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1. Introduction

Micro-Bump Probing for 3D-SIC Pre-Bond Test

- Pre-bond test is necessary to take die yield out of stacked-die yield equation
  - Without pre-bond test, the compound stack yield decreases drastically
- Non-bottom dies have only micro-bump arrays as their functional interface
- Micro-bump array characteristics

Micro-bump array characteristics		Probe Challenges
– Small diameters	: 25µm, 15µm	Probes on grid; landing on bump
– Dense pitches	: 50µm, 40µm	Fan-out routing in space transformer
– Large arrays	: WIO1: 4×(50×6)=1,200 WIO2: 4×(73×6)=1,752	#Tester channels, interfaces
– New metallurgies	: Sn: soft Cu, Cu/NiB: hard	Probe mark damage; dirt on tips Electrical contact; probe tip wear-out

- Conventional probe technology does not handle such micro-bump arrays
  - Cantilever probe cards : fine pitch, but not full-array
  - Vertical probe cards : full-array, but not fine pitch
- Industry adds dedicated pre-bond probe pads [ISSCC'11, CDNLive'11]
- Cascade Microtech and imec enable direct micro-bump probing [SWTW'11, ITC'11, 3D-TEST'12, ITC'14]

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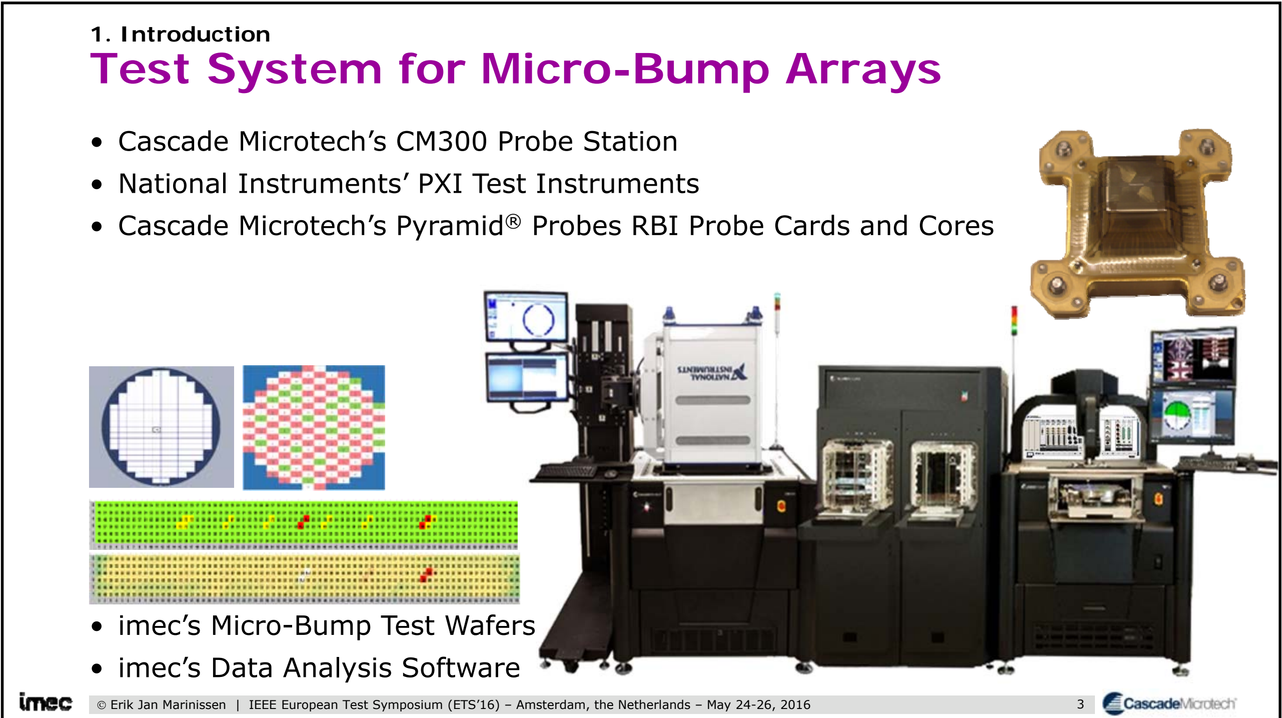

A Full-Automatic Test System for Direct Probing of JEDEC Wide-I/O Micro-Bumps

Presentation Outline

1. Introduction
2. Cascade Microtech's CM300 Probe Station
3. National Instruments' PXI Test Instruments
4. Cascade Microtech's Pyramid® Probes RBI Probe Cards and Cores
5. imec's Micro-Bump Test Wafers
6. imec's Data Analysis Software
7. Conclusion

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2. Cascade Microtech's CM300 Probe Station

CM300 Dual Configuration

- **Probers 1 and 2** (identical)
  - Manual front-port loading of
    - Ø200mm wafers
    - Ø300mm wafers
    - Tape frames ≤Ø300mm wafers
  - MicroAlign for use with vertical probe cards
  - Anti-vibration table
  - Thermal Control System: -60 – 200°C
  - GPIB command interface

- **MHU:**
  Material Handling Unit
  - Automatic loading of Ø200/Ø300mm wafers from FOUP/FOSB
  - Automatic wafer identification
  - One or two load-ports shared between two probers

2. Cascade Microtech's CM300 Probe Station

CM300 Adapted For Test Head Docking

- **Differences between Probers 1 and 2**
  - Prober 1:
    - 4.5" rectangular engineering probe cards
    - Cable interface from test instruments to probe cards
  - Prober 2:
    - No microscope bridge (for test head)
    - Ø300mm circular Apollo probe cards with 1644 pogo-pin landing pads

Prober 2 MHU Prober 1

2. Cascade Microtech's CM300 Probe Station

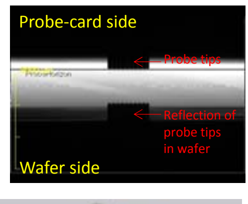
'Vortex-2' in imec's Fab-2

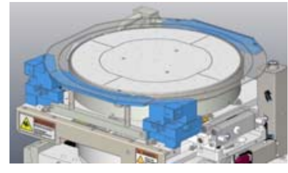
- Vortex-2/2: left-hand system
- Vortex-2/1: right-hand system

2. Cascade Microtech's CM300 Probe Station

Probe Station Features

- **Four Cameras per Prober**
  - ⬇ Top-view camera on bridge (*absent on Prober 2)
  - ⬇ Platen camera } Software overlay for
  - ⬆ Chuck camera } non-see-through probe cards
  - ➡ Side-view camera ('Probe Horizon')
- **Handles Large Tape Frames** [Marinissen – ITC'15]
  - – Up to Ø300mm wafers (SEMI G74-0699)
    - Extra maneuver space
    - Chuck camera away from chuck
    - Extra support bars for large frames
  - – Manual loading through front-port
- **Five Auxiliary Chucks per Prober**
  - – 2.5×2.5cm² each
  - – For tip-cleaning and calibration substrates
  - – Three aux chucks inaccessible if large tape frame is loaded





