SWTEST

PROBE TODAY, FOR TOMORROW

High-end, high-power devices: an integrated solution at probe card level

TECHNOPROBE

Wafer Probing Technologies

Emanuele Bertarelli

R&D Manager

June 2-5,2019

Overview

- **Introduction**
- **Challenges**
- **Improving performances in high-end, high power devices**
  - Probe design: Short and eXtra Short probes
  - Probe materials: Super Alloy
  - Probe card architecture
- **Summary & Future Developments**

Introduction

- **High-end devices progressively move to lower technology nodes**
  - Aim: Optimization / reduction of device size
  - Consequence: Pads & Pillars pitch moving down

    100µm → 80µm → 60µm → today even 40µm and potentially below
- **At the same time, performances are increasing**
  - High power is flowing from tester to DUT
- **High testing parallelism is required**
  - Low cost of test
  - High test throughput

Introduction

- **To be able to follow Customer requirements, Probe Card Vendors need to re-think the Probe Card**
  - **Probes** are still the core component,
  - … but an **organic approach** is required, driving a harmonized PCB / MLO / Probe Head / Probes joint development

Challenges

- **High-end devices (SOC, GPU, CPU…) probing requires**
  - Probing at both Room Temp and High Temp
  - Dense full arrays (“FA”) of probes
  - **Control of critical electrical parameters, such as**
    - **Stability of probe electrical contact (“Cres”) throughout testing**
    - **High current carrying capability (“CCC”)**

- **In this scenario, it is fundamental to understand and minimize probe burning events**

Probe burning event

- **Irreversible decay in probe electromechanical performances**
  - Mechanical performances degenerates (e.g., Force decrease)
  - Electrical performances are impacted (Cres value / stability degenerate)

- **The current level that a probe can withstand depends on actual testing scenario…**
  - ISMI2009 method is recognized as a standard
  - MAC and other parameters are also a viable option
  - However, actual testing parameters should be considered

Probe burning event

- **High current probes can be connected as**
  - **Single probes** > Probe electromechanical performance is key
  - **PWR/GND domains** > Probe card architecture to be studied as well to maximize CCC performances

Probe burning event

- **How to reduce risk of probe burning due to high current?**

1) **To deploy high CCC probes**
    - Design improvements > Geometry the of probe
    - High performance materials > Conductivity, strength at RT and HT

2) To achieve **low and stable contact resistance** > NO fritting occurrence, therefore NO localized heating/damage at probe tip level

3) **To balance the current load** on probes for PWR/GND domains

Probe design

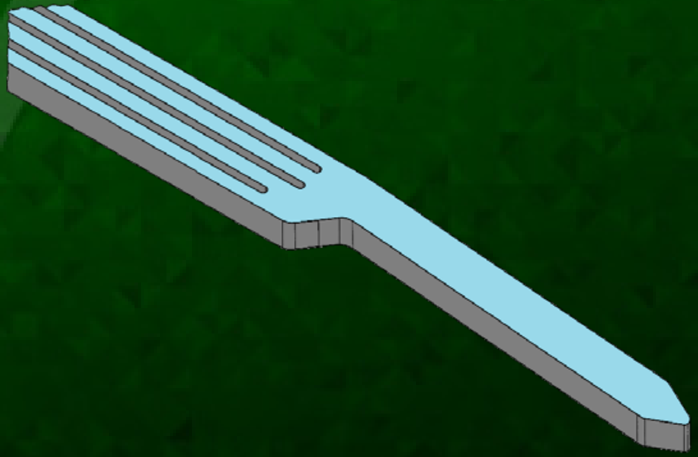
- **Probe design is customized to target specific requirements:**
  - Probe force / Mechanical action
  - Probe pitch
  - Current Carrying Capability
  - Lifetime
  - High Frequency performances
  - …

- **New generations of Short and eXtra-Short probes demonstrate improved HF as well as Current Carrying Capability performances**

Short and eXtra Short probes

- **Challenge**
  - Short needles will have higher force and smaller working overdrive range
  - It is required then to design short needles:
    - To maintain the same force
    - To maintain the same overdrive working range

- **Solution**
  - Multi-arm body allows to control the force
  - License rights to the multi-arm patent owned by Technoprobe



Probe Materials: Super Alloy

- **Materials for high-current probing require to match diversified and often conflicting performances**
  - Low probe electrical resistance, to limit Joule heating
  - High mechanical strength
  - Low contact resistance, to avoid fritting and tip damage
  - Stability of both mechanical and electrical properties in the entire application temperature range

- **Super Alloy is developed by Technoprobe to achieve an optimal balance of Current Carrying Capability and High Temperature performances**

