Cantilever Based Ultra Fine Pitch Probing

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CAPRES A/S

COPENHAGEN APPLIED RESEARCH

About CAPRES

Danish MEMS probe & interfacing venture

Mission:
- **To provide micro- and nano-scale probing solutions that improve quality and increase yield in device manufacturing**

Technology:
- **Multi-point probing with micro-fabricated cantilever arrays**

Products:
- **Multi-point probes, interfacing and development platforms**

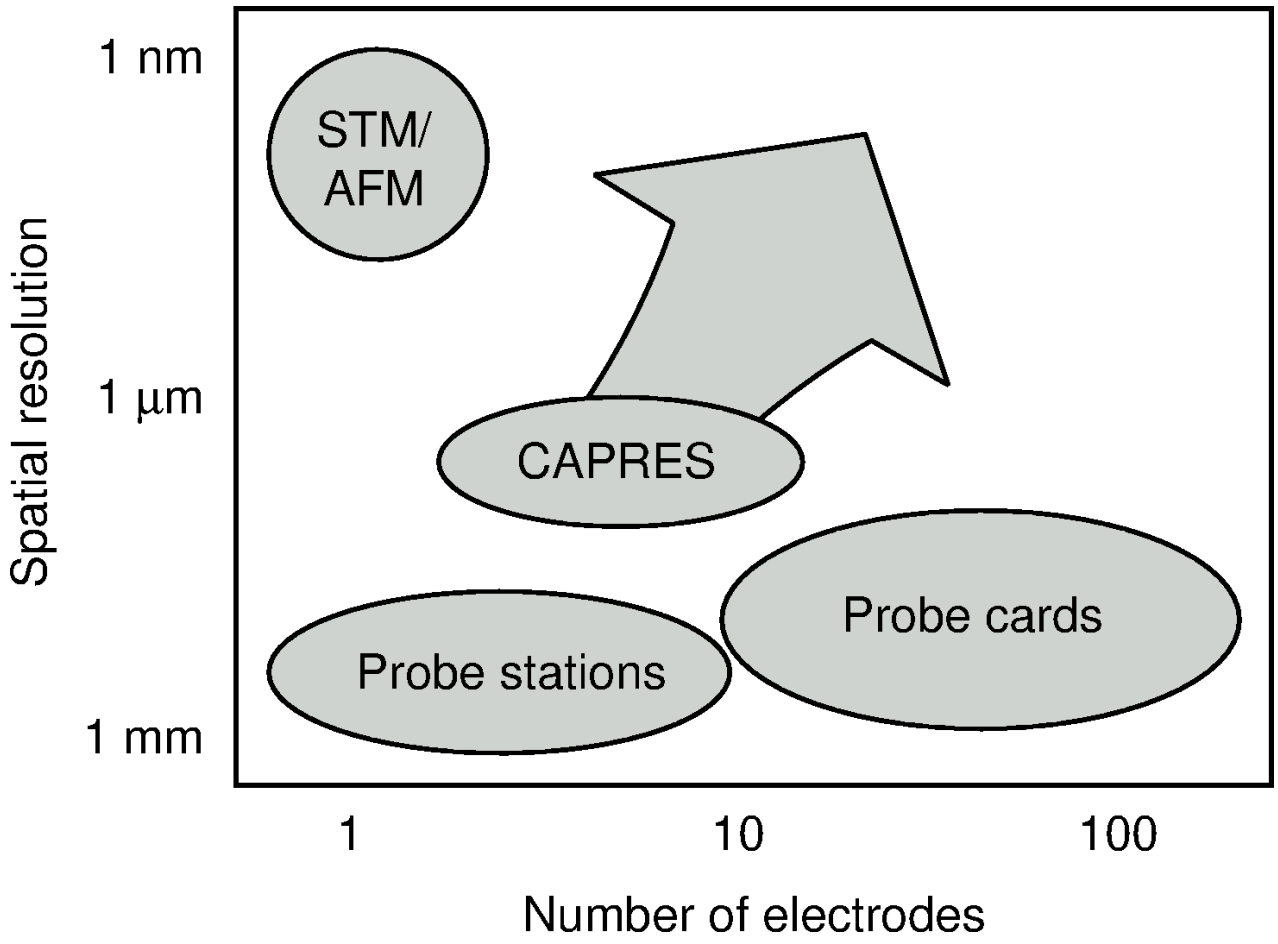
Company Milestones

May 1999:	**Established in Denmark with $100k seed**
Jan 2001:	**$3m VC funding**
May 2002:	**First tool installed at IBM, NY**
Feb 2003:	**$2.5m VC funding**
Mar 2003:	**License agreement with IBM and Infineon Technologies**
Jul 2003:	**OEM agreement with Veeco Instruments**
Jun 2004:	**Multiple probing tools installed worldwide**

MIC Research Center Profile

- **National research center for advanced semiconductor micro-technologies**
- **Established 1990, in operation 1993**
- **6000 sq.ft. class 100 clean-room**
- **7000 sq.ft. adjoining lab space**
- **Staff >100**