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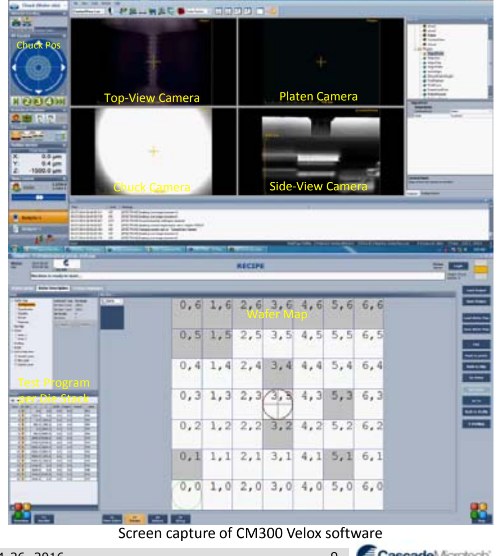
2. Cascade Microtech's CM300 Probe Station

Control Software Functions

- **Velox™** – Probe Station Control Software
  - WaferMap with Z-profiling, binning, sub-die stepping, etc.
  - Integrated thermal control, automated environment conditioning
  - CellView: stitched image of full device
  - ProbeHorizon™ for easy wafer loading
  - Cleaning routines for probe tips
- **VeloxPro** – Test Automation Software
  - Cassette mapping and visualization
  - Test sequence customization
  - Load new wafers into cassette during test
  - AutoInventory: address wafers by wafer ID
  - Multiple wafer types in single cassette
  - Load any wafer out of any cassette to any chuck
  - Setup new recipes, parameters, and pattern recognition



Screen capture of CM300 Velox software

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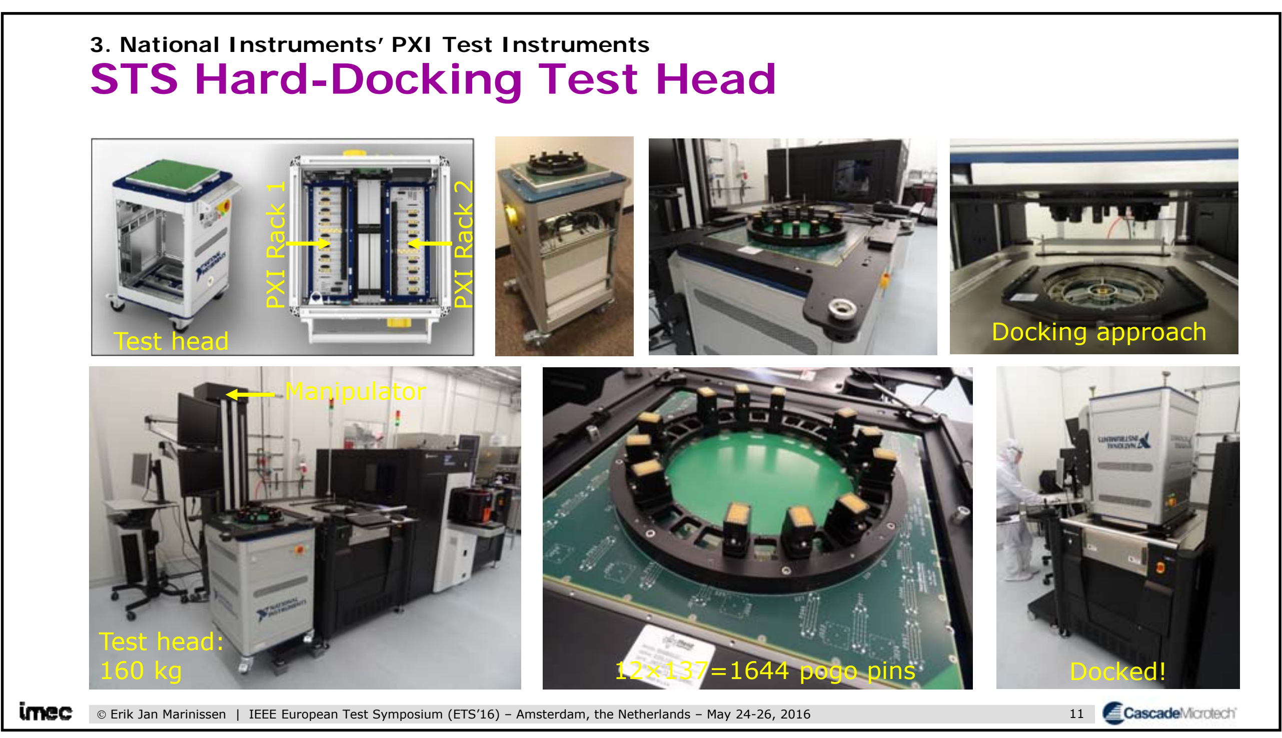

