IEEE SW Test Workshop
Semiconductor Wafer Test Workshop

June 7-10, 2009
San Diego, CA

ISMI Probe Council

Current Carrying Capability Measurement Standard

E Boyd Daniels
Probe Council Chairman
Texas Instruments

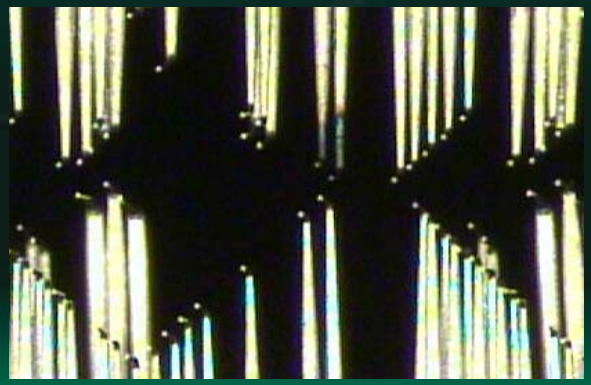
INTERNATIONAL SEMATECH
ISMI
MANUFACTURING INITIATIVE

Overview

- Introduction
- Scope
- Measurement Conditions
- Setup
- Method
- Summary

Introduction

- The measurement of current carrying capability (CCC) for wafer probes is a critical parameter for probe cards in production.
- Failure of a probe subjected to high current is a thermal event. Heat transferred through the mounting and contact of the probe to the pad or bump drives significant variation in the CCC.
- The goal of this guideline is to minimize variability in the measurement of this critical parameter.

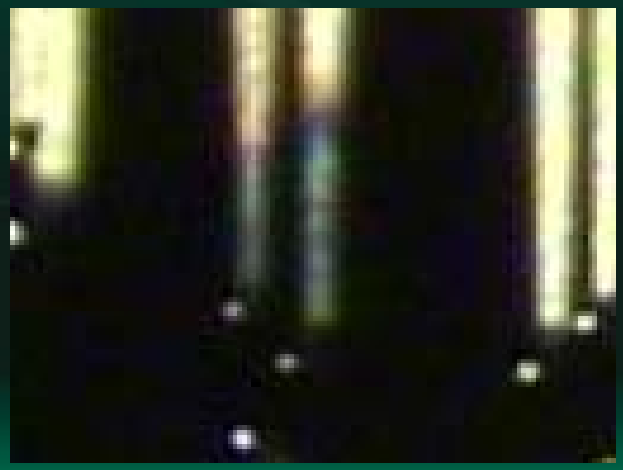


Scope

- With a focus on reproducible measurements, this guideline provides CCC ratings that are inherently different from what a user will see in a production environment.
- The CCC measured for single probes with excellent electrical connections are typically higher than values seen in a large array of wires with varying contact resistance.
- The factors that translate measurements made using this guideline into ratings for any particular production application will be unique.

Scope

- By focusing on a reproducible technique, the guideline provides a comparison metric for CCC that can be used to easily rate any probe.
- Accuracy relative to each unique test application is sacrificed for the sake of a repeatable and standard set of measurements.
- The underlying value of this measurement standard is relative comparison between different probing technologies.

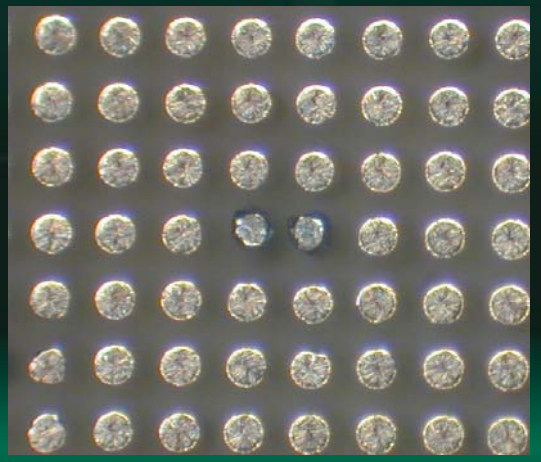


Measurement Conditions

- **The fail signature chosen for the CCC value is a permanent reduction of force in the probe.**
- **By measuring the point at which this force is reduced by 20% for nominal overdrive settings, good electrical contact is still temporarily maintained.**
- **However, the robustness of the contact has changed dramatically and further use in production may lead to higher maintenance and eventual loss of contact.**

