Elevated Temperature Probing Development at SEMATECH

Southwest Test Workshop

June 3, 1997

Elevated Temperature Probing Development Subcommittee

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Phil Seitzer - Lucent Technologies
Ken Papworth - Motorola
Rex Lewis - Texas Instruments

SEMATECH
Mission Statement

- SEMATECH members will create shared competitive advantage by working together to achieve and strengthen manufacturing technology leadership.

The SEMATECH Probes PTAB Members and their Member Companies

AMD	Pete Dodd	
Digital	Al Miller	Suresh Nadig
HP	Susan Stirrat	Henry Chen
IBM	Gobinda Das	Norm Rapoport
Intel	Barry Lieberman	Ken Karklin
Lucent	Phil Seitzer	
Motorola	Ken Papworth	Bill Williams
National	John Hsia	
Rockwell	Mike Nakamura	
TI	Rex Lewis	Mike Wong
TI/SEMATECH	Rey Rincon	(Project Manager)

SEMATECH Elevated Temperature Development

- **Background -**
  - ✍ **Why do we need elevated temperature probing?**
  - ✍ **What are the associated problems?**
- **What is SEMATECH's development roadmap for elevated temperature probing?**
  - ✍ **1997 Benchmarking**
  - ✍ **High Temperature Experiments**
- **What will be the outcome of these development efforts?**

Why Probe at Elevated Temperature?

SOME REASONS:

- **Improved package yield.**
- **Required for “trim” operations.**
- **Customer specified test requirements.**
- **Test yield affected on temperature sensitive devices.**
- **Requirement to demonstrate that the device functions over a temperature range.**
- **KGD requirements**
  - ✍ **No package test**
  - ✍ **Low cost test option**

What are the Problems with Elevated Temperature Probing?

- **<u>Everything moves around</u>**
  - **Different parts of the probe card have different TCEs*.**
  - **Material expansion plus mechanical constraint produce forces that cause twists, warps and bends.**
  - **Some critical materials (such as epoxy) develop undesirable characteristics:**

    (soften, become electrically conductive)
  - **The wafer expands, but not as much as the probe card.**

    Most new probers can compensate for wafer expansion.

* TCE = Temperature Coefficient of Expansion

Probe Card Material TCEs

MATERIAL	***TEMP. COEFF. of EXP.***
Silicon Wafer	2.50 X 10^{-6} /deg. C
Beryllium Copper (Cu)	7.78 X 10^{-6} /deg. C
Tungsten/Rhenium	4.92 X 10^{-6} /deg. C
Tungsten *	4.43 X 10^{-6} /deg. C
Aluminum *	24.00 X 10^{-6} /deg. C
Ceramic *	9.30 X 10^{-6} /deg. C
PCB (FR4) *	13 - 18 X 10^{-6} /deg. C
PCB (Polyimide) *	12 - 16 X 10^{-6} /deg. C
Epoxy (Typical-25C) *	65.00 X 10^{-6} /deg. C
Epoxy (PTC125) *	25.00 X 10^{-6} /deg. C

* = Probe Technology Corporation supplied data

More Elevated Temperature Problems…..

- **Characteristics of the probe/pad interface change**
  - **Contact resistance is believed to increase for some metal systems.**
    - **Tungsten Vs. Tungsten/Rhenium on Aluminum**
  - **Scrub length has been observed to vary:**
    - **Change in Aluminum texture, oxide characteristics**
    - **OR - is it purely mechanical?**
  - **Enhancement of Contamination.**
    - **Environmental contaminants cause more problems when heated.**
  - **These problems definitely increase with finer pad pitches and higher probing temperatures.**

SEMATECH’s Development Roadmap
Probes & KGD PTAB’s

(Peripheral Probe - Aluminum Pads Only)

	1997	1998	1999
Probes	70 µm pitch	50 µm pitch	50 µm pitch
	25°C/85°C	25°C/85°C	25°C/85°C/125°C
	500 in-line pads	500 staggered pads	500 in-line pads
KGD **Wafer Level Test**	125/100 µm pitch	70 µm pitch	
	125°C	125°C	
	150 in-line pads	500 in-line pads	

SEMATECH’s 1997 Benchmarking

Peripheral (70 µm pitch) @ 85 C

Mechanical

Probe Card Analyzer

Scrub Mark Analysis

Prober for Lifetest

DC

Tester (Lifetest)

Parametric Analyzer

AC

AC Characterization

CHARTER of the Elevated Temperature Development Subcommittee

- **Define experiments to insure that our 1998 probe requirements will be met.**
  - **Experiments that will reveal the “*best known practices*” for manufacturing a 70 μm pitch, 125° C probe card by EOY 1997.**
  - **Determine which probe needle metal system at 125° C (Tungsten or Tungsten/Rhenium) performs better over time on Aluminum pads.**

High Temp. Experiments

- **Selected probe card vendor(s) will provide the following:**
  - ✍ **An assembled 70 *μ*m probe card built for 125 C:**

    Hot chuck alignment

    Tested for Continuity, Planarity and Alignment

    High temperature epoxy (125 C)

    Best known manufacturing methods for a 125 C probe card

    50% of the probes will be Tungsten and the other half will be Tungsten/Rhenium (separated to avoid mechanical coupling)

    Room temperature probe card analyzer data

  - ✍ **Recommended cleaning procedure and frequency**
  - ✍ **Wiring information to differentiate needle materials**

High Temp. Experiments
Test Plan

- **Initial Mechanical Metrology**
  - **Probe card analyzer**
    - **Planarity and Alignment**
    - **Tip Diameter**
- **DC Metrology (125 C)**
  - **CRES over 500k touchdowns, sampling every Nth touchdown**
    - **Separate CRES between Tungsten & Tungsten/Rhenium probes**
    - **Plot of Max., Min., Avg. CRES Vs. # of touchdowns**
  - **Cleaning at manufacturer's recommended interval**
- **Mechanical Metrology (Initial, 25k, 125k, 250k and 500k touchdowns)**
  - **Probe card analyzer (change over time)**
    - **Planarity and Alignment**
    - **Tip Diameter**
    - **Scrub mark damage measured**

Schedule

Benchmarking	Start	End
Peripheral	May	June
Report	August	Sept.
High Temp. Experiments		
Probe card		
Vendors selection	June	July
Test program complete	May	July
Probe card build	July	August
Test Wafers	June	July
Lifetesting	August	Oct.
Report	Nov.	Dec.

Expected Outcomes

- We anticipate that:
  - One needle metal system (either Tungsten or Tungsten/Rhenium) will perform better at elevated temperature over time.
  - One or more of the selected probe card vendors will produce a probe card with acceptable life and performance.
- Leverage the lessons learned from the Benchmarking and High Temperature experiments
- Provide feedback to the probe card industry such that our future requirements of finer pad pitches at higher probing temperatures will be met.