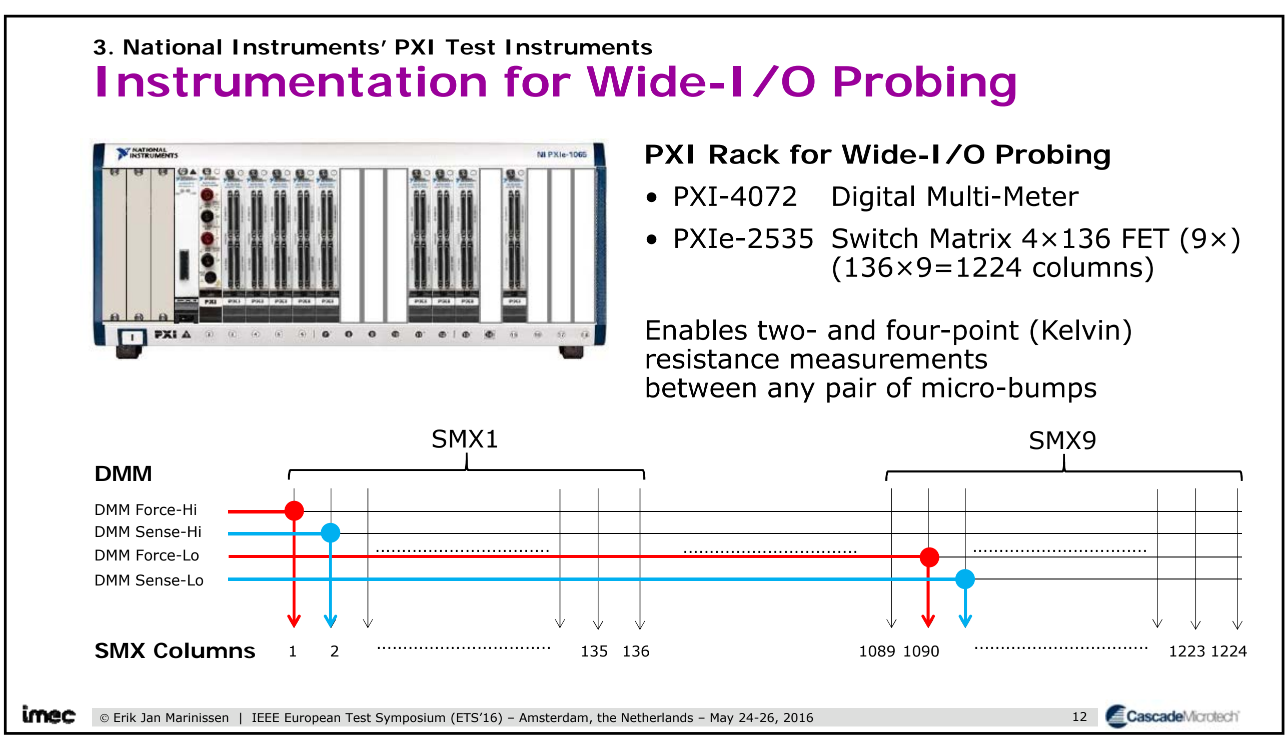

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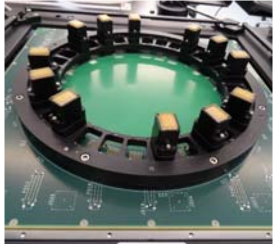
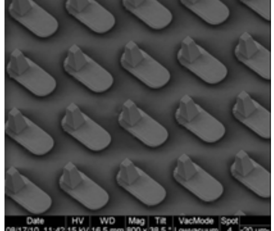
4. Cascade Microtech's Pyramid® Probes RBI Probe Cards and Cores

Test System's Interconnect Overview





Pogo Pins

- Spring-loaded pins
- 12 blocks × 137 pins = 1644 pogo pins
- Connected to PXI instrumentation outputs (e.g., Wide-I/O Switch Matrix columns)

Probe Card

- Pogo pad pattern matches the pogo pin layout
- Pogo pads connect one-to-one to Core-I/Os through multi-layered probe card

Probe Core

- Chip-design specific insert in probe card hole
- Consists of
  - Metal frame + 'plunger'
  - First thin-film membrane for routing signals from Core-I/Os to center of probe core
  - Second thin-film coupon contains the MEMS probe tips

Probe Tips

- Probe tip pattern matches the micro-bump layout
- Probe tips
  - Probe area $6 \times 6 \mu m^2$
  - Tip height: 12μm
  - On Rocking Beam Interposer ("RBI")

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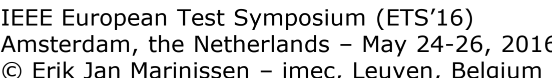

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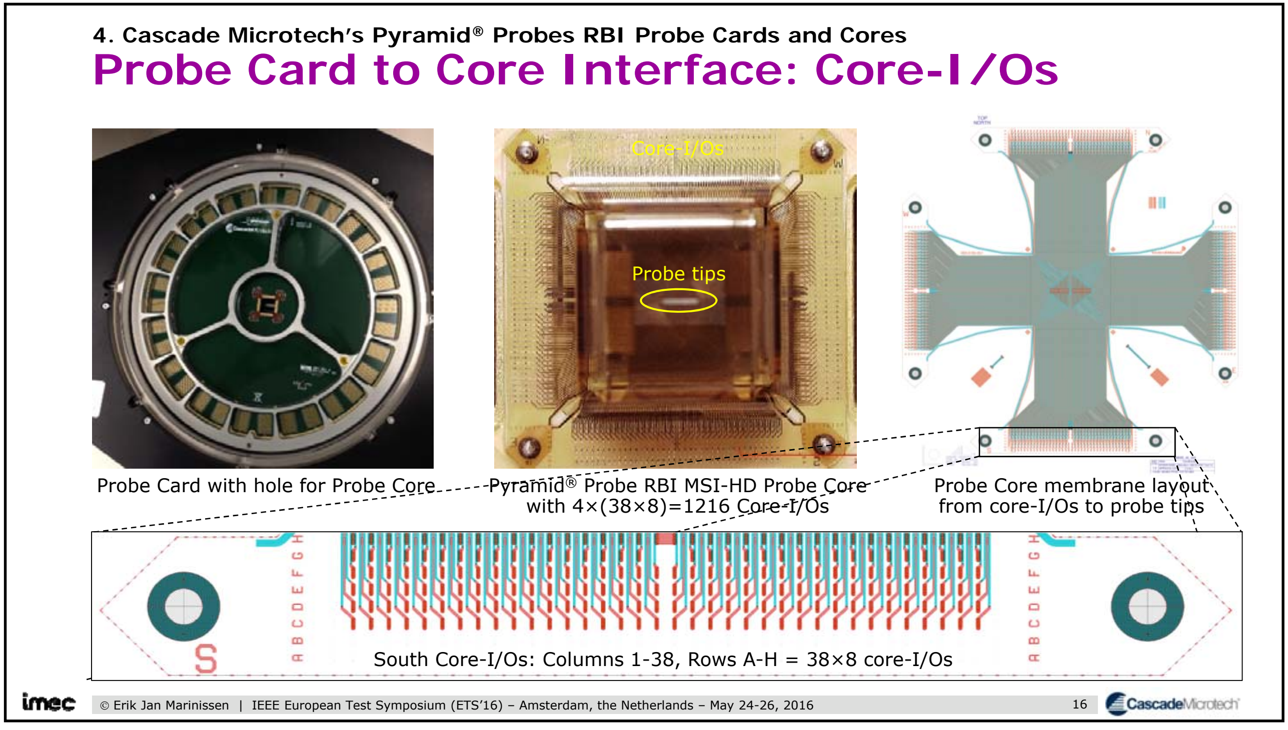

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imec's Micro-Bump Probe Applications

1. **Probe-Card Characterization**
   - Micro-bumps all shorted
   - Execute 'ProbeCheck' routine:

```
for ch=2 to 48 do {
    Gang = {2...48}\{ch};
    measure Rc between ch and Gang with I constant;
}
```

   - Wafers cannot be used for subsequent stacking
2. **Pre-Bond Micro-Bump Probing**
   - Main driver for this work
   - Evaluation of test system: probe station, test instrumentation, probe card + core
   - Evaluation of micro-bumps-under-test (MBuTs)
3. **High-Density Post-Bond Daisy-Chain Testing**
   - Use as high-probe-count probe card, e.g., for testing post-bond micro-bump daisy-chains with higher tap-off density

