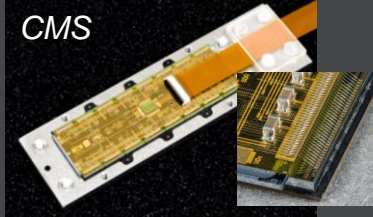
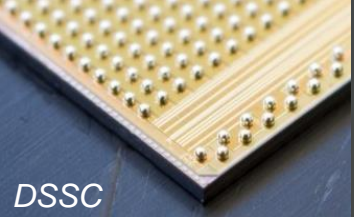
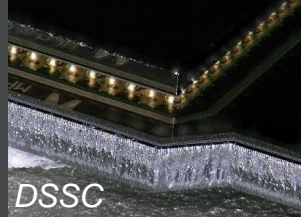
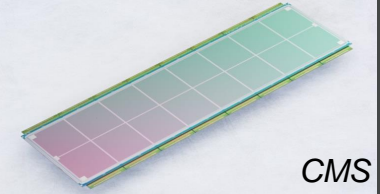
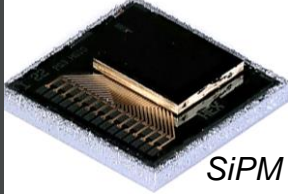


https://www.circuitinsight.com/pdf/status_outlooks_flip_chip_technology_ipc.pdf

Pictures from Internet

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Competences

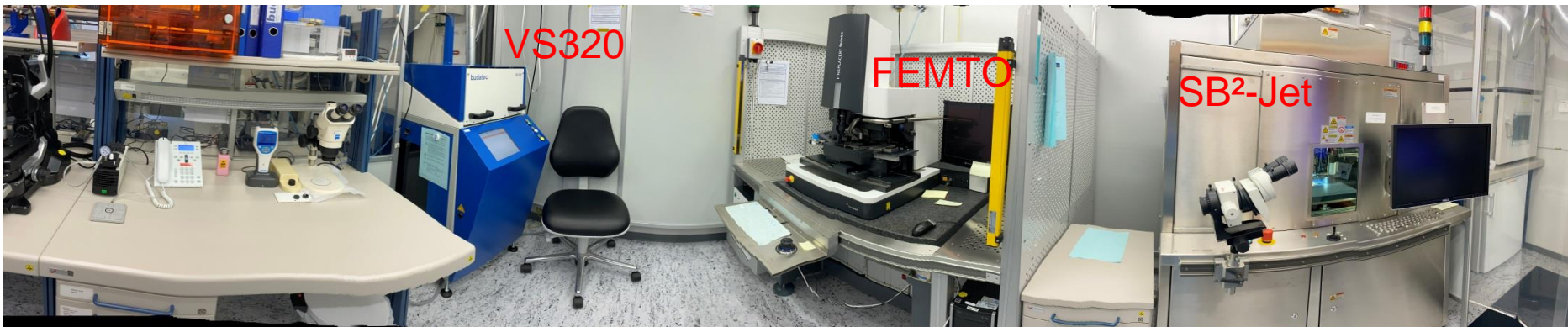
Technology		Examples	DESY	Service Provider
Surface-Mount (housed)	Soldering	 	~400 μm ZE	~200 μm (COB) many
Chip-and-Wire (naked)	Welding	  	~50 μm ZE, DAF (FEC)	~50 μm many
Flip-Chip (naked)	Soldering	   	$\geq 150 \mu\text{m}$ FEC ~50 μm FEC	~100 μm (WLB) some $\leq 100 \mu\text{m}$ some

Soldering: Lead-free

Values: Array Pitch

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FEC Lab with Iso-6 Cleanroom Area



➤ Chip-level, Flux-less and Lead-free Processes In-House → fast Prototyping

1. Solder-Ball Placement (Pactech's SB²-Jet)

- ✓ Chip-level
- ✓ Laser-assisted

2. Bonding (Finetech's FEMTO)

- ✓ Flux-less
- ✓ Cleaning (semi-closed)
- ✓ Ball Reflow
- ✓ Module Reflow

3. Reflow (in 2018) (Budatec's VS320: closed)

- ✓ Surface Treatment
- ✓ Ball Reflow
- ✓ Module Reflow

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History

A. SB²-Jet & FEMTO for 40- μm Bumps & Ni-Au Under-Bump Metallization (UBM)

Commissioning:	~3 Month until late Summer 2012
Process Evaluation:	~6 Month using thick small-format (SF) Samples (“Babies”)
Process Optimization:	~15 Month using thick SFs for Reliability & large-format (LF) Samples for Homogeneity ~9 Month using thinned LFs for Homogeneity and Production Speed (sequential)
Series Production:	~12 Month CMS Pixel Detector Upgrade Phase 1 until Summer 2016
Scientific Analysis:	~12 Month → see: JINST 12 T09006, September 2017