Market Position



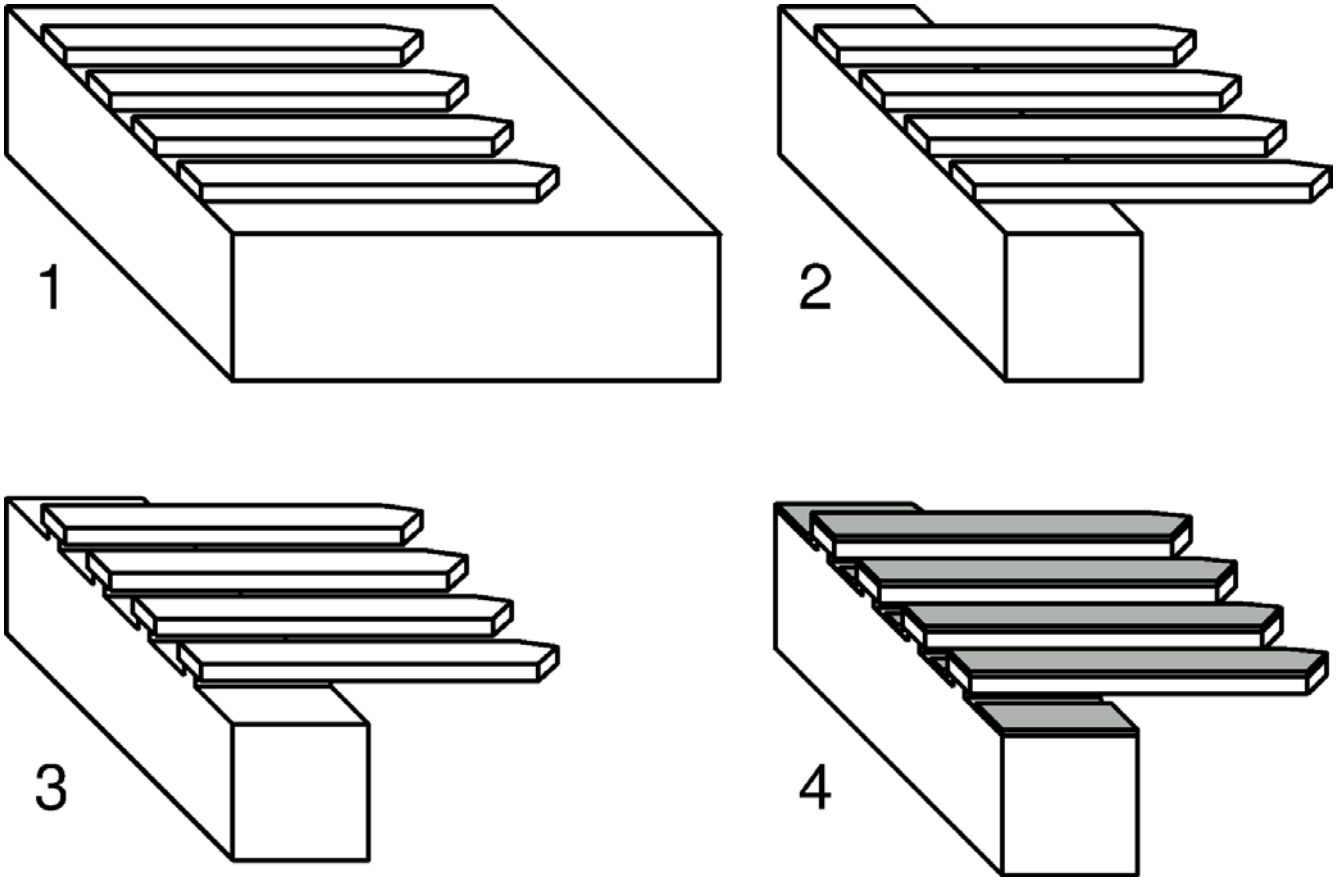
Core Technology

- **Multi-point probes based on micro-fabricated cantilever arrays**
- **Electronic and mechanical multi-point probe interfacing**

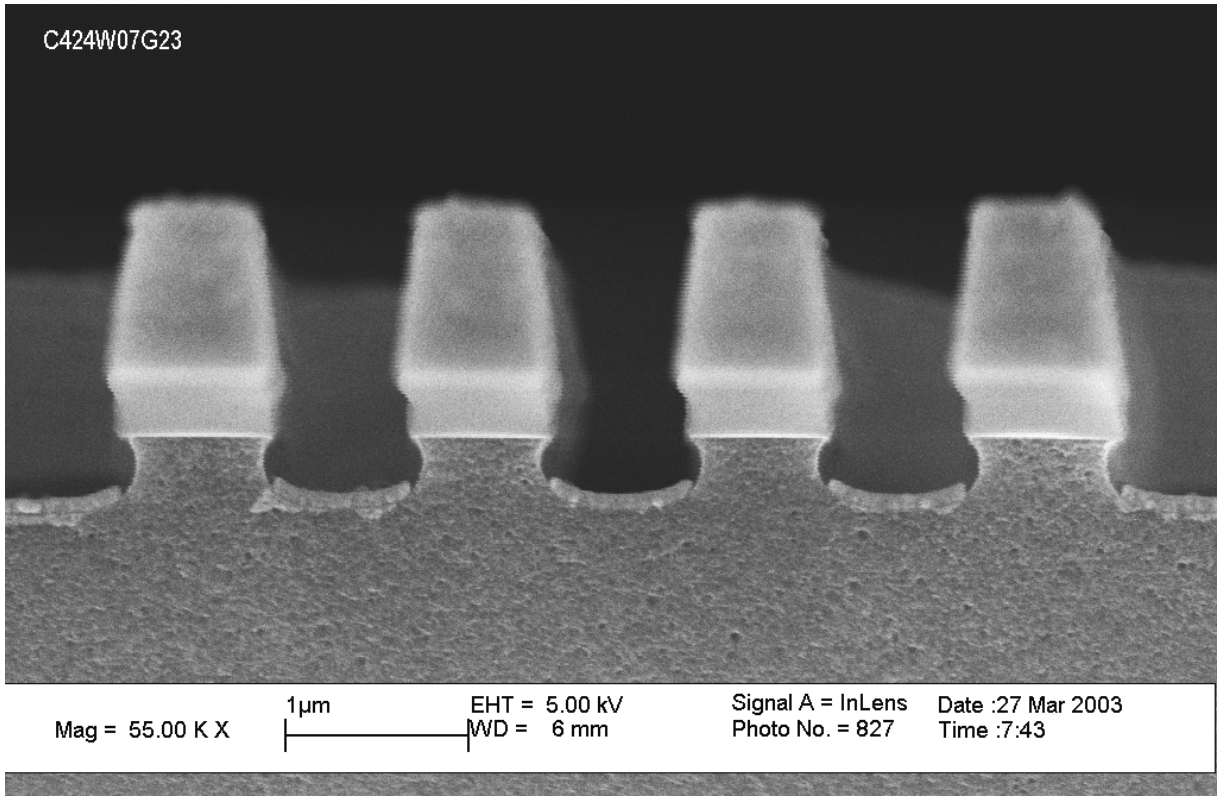
Features:

- **10× smaller pitch than existing probe card technologies**
- **Short lead-time due to fast and simple manufacturing processes**
- **Cheap disposable probe cards**