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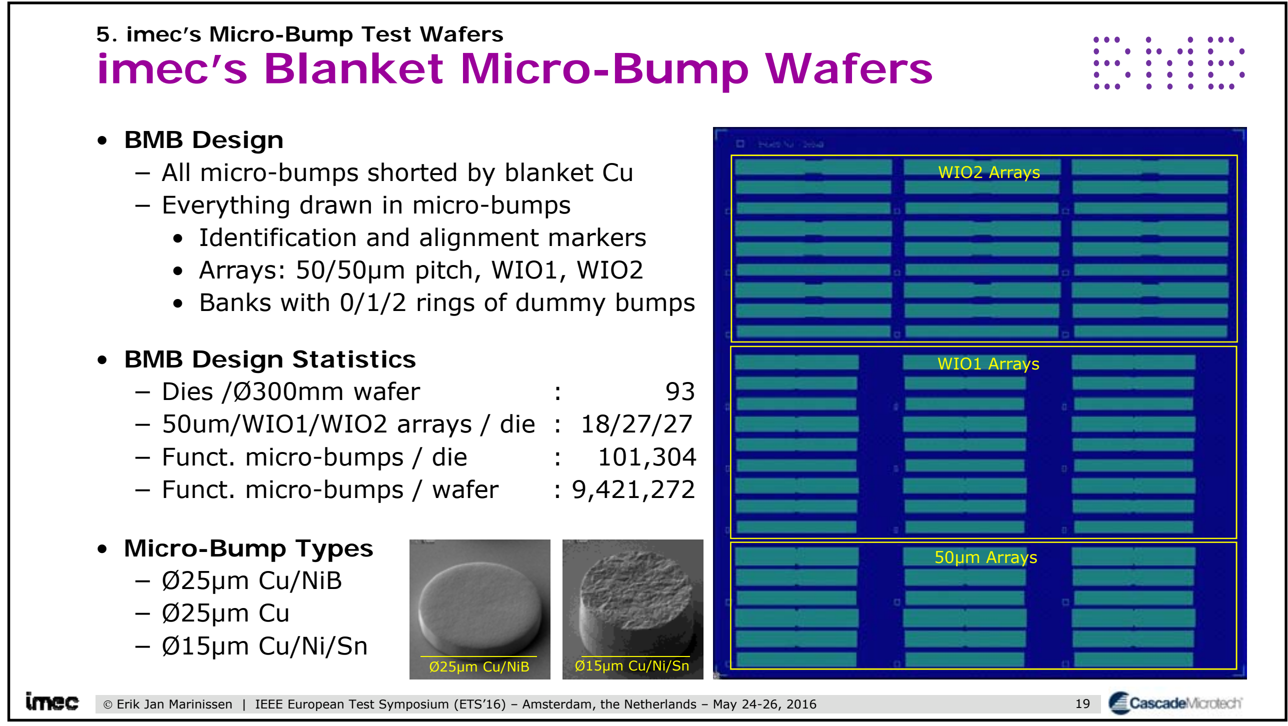

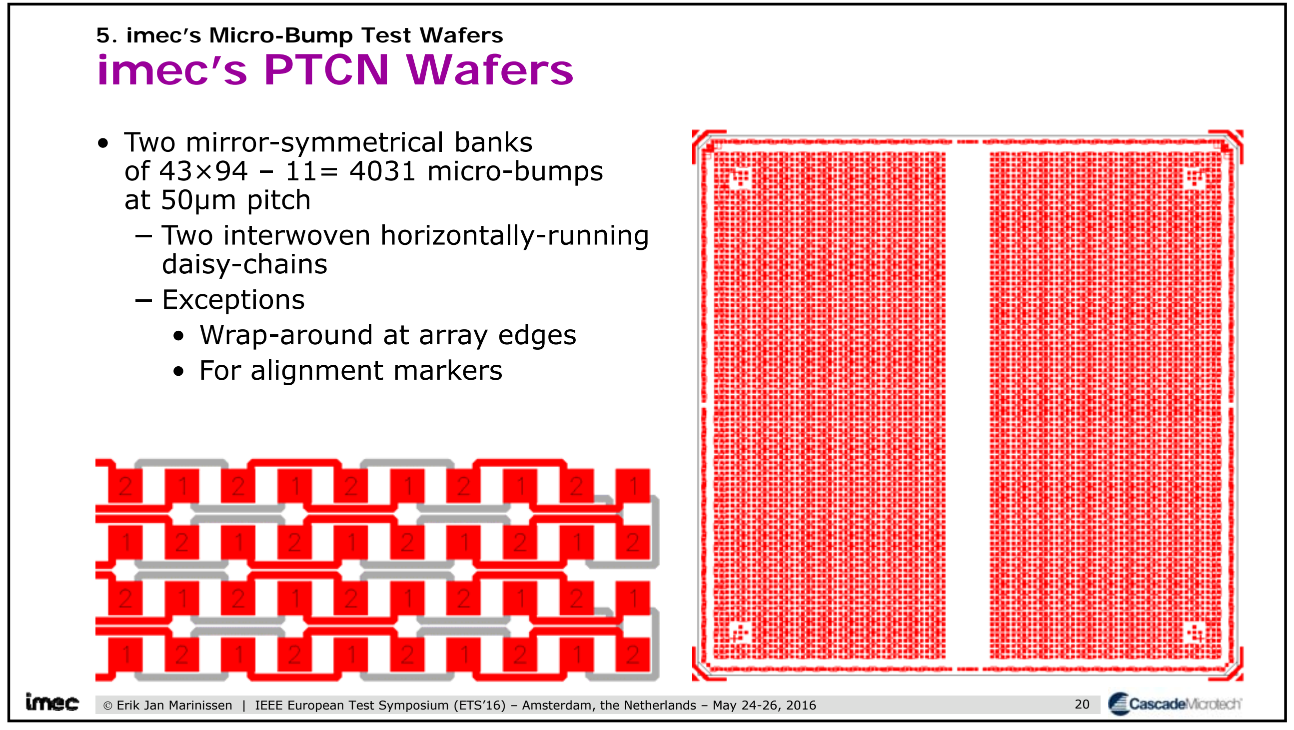

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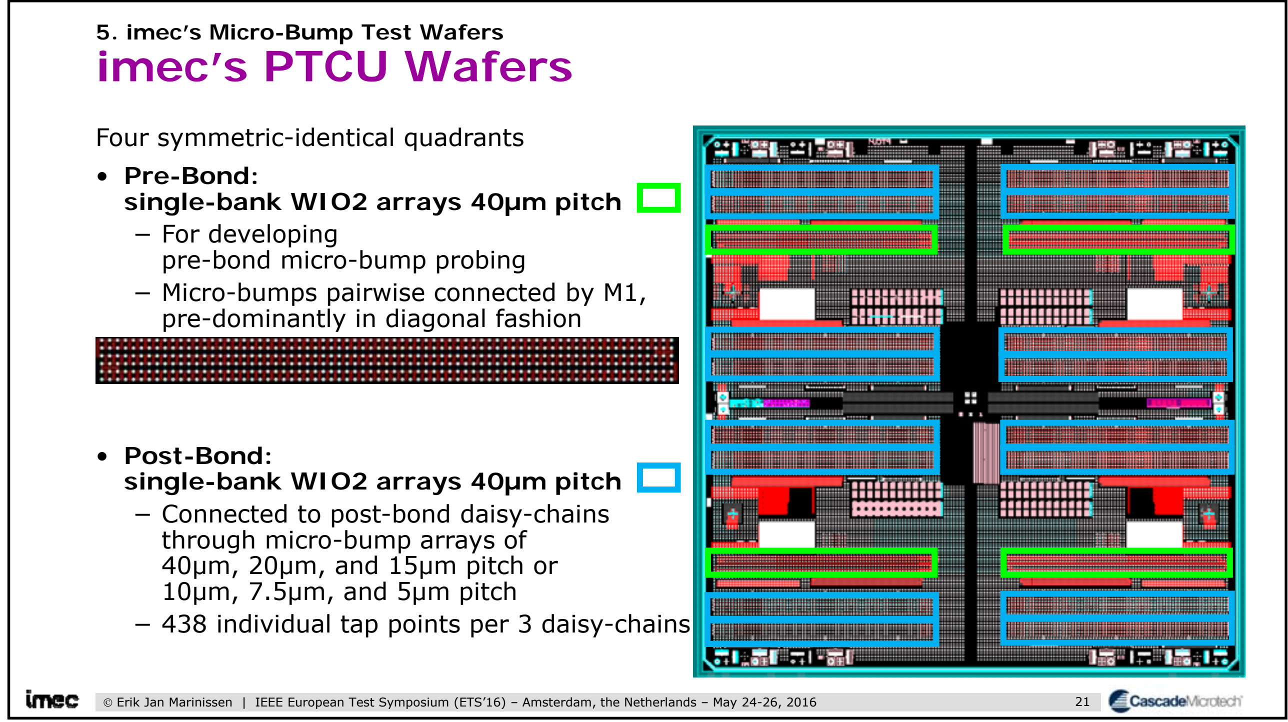