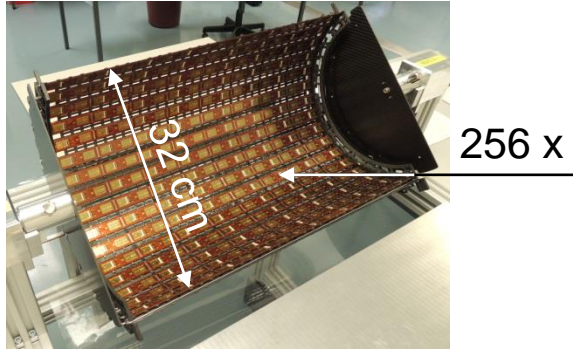
B. VS320 for Cu UBM & Pillars and Upgrade of SB²-Jet & FEMTO for 30- μm Bumps

Commissioning:	Summer 2019
Process Evaluation:	~12 Month
1 st Application:	~4 Month CMS Pixel-Luminosity Telescope for Run 3 (PSI, U Tennessee & Rutgers) until April 2021

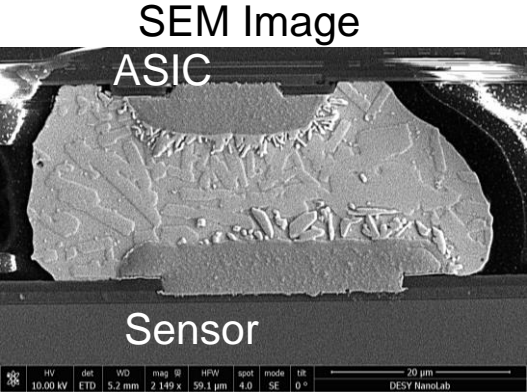
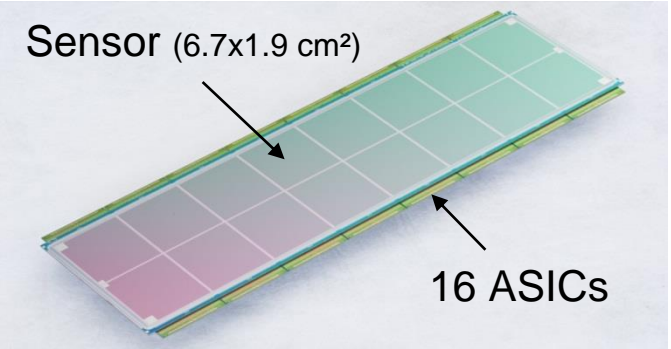
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Introductory Project: CMS Pixel Detector Upgrade Phase I

1/2 Barrel Layer 4 (0.32 m²)