MEMS Multi-Point Probe

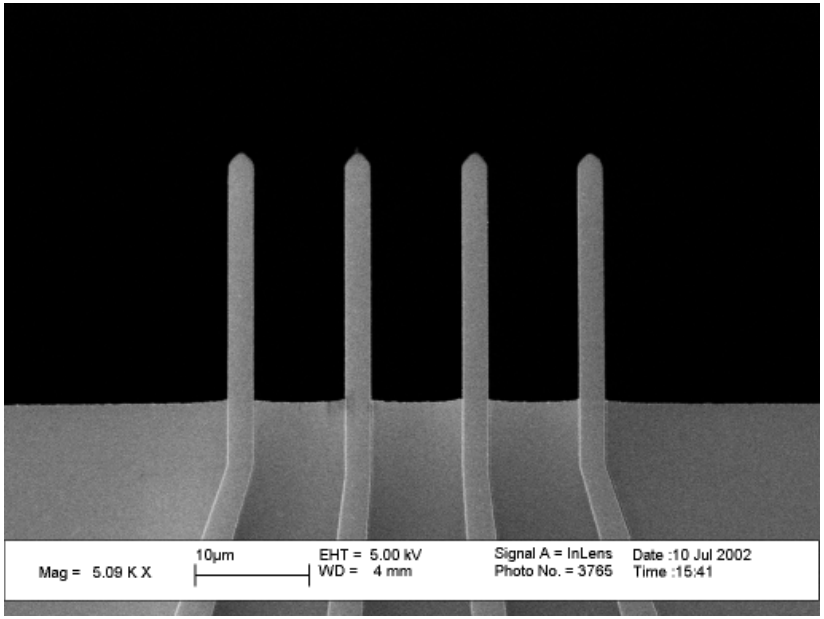


MEMS Probe Fabrication

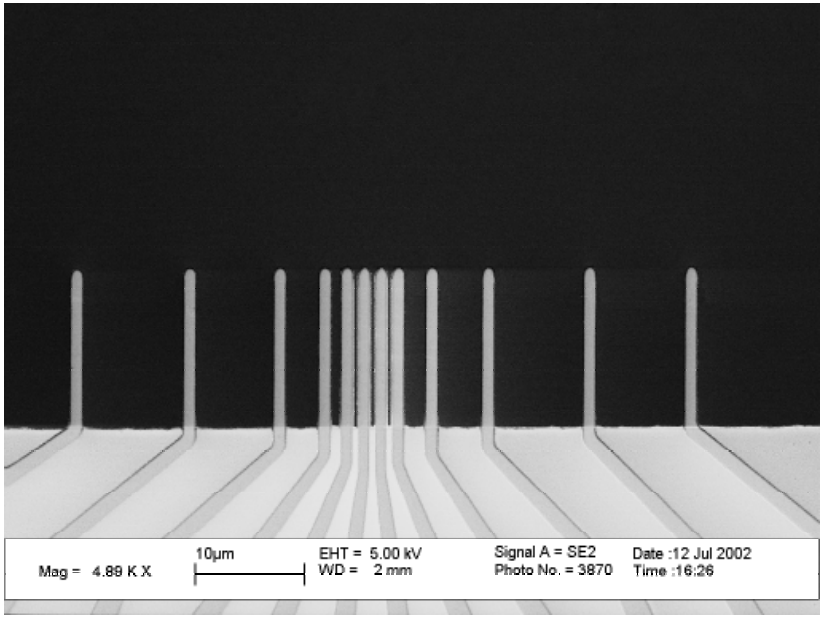


- **Prototyping and R&D activities at MIC Research Center**
- **Production at European MEMS foundry**

Probe Specifications



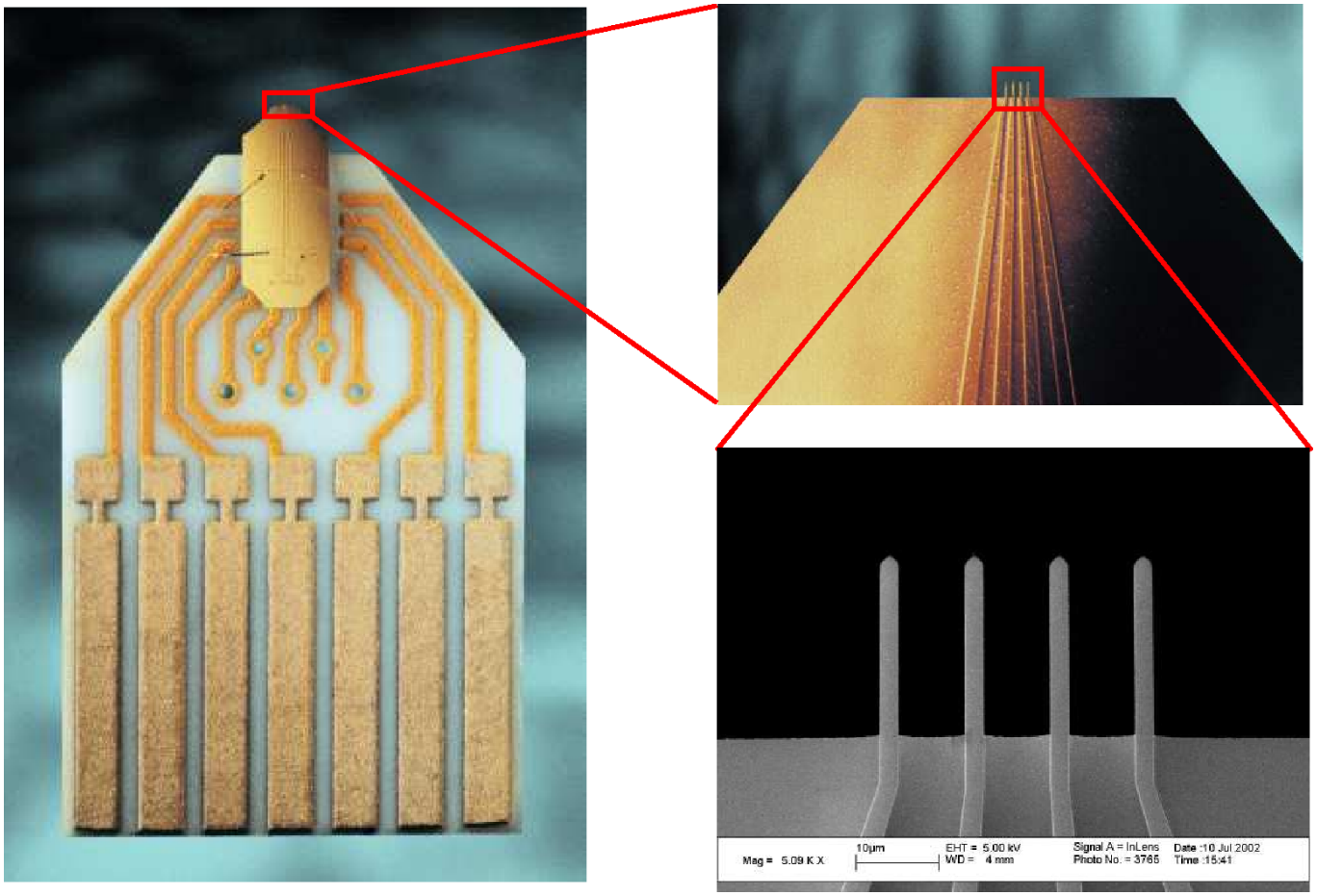
Four point probe



Twelve point probe

- Cr/Au coated SiO_2 cantilevers on Si substrate
- Contact diameter 10-100 nm
- Minimum pitch 1.5 µm
- Accurately aligned in-line tapered tips