Probe Materials: Super Alloy

Achieving high CCC :

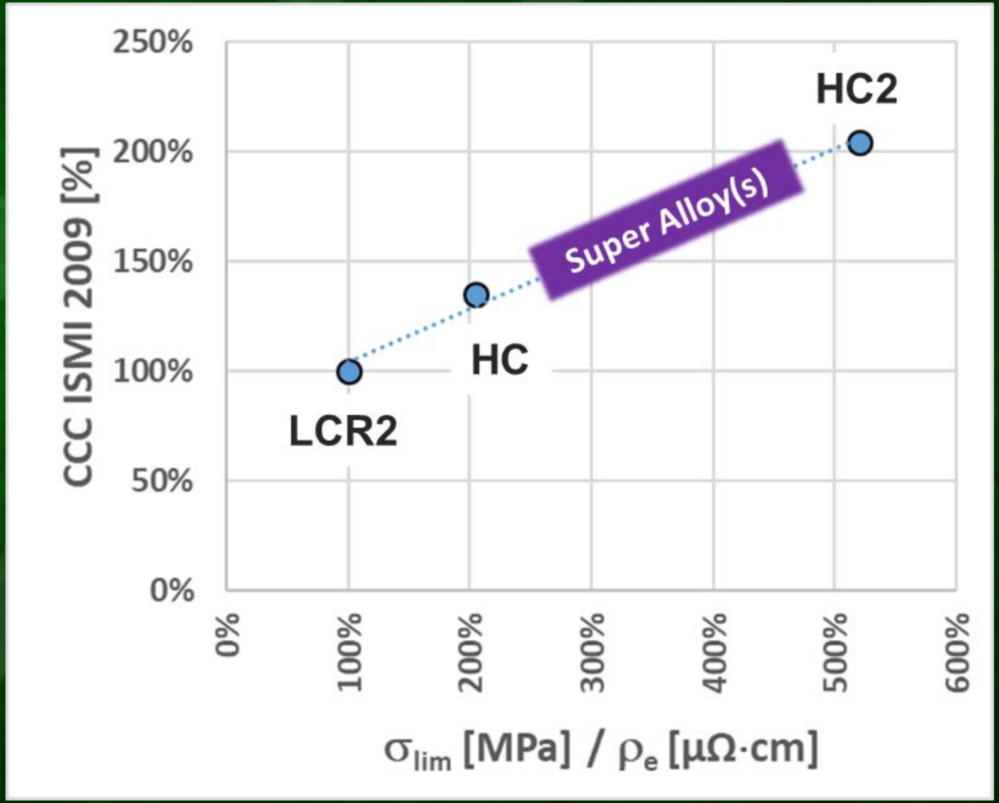
- High strength
- Low resistivity

Setup: ISMI2009 (F -20%)

The following simplified parameter can be used to classify current capability performances:

$$CCC \propto \frac{\sigma_{lim}(\cancel{T})}{\rho_e(\cancel{T})}$$

Example on reference technology:



Probe Materials: Super Alloy

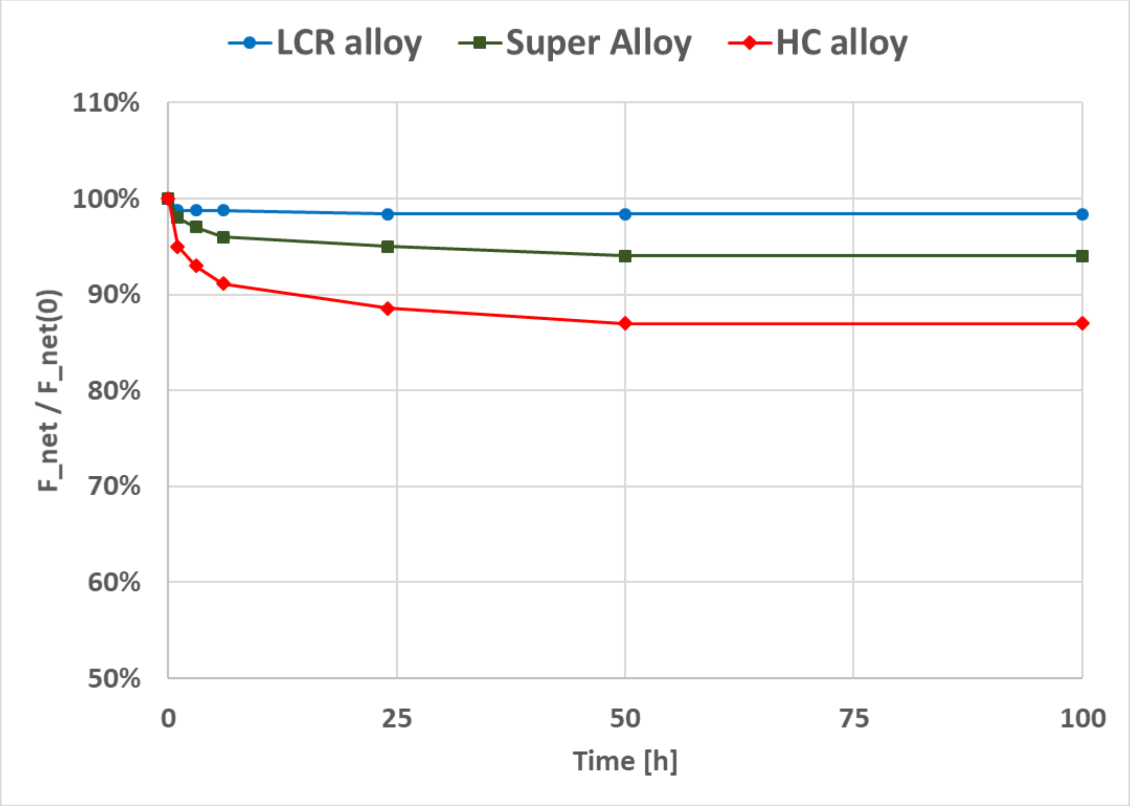
Improving HT stability:

- High strength at high temperature

Setup: stress relaxation on prober

  - Chuck temperature = 150 °C
  - Imposed displacement = max working OT
  - Parameter = probe force

Example on reference technology:

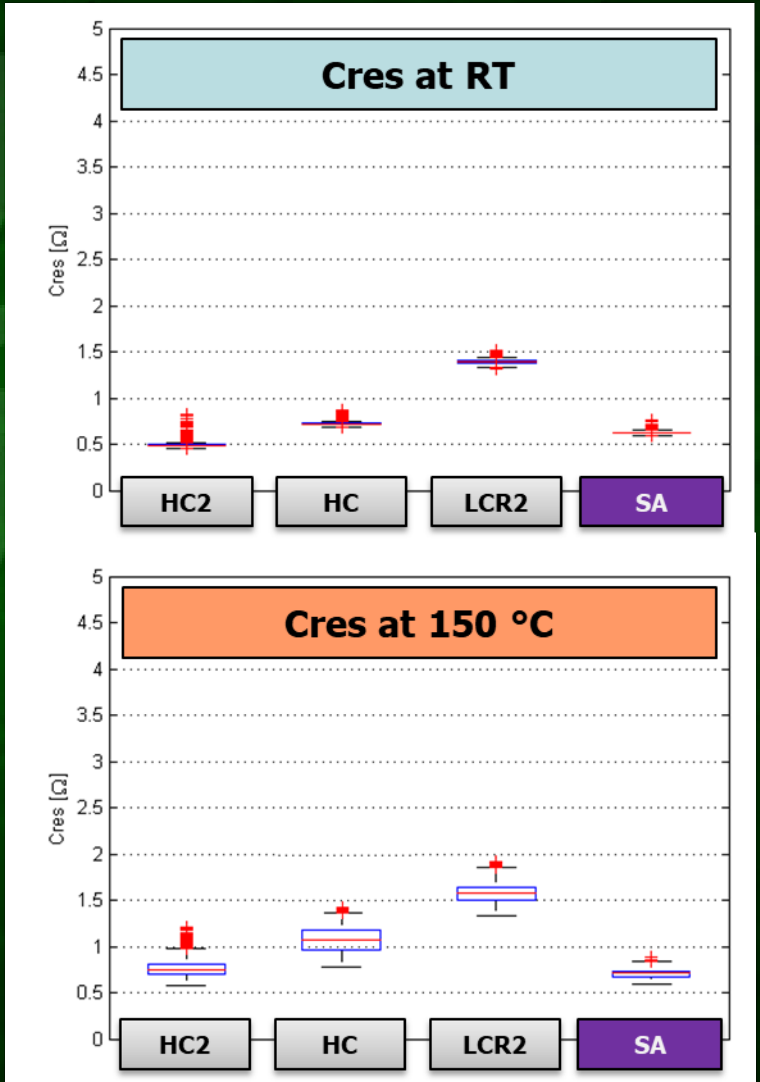


Probe Materials: Super Alloy

Stable contact resistance:

- Low Cres baseline
- Low Cres STD DEV
- Performances at both RT and HT

Example on reference technology:



Setup: Cres measurements on prober

- Al wafer (Customer metallurgy)
- Pointed tips
- 1k TDs with cleaning
- Chuck temperature = RT and 150 °C

PC architecture

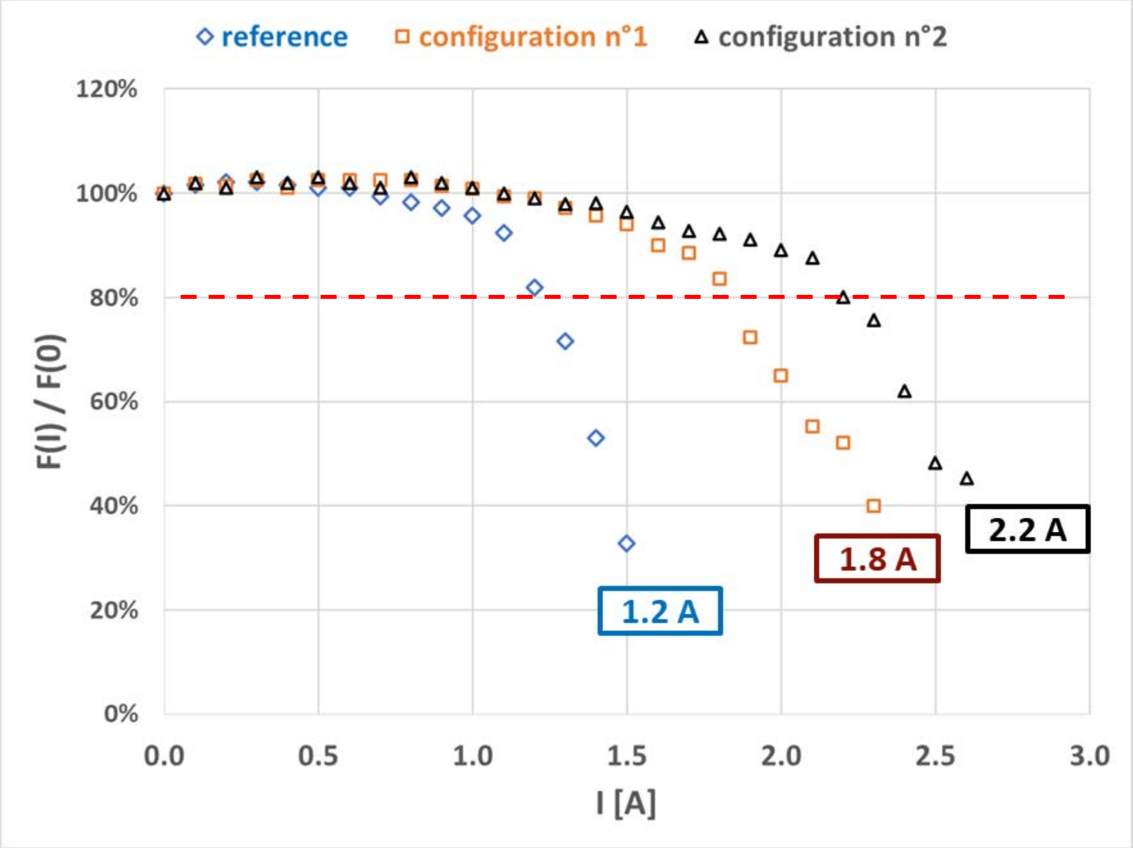
- **Technoprobe developed a novel probe card architecture to further increase Current Carrying Capability of probes**
  - The idea is to balance the current load on probes to avoid single probe damage
  - This approach applies to PWR/GND probe domains
  - Increased **effective CCC-per-probe** is achieved by introducing a **new Probe Card Architecture and PCB/MLO high-power design rules**

- **The aim is to avoid PWR/GND domain probes damage during high-power testing**

Example 1: Short probes

- **Setup**
  - Probe in Full Array at 90um pitch
  - ISMI2009 CCC probe test
  - AVERAGE of 10 measurements

- **Case studies**
  - reference: single probe
  - configuration n°1: 10 probes PWR/GND domain
    CCC increase +50 %
  - configuration n°2: 20 probes PWR/GND domain
    CCC increase +80 %