Bare Module with 66,592 Bumps



Volume

418 Modules with 6,688 ASICs and ~28 Mio Pixels

Rate

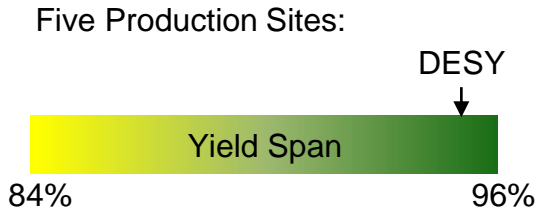
6.7 Modules per Week

Connectivity Yield

≥ 99.96% best 256 Modules

Module Yield Loss

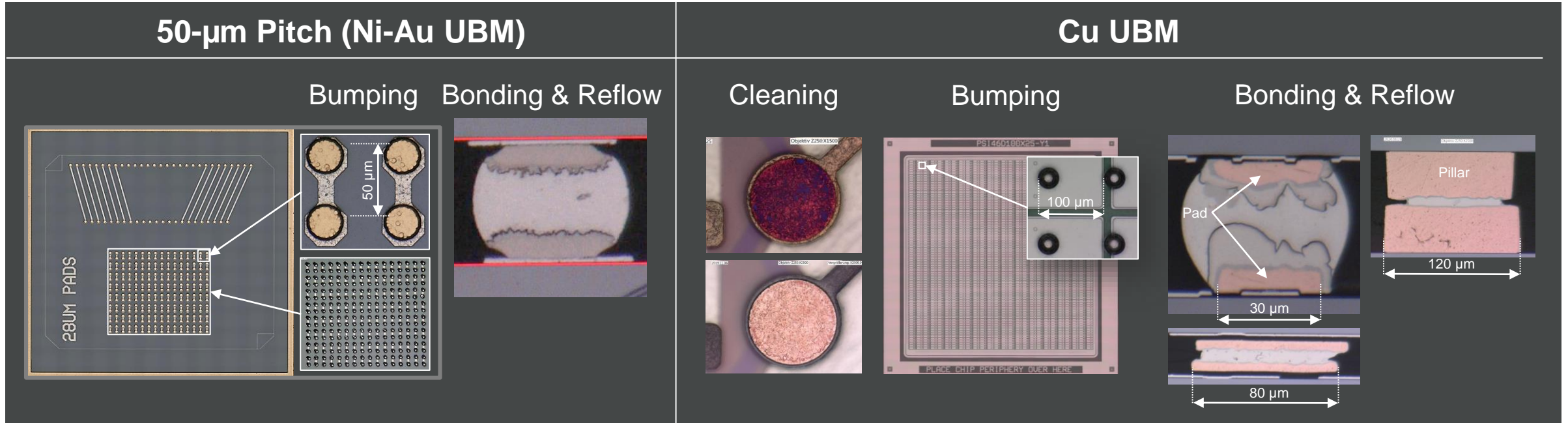
- missing Connections 1.2%
- high Sensor Leakage 3.3%
- ASIC Failures 1% after Repair



see Center Evaluation DESY 2018: <https://indico.desy.de/event/19351/>

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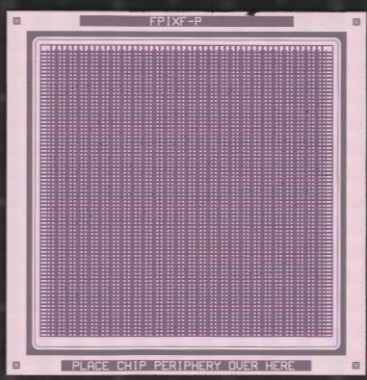
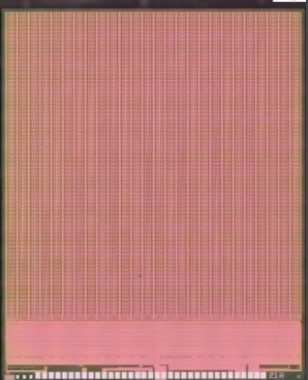
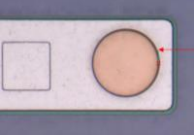

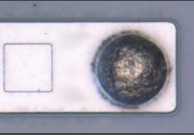
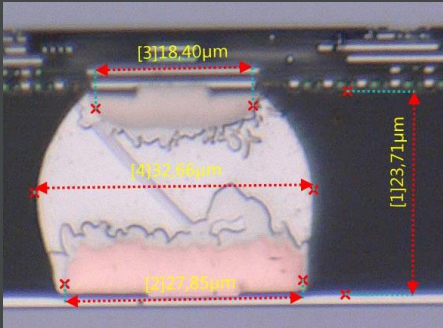
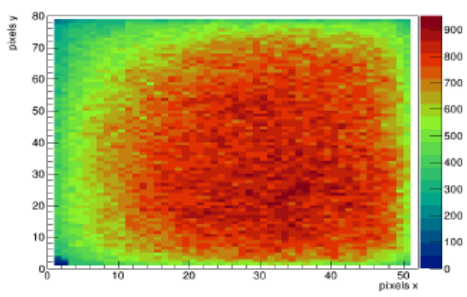
Smaller Pitches and Copper Metallization



- All Processes now available in-house
- Ball Placement, Bonding & Reflow tested for 50-µm Pitch & Cu UBM
- Thin Solder Layers completely converts into Phases with high Melting Point

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Cu UBM: 1st Application CMS-Pixel Luminosity Telescope

Mating Parts	Flip-Chip Mounting	Beam Test
<p>Sensor</p>  <p>ASIC</p> 	<p>Surface Treatment</p>  <p>Ball Jetting</p>  <p>Ball Reflow</p>  <p>ASIC</p>  <p>Sensor</p> <p>[3] 18.40 μm</p> <p>[4] 12.66 μm</p> <p>[2] 23.85 μm</p> <p>[1] 23.74 μm</p>	 <p>Hit Map</p>

> Bare Modules successfully mounted and tested

Thank you

- > Fast Prototyping, Small Volume Production
- > Cu and Ni(Pd)Au UBM
- > 50µm Pitch

Contact

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