Probe Mount



Die carrier size: 8.6x12.5mm

Probe Product Line

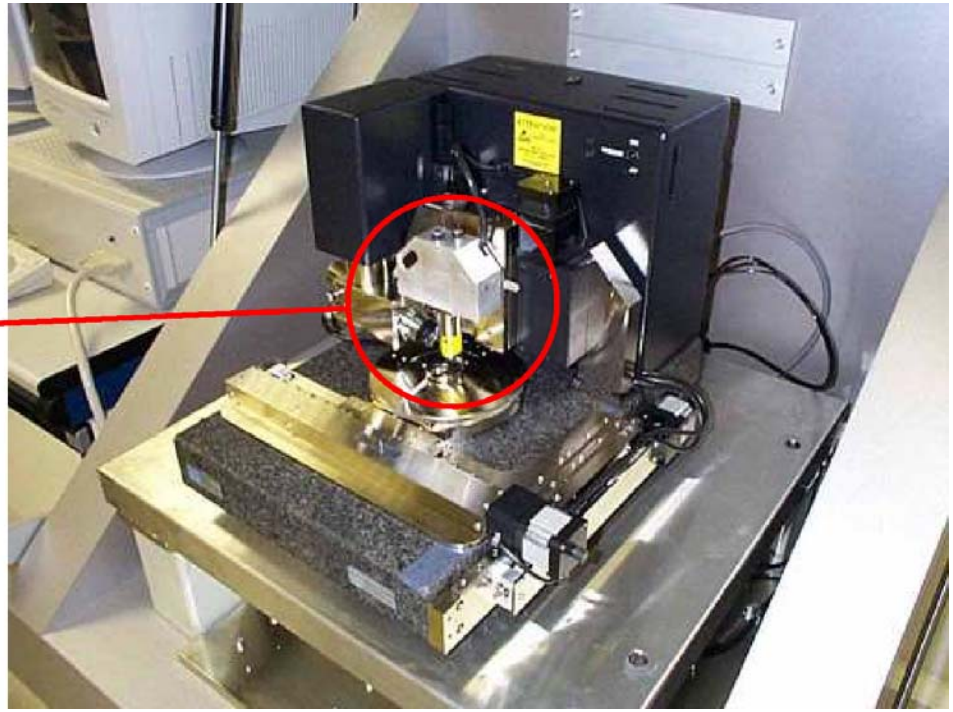
- **Micro four-point probes with 5, 10, 15, 20, 25 and 30 µm electrode spacing**

- **Twelve-point probes with 1.5 to 20 µm electrode spacing**

Modular Probing Interface

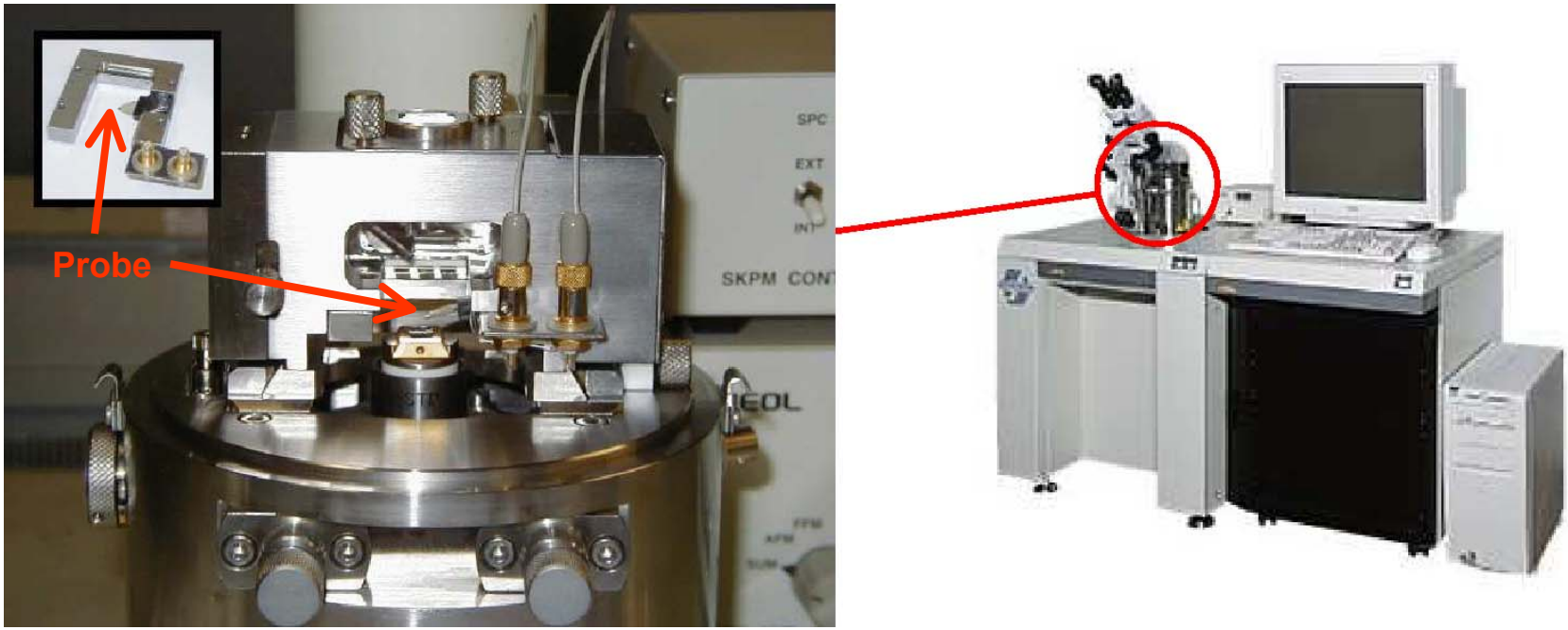
- **Probe head assembly with sensitive signal conditioning**
- **Digital control unit with serial communication interface**