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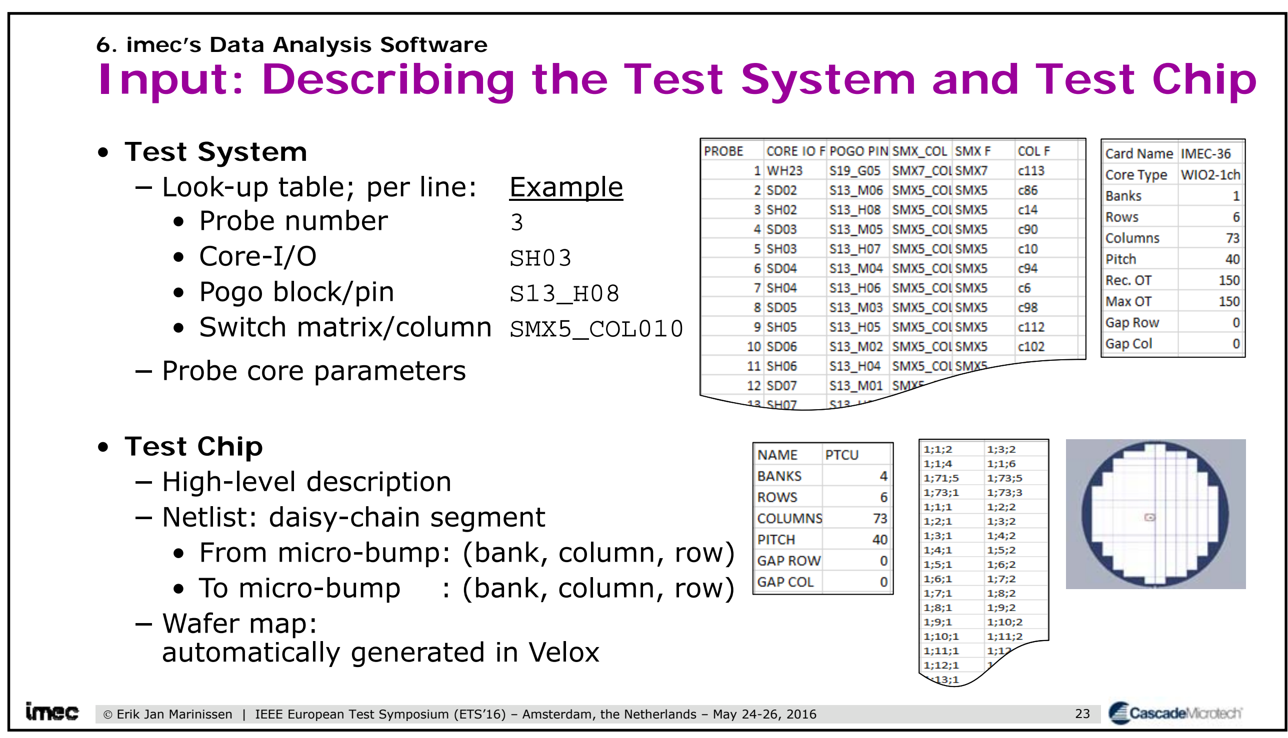