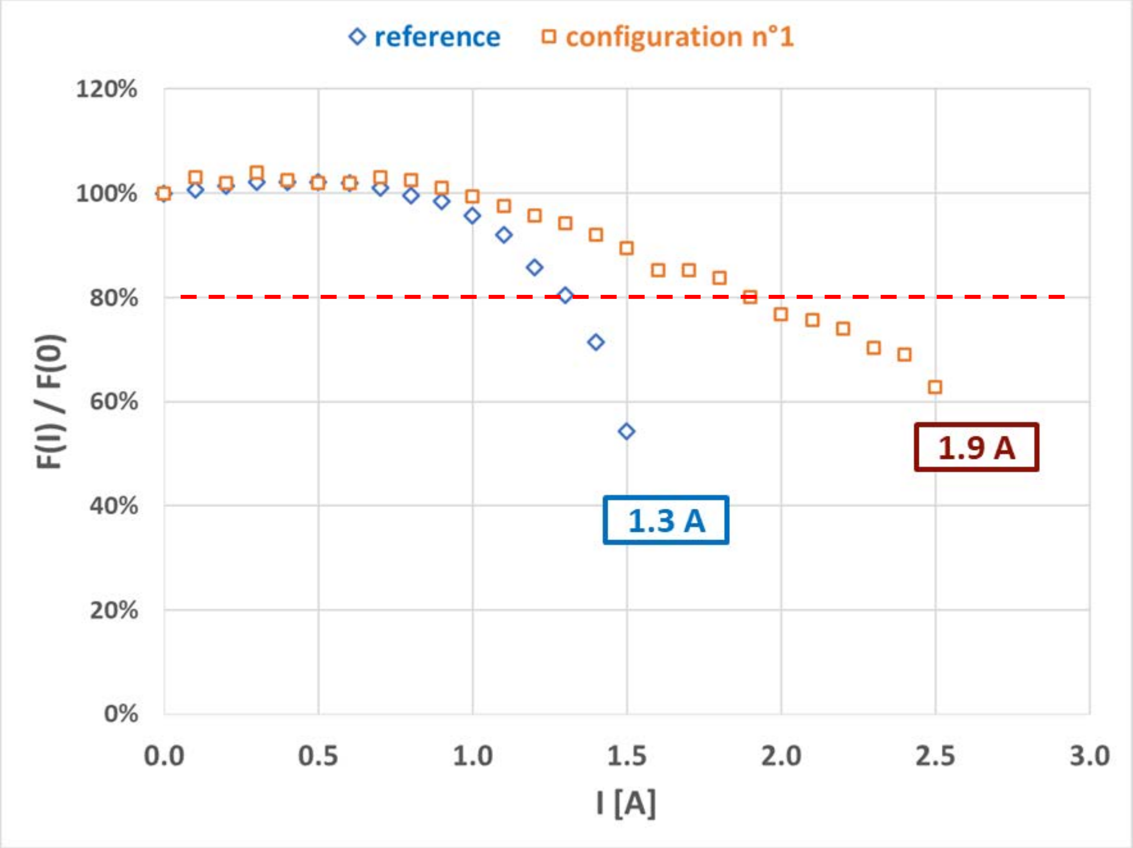


Example 2: eXtra-Short probes

- **Setup**
  - Probe in Full Array at 90um pitch
  - ISMI2009 CCC probe test
  - AVERAGE of 10 measurements

- **Case studies**
  - reference: single probe
  - configuration n°1: 10 probes PWR/GND domain

    CCC increase +45 %



E. Bertarelli

Summary

- **Technoprobe TPEG™ MEMS technology enables high-power probing introducing innovations at different levels**
  - **Design**: Standard, Short and eXtra-Short needles available
  - **Materials**: Super Alloy material is introduced, besides LCR and HC alloys
  - **Probe card architecture**

Summary

- **By the combination of**
  - Short & eXtra-Short multi-arm probe designs
  - Super Alloy probe material
  - A novel probe card architecture

probe Current Carrying Capability exceeding 2.0A at 90µm pitch Full Array is demonstrated.

Future developments

- **Development of Super Alloy(s) is ongoing, to further increase electro-mechanical performances of probe needles**

- **Improvements enabled by the new probe card architecture will be investigated in new scenarios**
  - Characterization under pulsed current conditions is ongoing
  - Further different probe configurations will be compared

- **The first full probe card with the new architecture will be provided to a major Customer for Engineering Testing by the end of Q2_2019**

Thank you for your attention

Speaker & contact author:

Emanuele Bertarelli, Ph.D.
R&D Manager
Technoprobe Italy
E: emanuele.bertarelli@technoprobe.com

Alice Mari
R&D Engineer
Technoprobe Italy

Raffaele Vallauri
Executive VP – R&D and Process Engineering
Technoprobe Italy

Flavio Maggioni
SI/PI Team Manager
Technoprobe Italy

Stefano Felici
Chief Executive Officer
Technoprobe America

The work done by technical team members at Technoprobe R&D & Process Engineering Department is gratefully acknowledged.