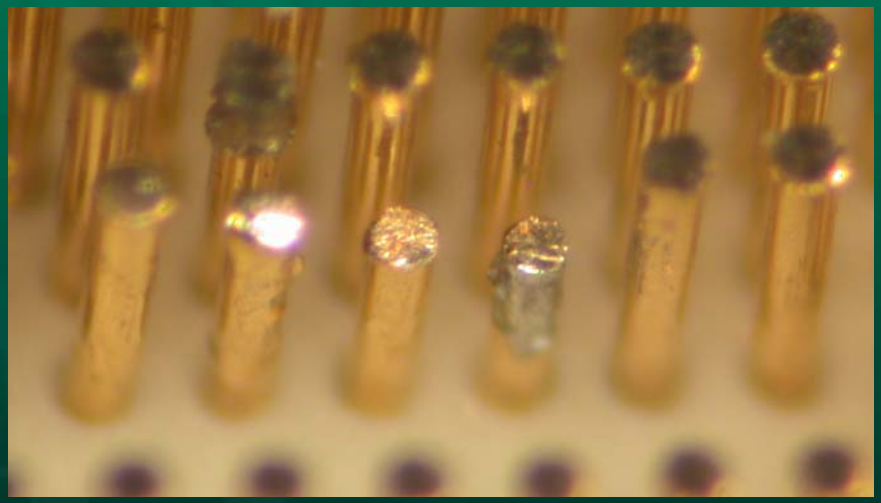
Measurement Conditions

- **Fail Definition**
  - The 20% force reduction method is applied to the force measured for a new probe prior to exposure to current. In practice, the force of the probe at nominal overdrive actually increases as current is first applied and there is also some amount of work hardening that increases the spring constant of the wire during the initial touchdowns. The 20% force reduction does not apply to the higher force seen early on during testing.
- **Measurement Timing**
  - While measurements can certainly be made in situ while current is being applied, this standard calls for the measurement to be made at least 10 seconds after current has stopped. This gives the probe a chance to cool and recover and is felt to be more representative of a production environment.
- **Temperature**
  - Given that the failure mode is directly caused by heat, the temperature of the testing environment will have a significant impact on the CCC. For comparison purposes, the simplest environment, ambient (23° to 25° C), was chosen.



Measurement Conditions

- **Overdrive**
  - Once again there are many recipes used by different companies for production. For this guideline, the overdrive chosen is the distance recommended by the probe vendor for production setup for the probe being tested.