Veeco Application Module



Fits Veeco Dimension 3100 series Scanning Probe Microscopes

JEOL Application Module

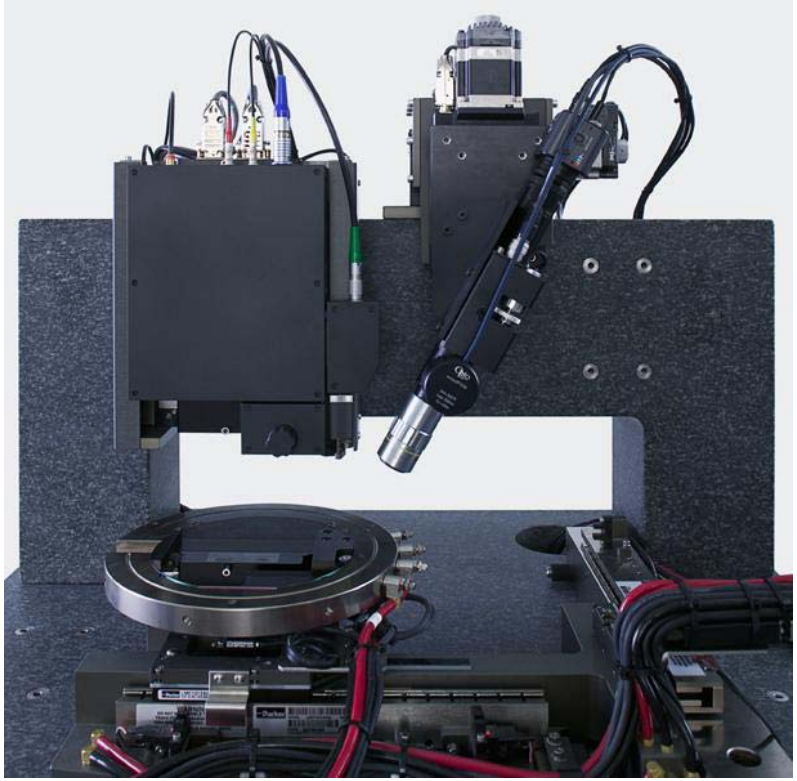


Fits JEOL JSPM-4210 series Scanning Probe Microscopes

Probe Development Platform

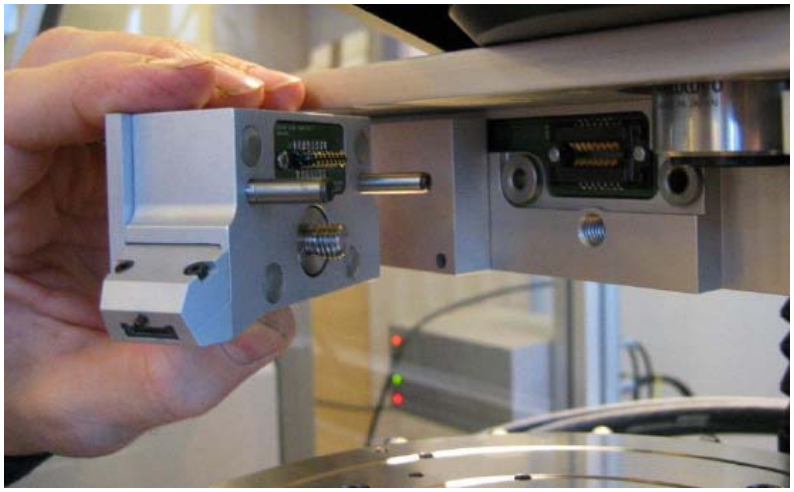
- **High precision “flying probe” platform**
- **Sub-micron mechanical resolution enables landing of probes with ultra fine pitch**
- **Automated probing across wafers and coupons**
- **General purpose user interface**

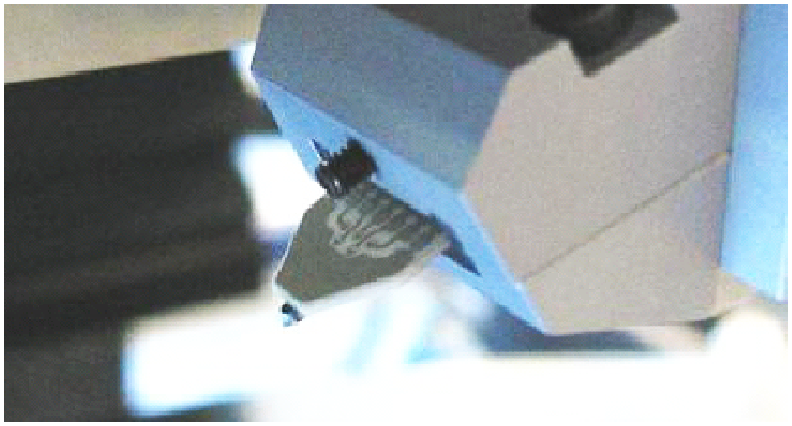
Stage Specifications



- **Linear motors**
- **Air bearings & suspension**
- **20 nm xy resolution**
- **5 nm z resolution**
- **6" (150 mm) xy travel**