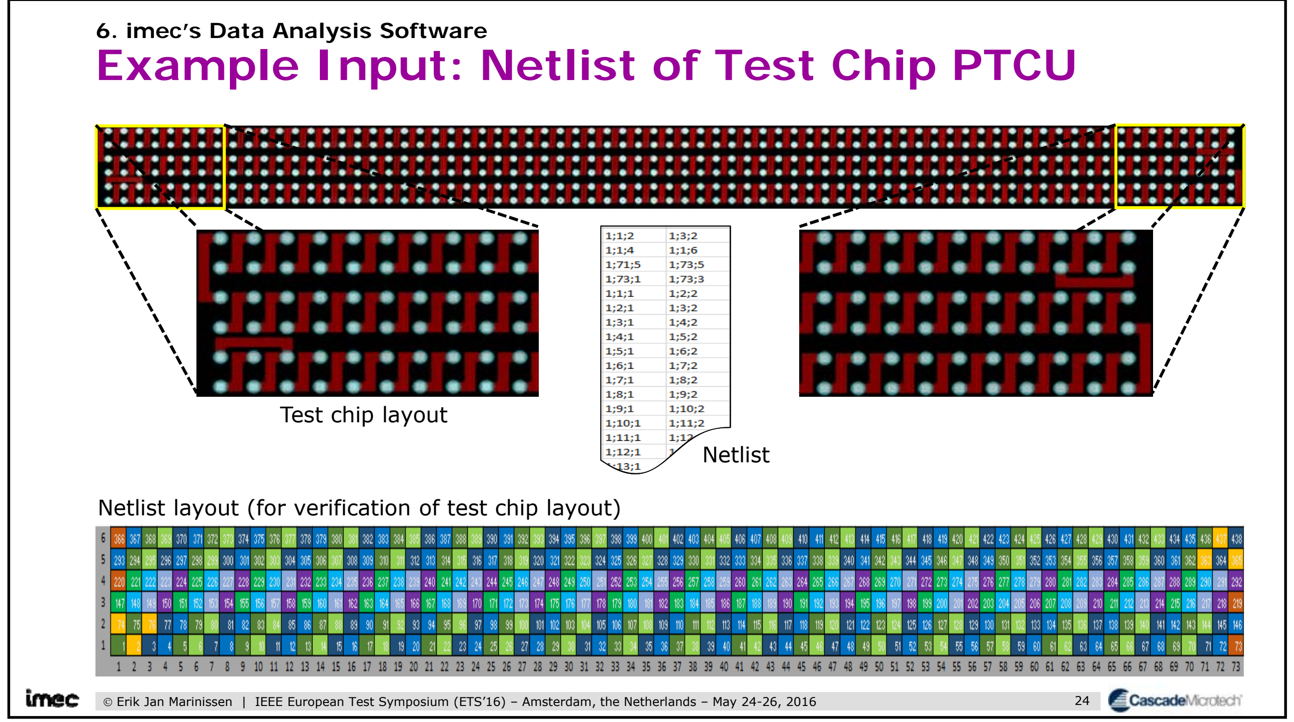

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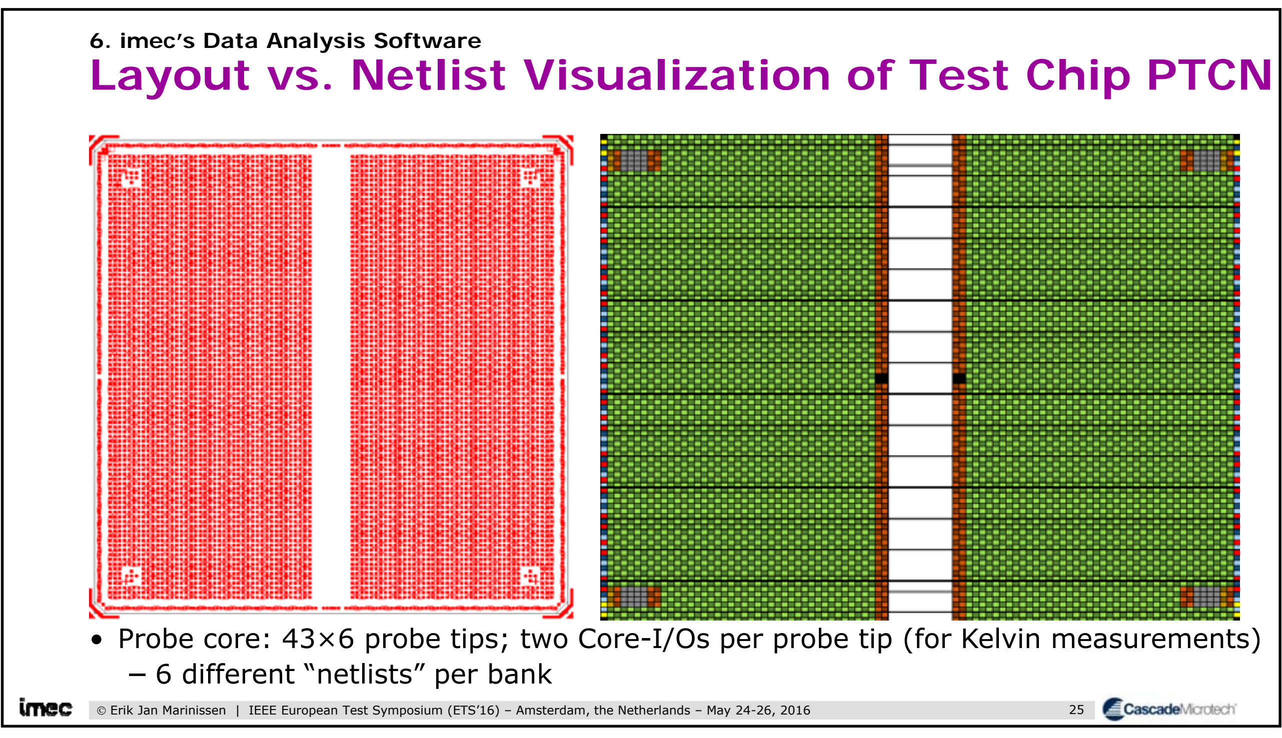

6. imec's Data Analysis Software

Output: Raw Data

- **Raw Data**: list of
  - Date and time stamp
  - Daisy-chain segment
    - From micro-bump: (bank; column; row)
    - To micro-bump : (bank; column; row)
    - Measured resistance value R (in Ohm)

- **Lots of Measurement Data**
  Example: BMB wafers, WIO1 Arrays
  - #Wafers : 5
  - #Dies / wafer : 93
  - #WIO1 arrays / die : 27
  - #R measurements / WIO1 array : 1,200

  Total #R measurements / 5 wafers: 15,066,000

- **Data Abstraction & Visualization is Necessary!**

PROBE STATION	CM300 VORTEX 2/2		
DATE	8/4/2016		
SAS DATE	08Apr2016:14:00:42.25		
CORE [TYPE]	IMEC-36 [WIO2-1ch]		
CHIP TYPE	PTCU		
OPERATOR	user		
08Apr2016:14:00:42.90	1;1;2	1;3;2	44.80485
08Apr2016:14:00:43.12	1;1;4	1;1;6	39.22808
08Apr2016:14:00:43.33	1;71;5	1;73;5	41.65223
08Apr2016:14:00:43.54	1;73;1	1;73;3	40.69714
08Apr2016:14:00:43.75	1;1;1	1;2;2	46.43578
08Apr2016:14:00:43.96	1;2;1	1;3;2	48.29134
08Apr2016:14:00:44.18	1;3;1	1;4;2	55.32705
08Apr2016:14:00:44.38	1;4;1	1;5;2	49.34558
08Apr2016:14:00:44.59	1;5;1	1;6;2	53.37437
08Apr2016:14:00:44.80	1;6;1	1;7;2	49.41641
08Apr2016:14:00:45.01	1;7;1	1;8;2	52.96967
08Apr2016:14:00:45.22	1;8;1	1;9;2	48.96112
08Apr2016:14:00:45.43	1;9;1	1;10;2	
08Apr2016:14:00:45.64	1;10;1	[illegible]	
08Apr2016:14:00:45.85	1;11;1		
[illegible]Apr2016:14:00:46.07	[illegible]		