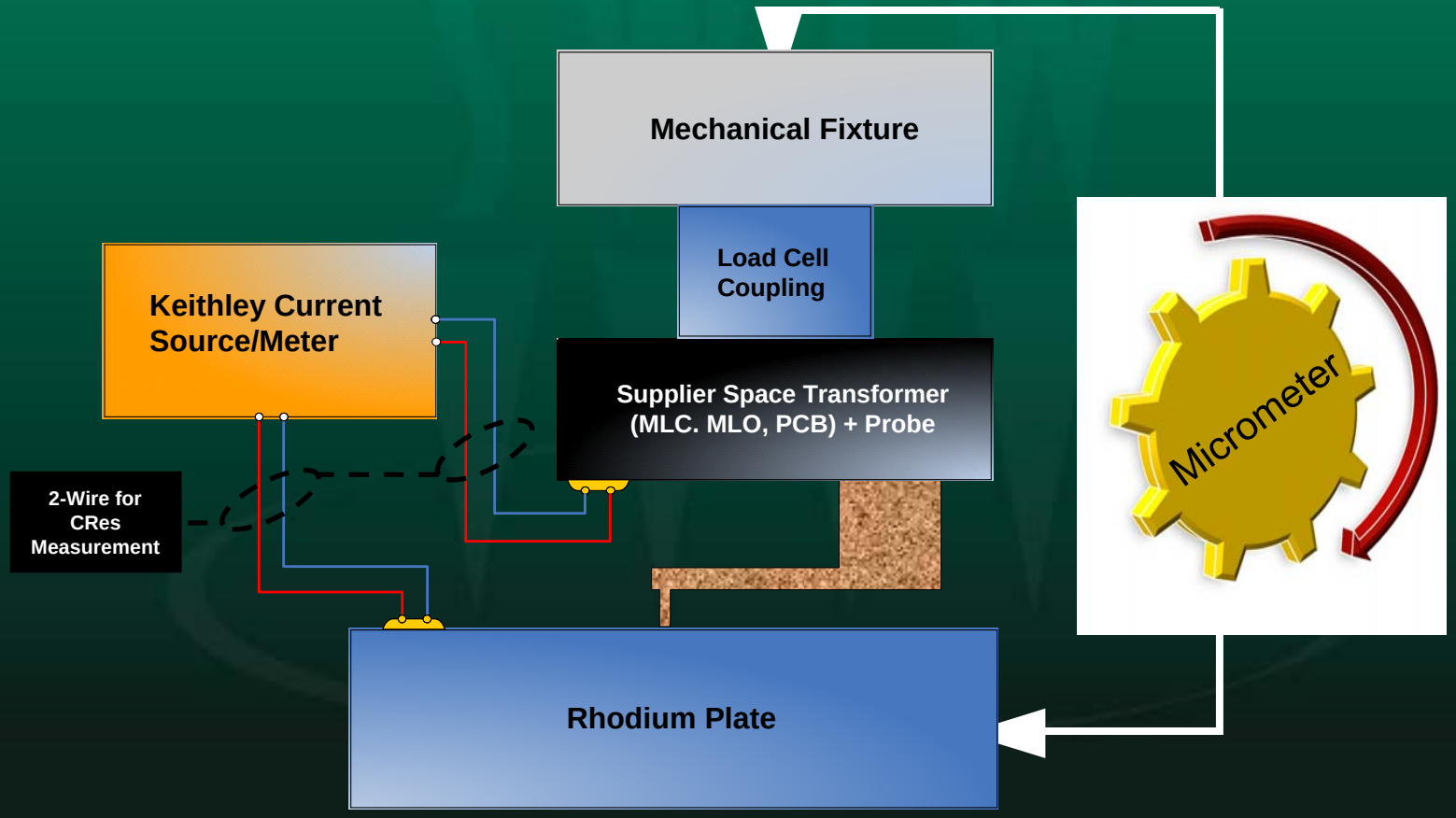


- **Extensions**
  - While the guideline addresses simple DC application of current on a single wire at ambient temperature, the production environment is likely quite different. Multiple wires, test at high or low temp, pulsing current supplies and different interface materials and metallurgy are just a few of the items which will cause the wire to have a different CCC during production. Any of these items and many others may lead to a de-rating of the standard CCC for most production applications.