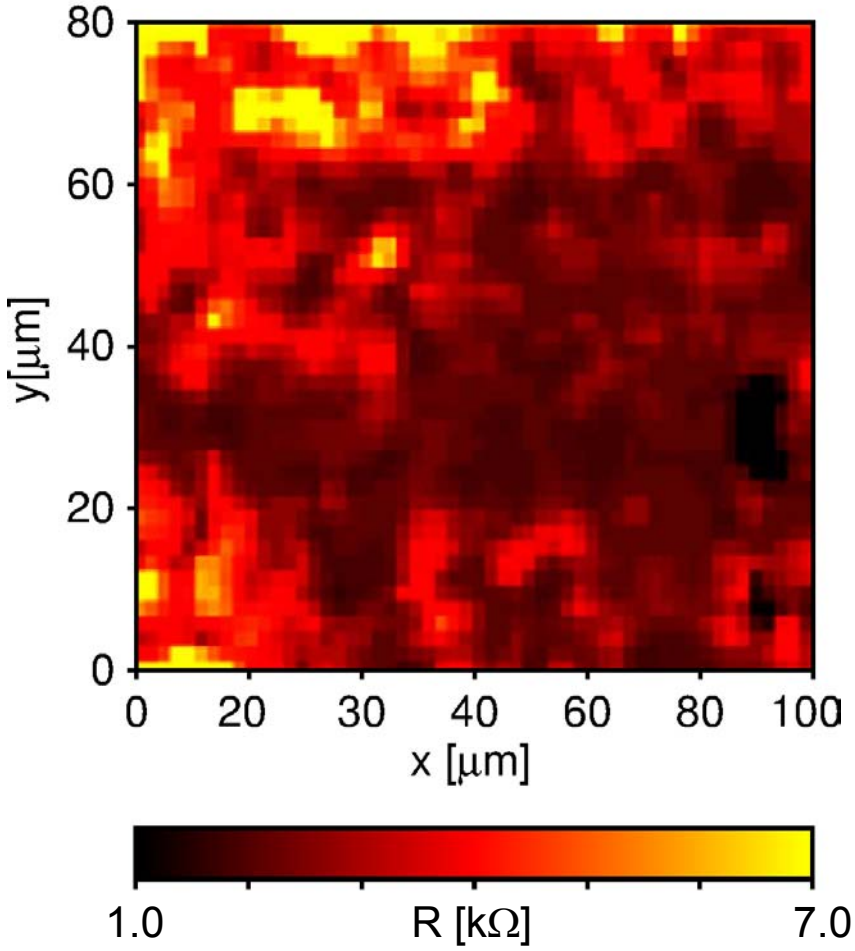
Probe Head Specifications





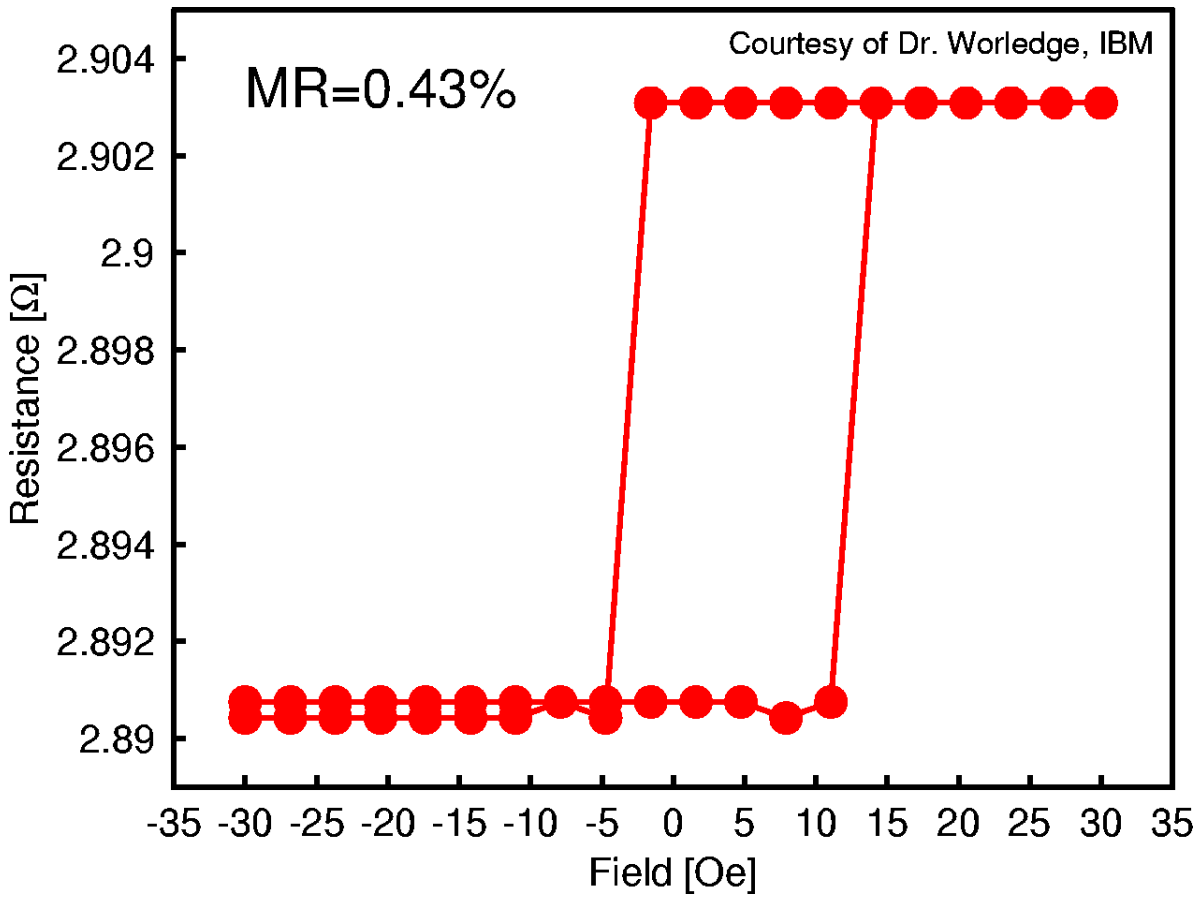
- **Integrated signal conditioning and multiplexing**
- **Microcontroller based interface**
- **Detachable for fast probe replacement**