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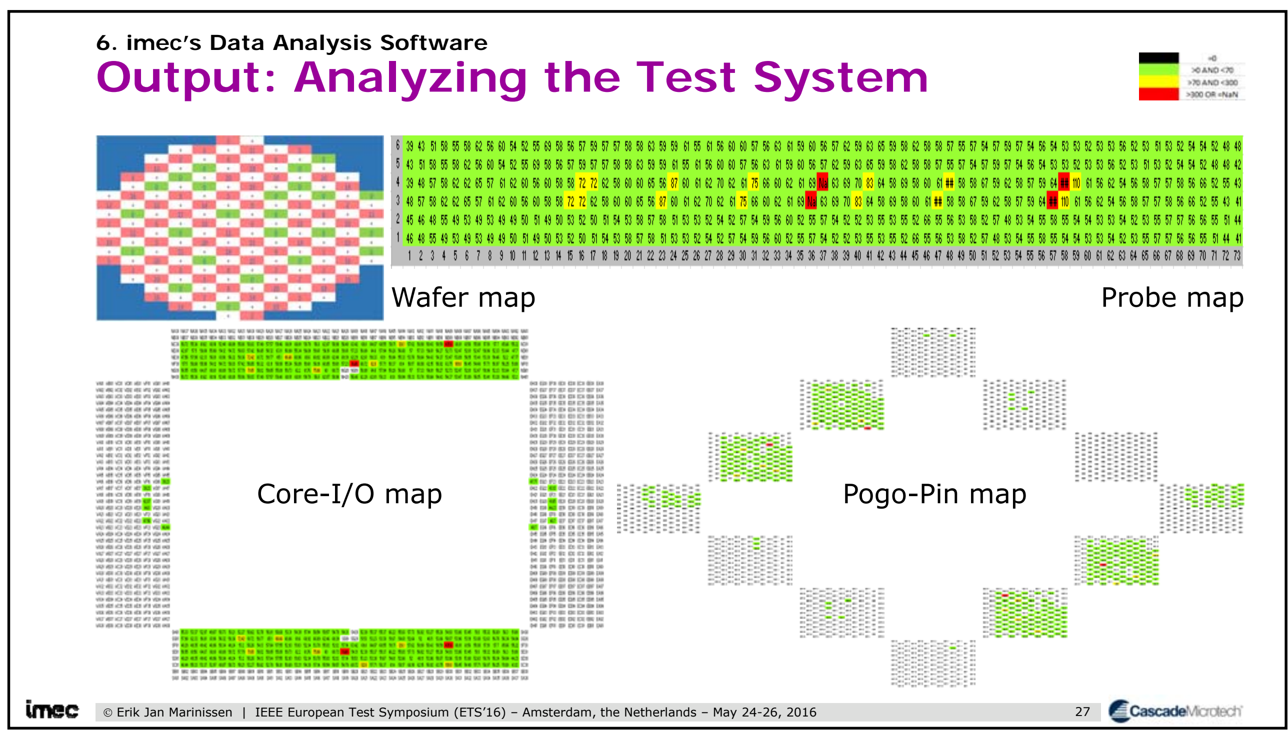