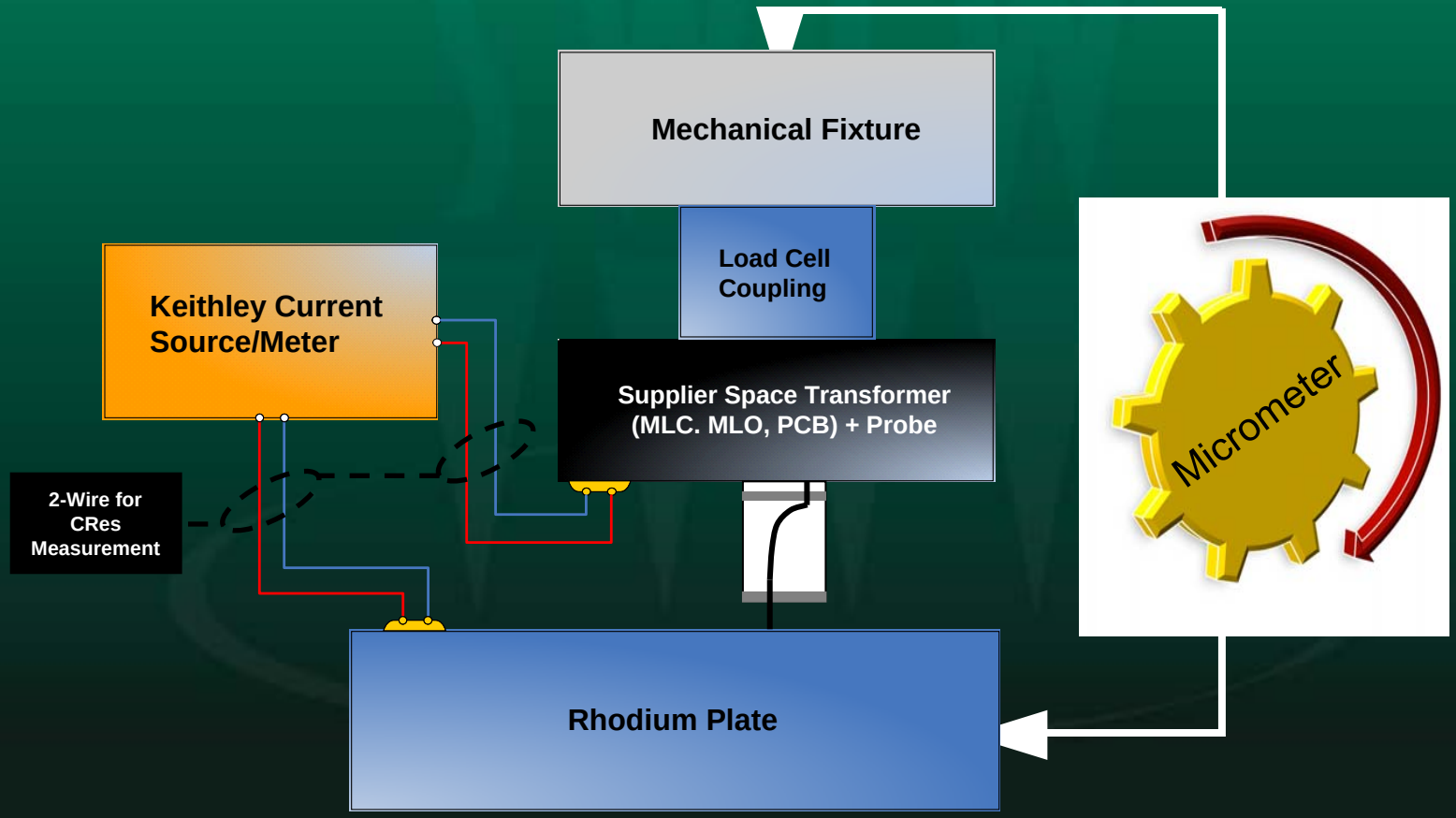
Setup

- The setup for CCC measurement is shown in Fig 1, 2 and 3. The basic system consists of a force transducer mounted on a vertical micrometer stage and a fixture that captures the probe between two conductive contacts. A constant current power supply and current and voltage meters complete the setup.