Conducting Polymer Films



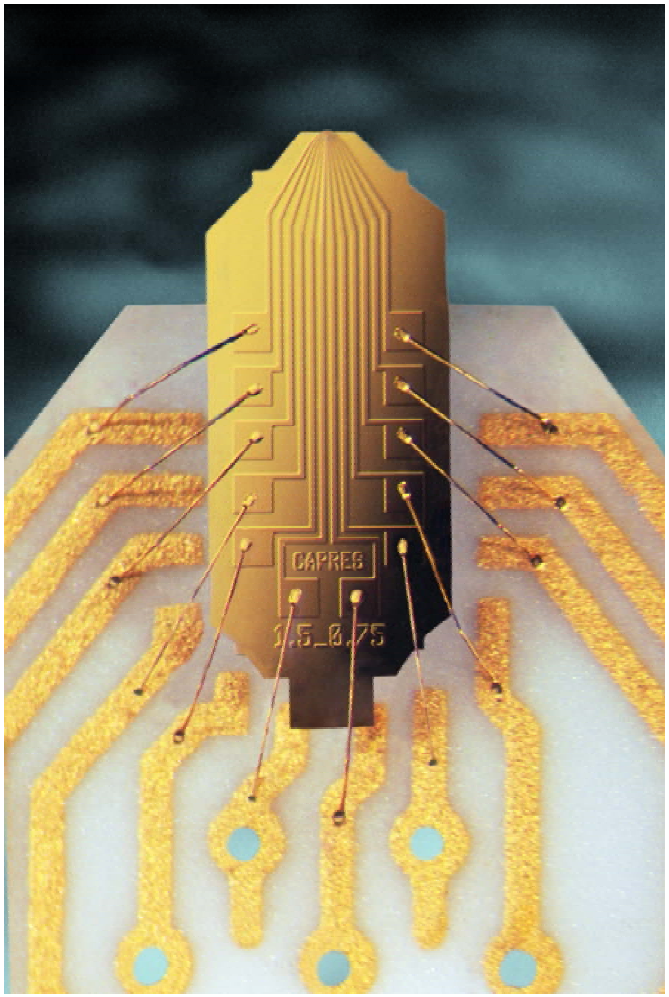
- **Automated probing of surface resistivity**
- **Spin coated polymer film**
- **Scan size 100x80 µm²**
- **20 µm probe spacing**

Magnetoresistance



Automated hysteresis measurements easily resolves MR < 0.3%

MRAM/Read Head MTJ films



- **Nano-scale twelve-point probes**
- **Current In-Plane Tunneling (CIPT) model from IBM & Infineon Technologies**
- **Extracts MR and RA instantly on blanket MTJ films**
- **Test time reduced from weeks to minutes!**

Wafer Probing

Potential applications:

- **Custom probing of scribe line structures & devices**
- **Probing of devices with miniature test pads**

User benefits:

- **100× reduction in needed pad area**
- **Cheap, disposable probes**
- **Short lead-time**

Technology Status

Current capabilities:

- **Custom single in-line probe arrays with 1.5 µm minimum pitch**
- **Dedicated high-performance probing platform**

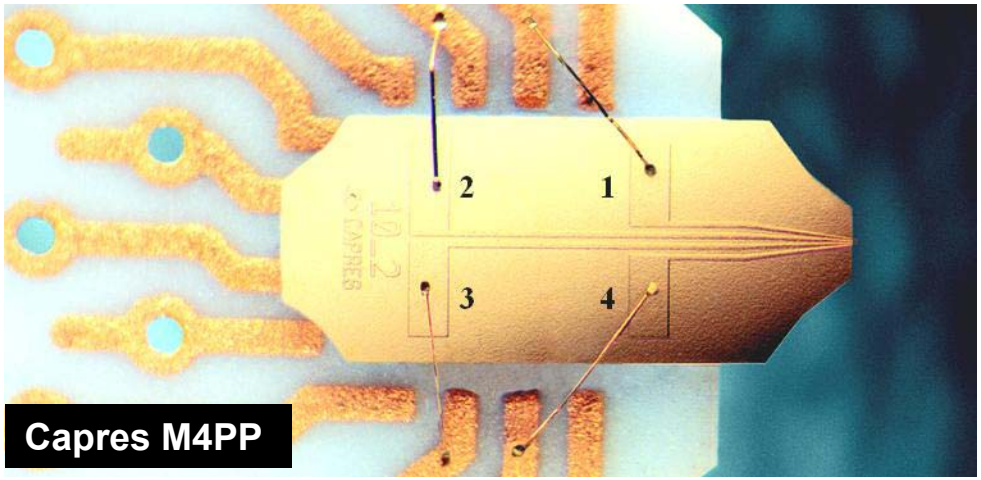
Future (potential):

- **Dual and/or quad in-line probing configurations**
- **Integration with conventional third-party probing platforms**

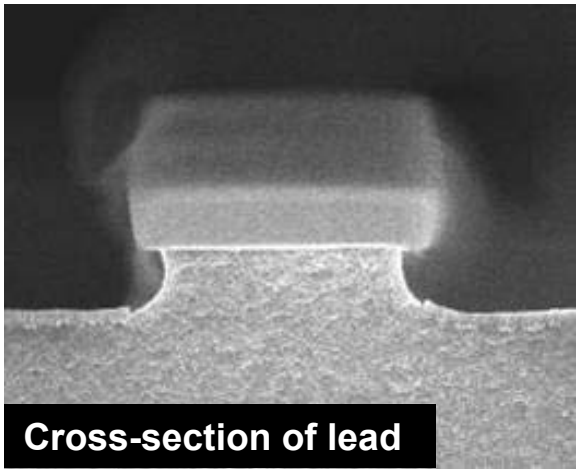
Preliminary Electrical Mapping

- **Capacitance between cantilevers measured with HP4280A 1MHz C Meter/C-V Plotter**
- **Leakage current between cantilevers measured with HP4145B Semiconductor Parameter Analyzer**
- **Measurements done on packaged die; reproducible for different batches and designs**

Capacitance Data



Capres M4PP


Cross-section of lead

Parallel plate capacitance: $C = \varepsilon_r \varepsilon_0 \frac{A}{d}$

Lead-to-Si capacitance: $C_1 = C_4 = 5.8\text{pF}$ $C_2 = C_3 = 7.9\text{pF}$

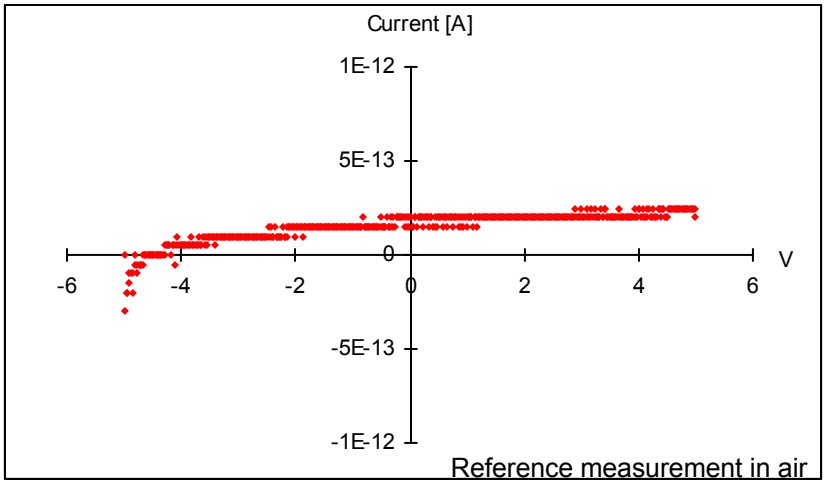
Lead-to-Lead capacitance: $C_{1-4} = \left(2 \cdot C_1^{-1}\right)^{-1} = 2.9\text{pF}$ $C_{2-3} = \left(2 \cdot C_2^{-1}\right)^{-1} = 4.0\text{pF}$