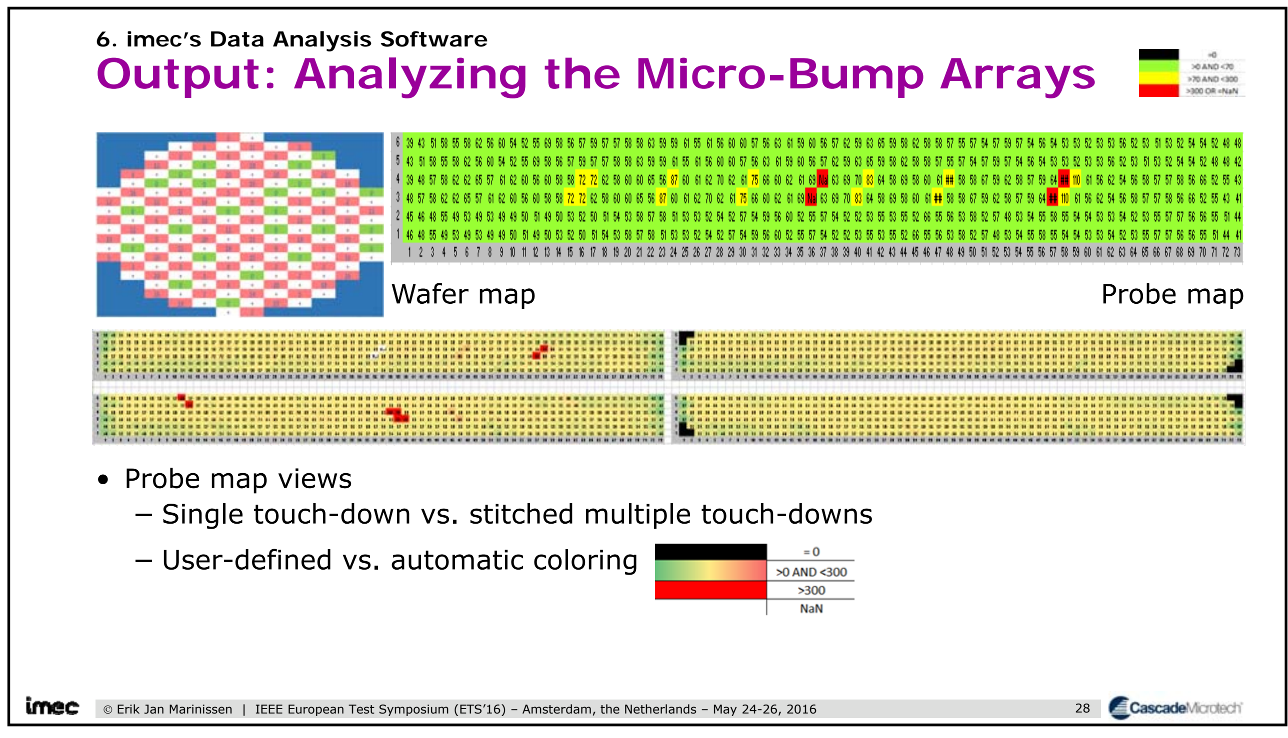

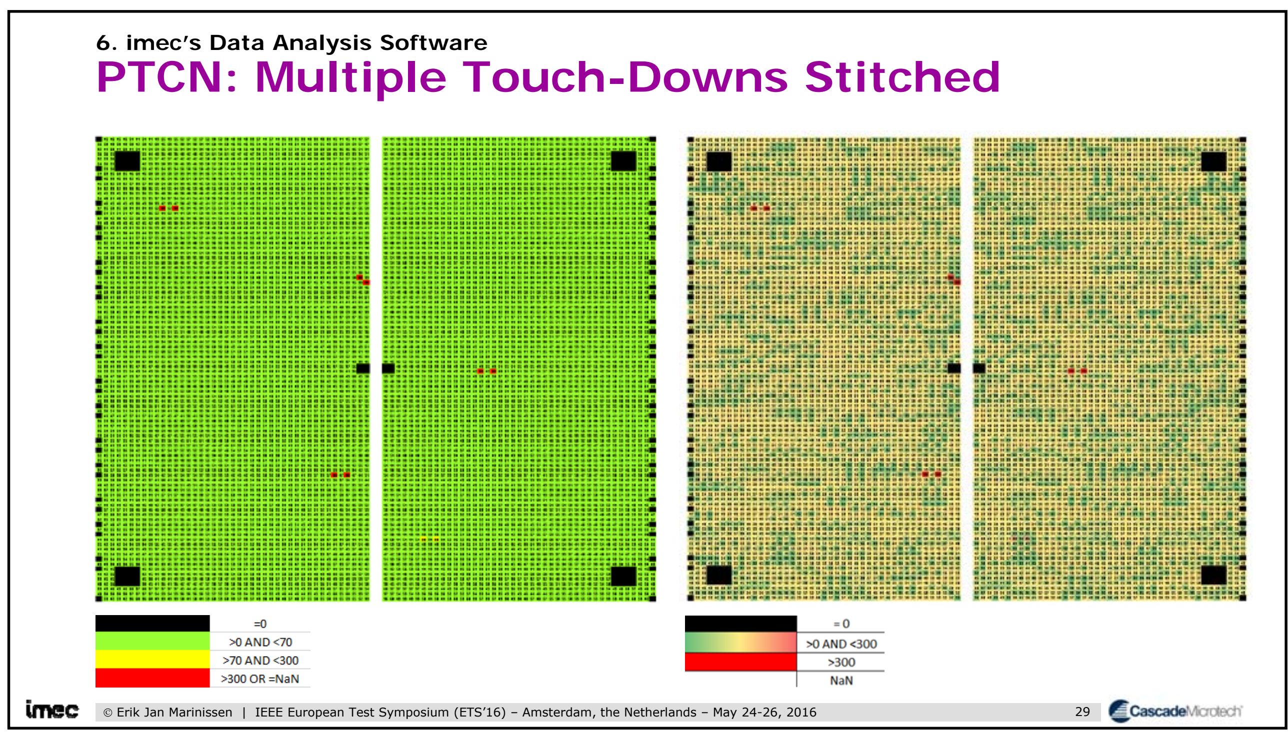

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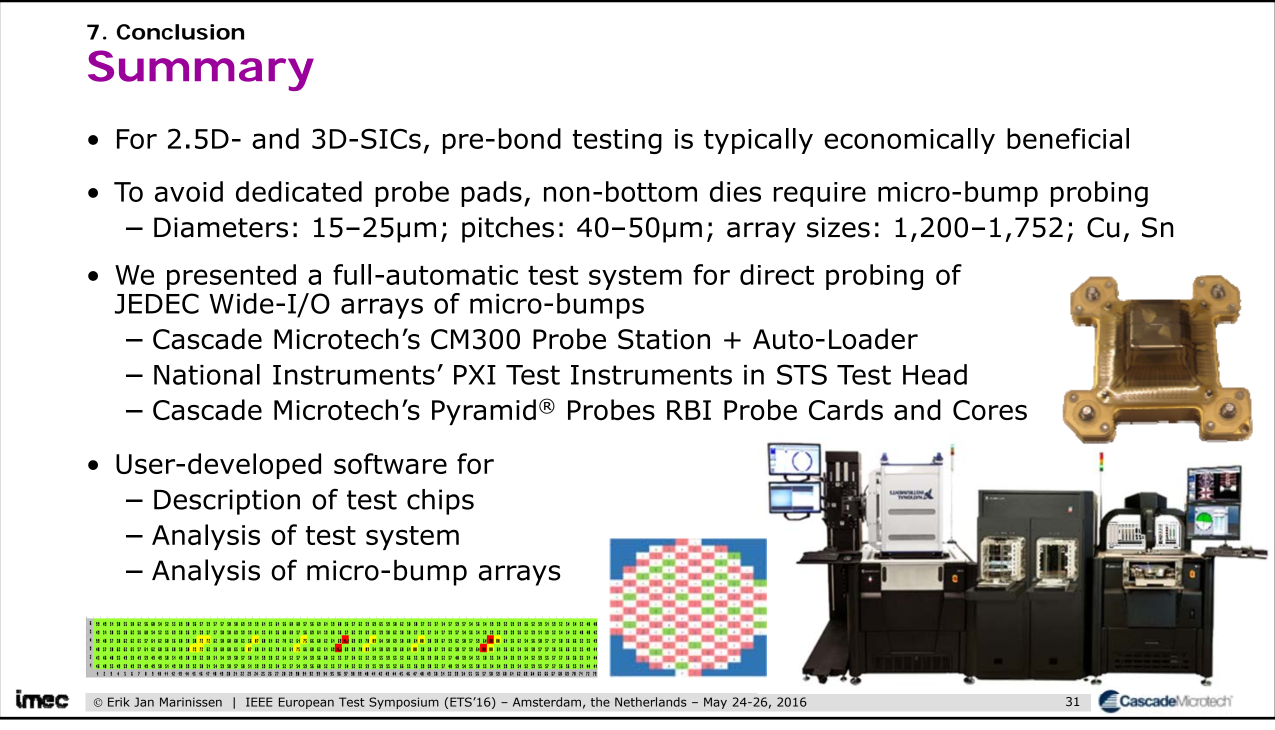

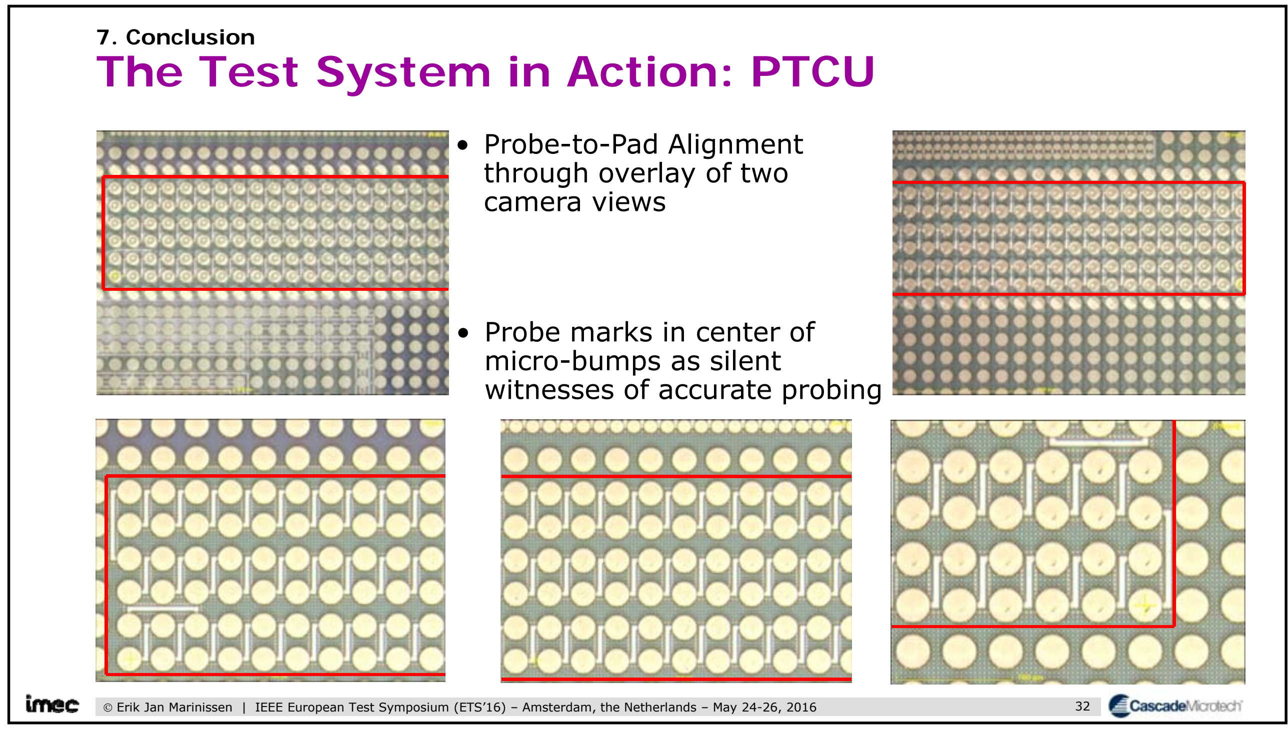

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7. Conclusion

Acknowledgments

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