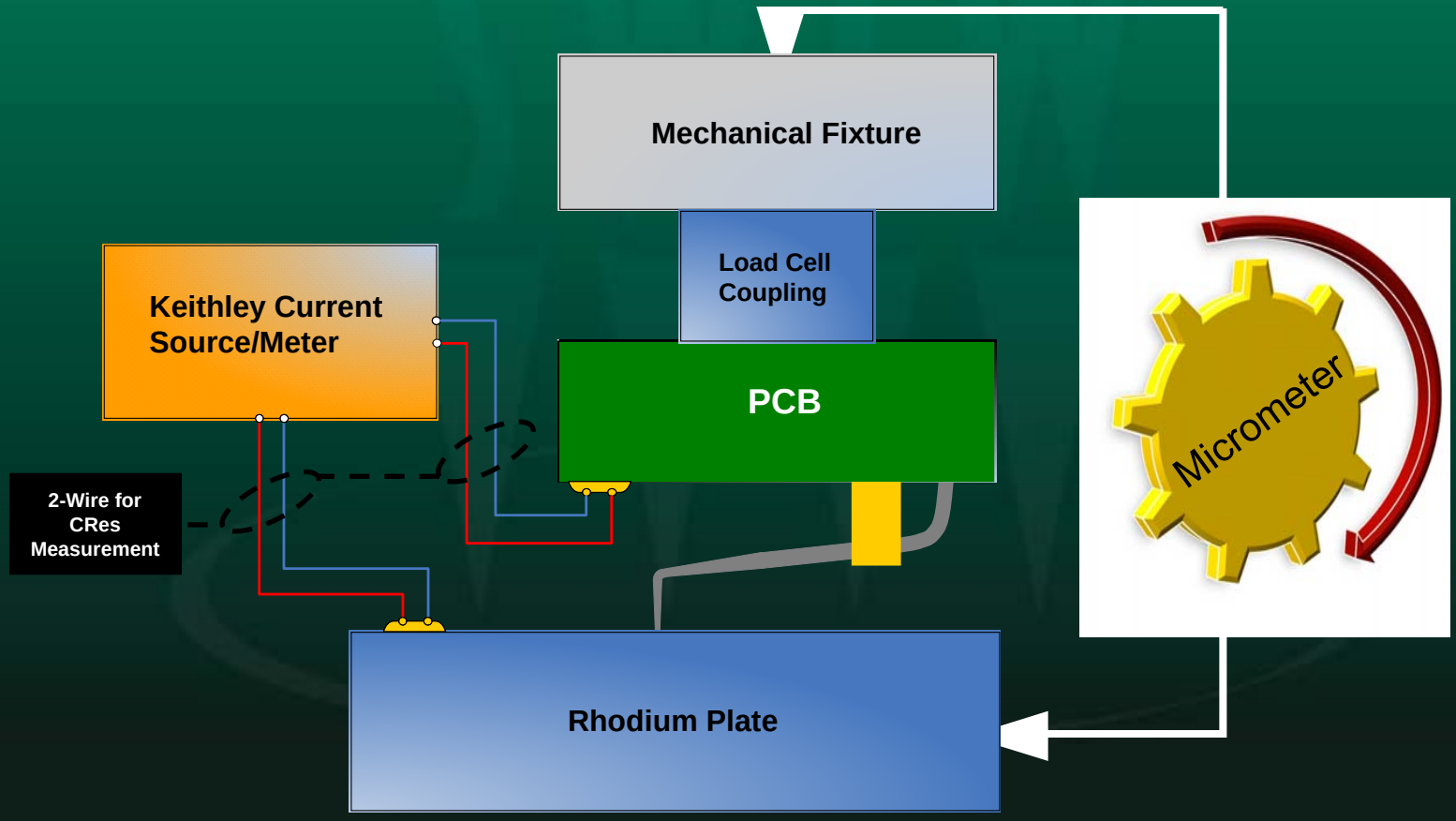
MEMS Setup


Mechanical Fixture
Load Cell Coupling
Keithley Current Source/Meter
Supplier Space Transformer (MLC. MLO, PCB) + Probe
2-Wire for CRes Measurement
Micrometer
Rhodium Plate

Vertical Setup



Cantilever Setup



Setup

Measurement of nominal overtravel

- **The force transducer is mounted on a micrometer table.**
- **Ranges and resolution recommended for measurement equipment.**
  - *Force Transducer* with a resolution of <0.1 gm and a range of 0 to 50 gm
  - *Current Meter* with a resolution of 10 mA and a range of 0 to 5 Amps
  - *Volt Meter* to ensure CRes and current path resistance is maintained below 1 ohm
  - *DC Power Supply* needs 10 mA resolution from 0 to 5 amps.
  - *Micrometer* with a resolution ≤1 µm

Method

- At nominal overtravel, DC current is applied to the probe for 2 minutes, then removed. A force measurement is taken at least 10 seconds after the current is removed. The current is then incremented and the cycle repeated until the probe spring force is reduced by 40%. The CCC rating becomes the average of all readings at which a permanent 20% force reduction is measured.

Method

- **Number of Samples**
  - The sample size will consists of 3 sets of 10 probes picked randomly from at least 3 different production batches for a total of 30 probes.
- **Ambient temperature**
  - The measurements are made at room temperature between 23°C and 25°C for the duration of the test.
- **Initial measurements**
  - Before any significant current is applied to the probe, the spring force of the probe should be measured at nominal overdrive.