Die #	Lead	Max. capacitance
C030219W1_09_J14	1-4	2.75 pF
C030219W1_09_J20	1-4	2.75 pF
C428W10_D05	1-4	2.73 pF

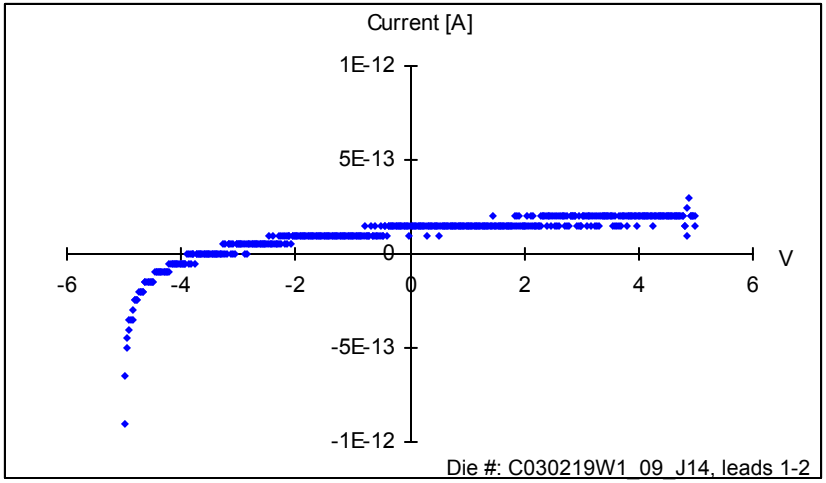
Die #	Lead	Max. capacitance
C030219W1_09_J14	2-3	3.85 pF
C030219W1_09_J20	2-3	3.21 pF
C428W10_D05	2-3	3.85 pF

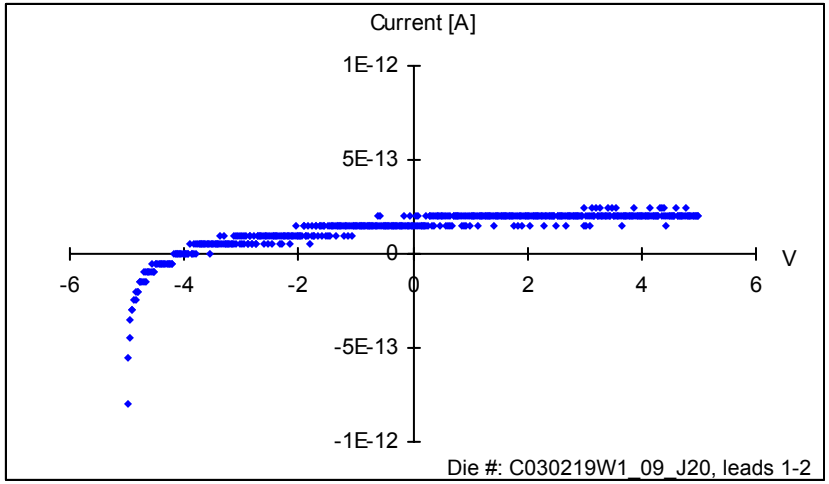
Leakage Current Data

The leakage current between two cantilevers is smaller than or on the order of the resolution of the instrument: 50fA

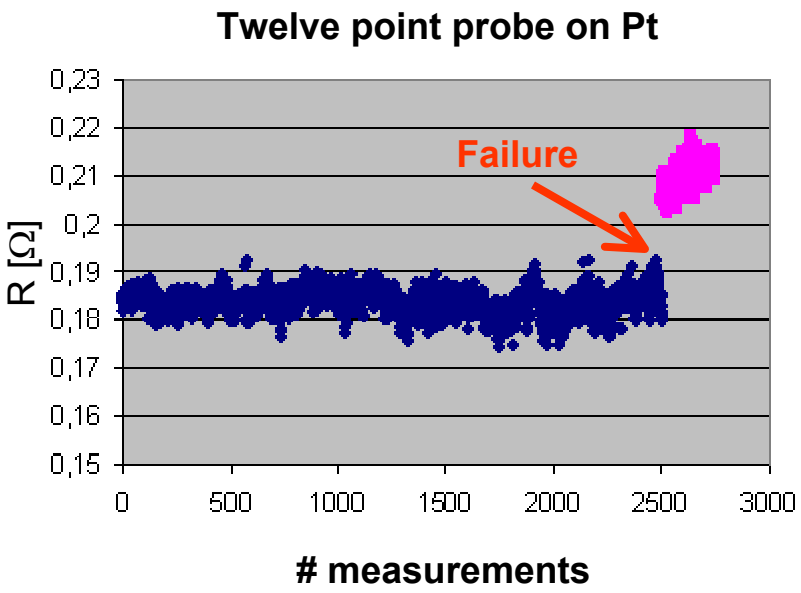


Leakage current between two cantilevers:





Probe Lifetime



Currently few thousand engages

Limiting factors:

- **Ultra fine pitch; larger probes likely to have longer life**
- **Soft, thin active electrode layer wears quickly**

Potential solutions:

- **Larger probe cantilevers**
- **Probe cantilever redundancy**
- **Other active electrode materials**

Probe Card Roadmap

Focus: Parametric test

Phase I:
- **Start collaboration with probe card end-user(s)**
- **Establish current technology capability on client demo wafers**

Phase II:
- **Develop and manufacture optimized parametric test probe**
- **Collaborate to further develop/optimize functionality**
- **Perform cross-correlation measurements**

Phase III:
- **Collaboration with tool manufacturer(s) to integrate technology on conventional probing platforms**

Summary

- CAPRES established 1999, venture funded & owned
- Core technology:
  - Micro-fabricated cantilever electrode arrays
  - Modular interfacing technology
- Existing Probe/Interface/Tool product line
- Ultra fine pitch capability
- Early electrical performance results promising
- Work towards parametric probe cards initiated