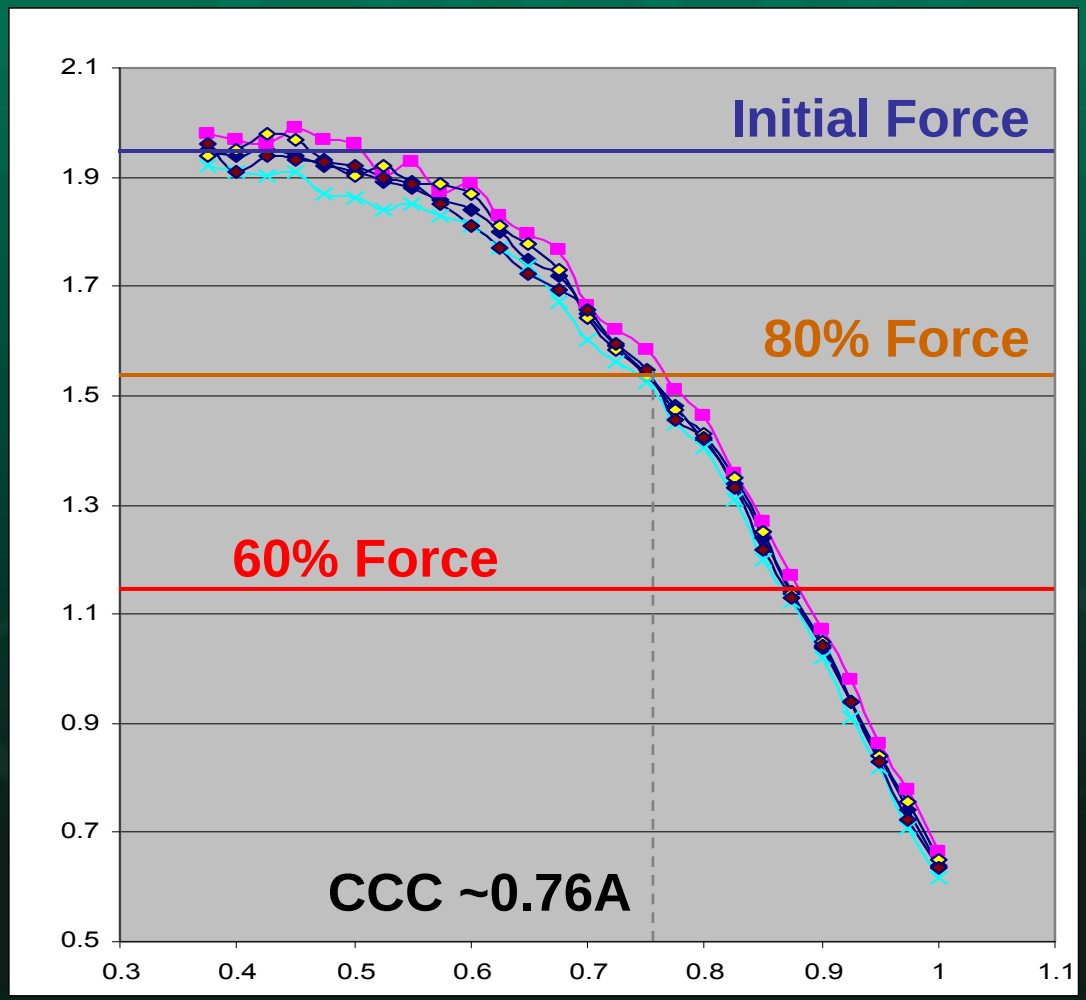
Method

- **DC Current Measurements**

  The steps for ramping and measuring the current limit are as follows:

  1. Determine a probable CCC fail value by referencing probe card supplier's specification. Set current source to 75% of specified value.
  2. Apply current for 2 minutes and then reduce to zero.
  3. Measure probe force after a 10 second cool down period.
  4. Increment current by 25mA.
  5. Repeat steps 2 – 4 until the force has dropped by 40% of initial value.

Method


Force - Grams
2.1
1.9
1.7
1.5
1.3
1.1
0.9
0.7
0.5
Initial Force
80% Force
60% Force
CCC ~0.76A
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
Current - Amp

Acknowledgements

- Jack Courtney – IBM
- John Caldwell – Micron Technology
- MPI – Taiwan
- Tom Wear – ISMI

Thank you