VIRTUAL EVENT

# TestConX™

## Presentation Archive
May 3-7, 2021

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# Resistance fluctuations in contacts under high current loading

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TestConX

Virtual Event • May 3 - 7, 2021

GateWave Northern, Inc.

# Agenda

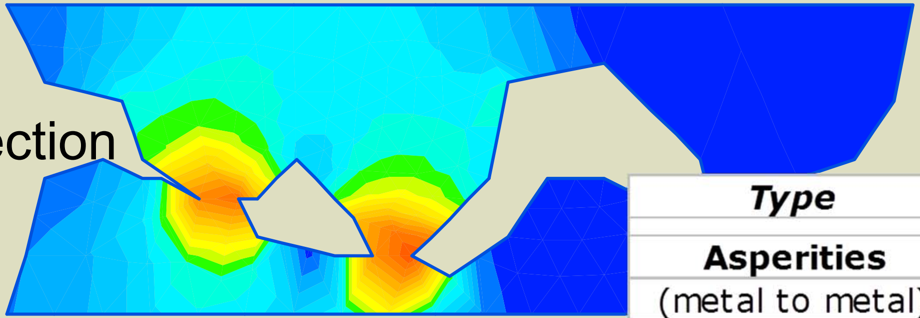
- Explore novel ways of assessing current carrying capability (CCC).
- Examine existing data base from many DC test reports.
- Assess feasibility and accuracy of method.

# Problem

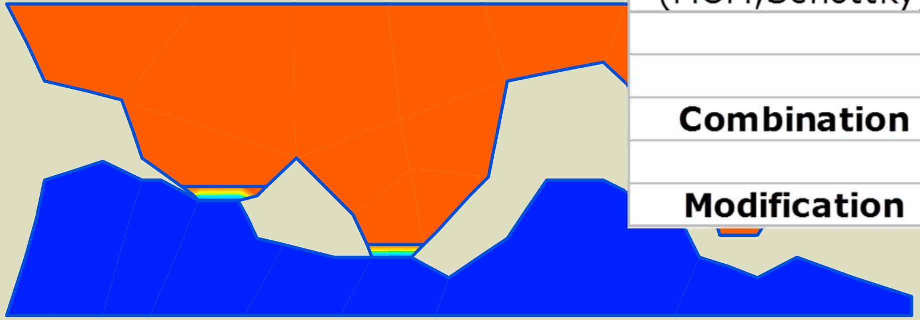
- It is not always possible to measure temperature rise with a probe or IR based thermometer. Surrounding materials or embedded contacts may restrict access for direct measurement via thermocouple or IR methods. Thus availability of an alternate method to establish maximum current capability appears desirable.
- Non-linearity has been observed in contact resistance as current flow increases. Can this be used as a potential gage for maximum current handling ?

# Potential causes of non-linear resistance

Asperities:
Reduced cross-section



Interface layers:
High resistance



| ***Type*** | ***Change due to*** | ***Effect*** | ***Reversible*** | ***Speed*** |
|---|---|---|---|---|
| **Asperities** | | | | |
| (metal to metal) | Heating | Shape change | no | µs |
| | | R(T) | yes | µs |
| | | | | |
| **Interface layers** | | | | |
| (MOM,Schottky) | Barrier | Nonlinear R | yes | GHz |
| | Heating | R(T) | yes | µs |
| | | | | |
| **Combination** | -"- | -"- | | µs, GHz |
| | | | | |
| **Modification** | Chemistry | e.g. oxidation | no | µs |

from 2009 presentation

# Approach

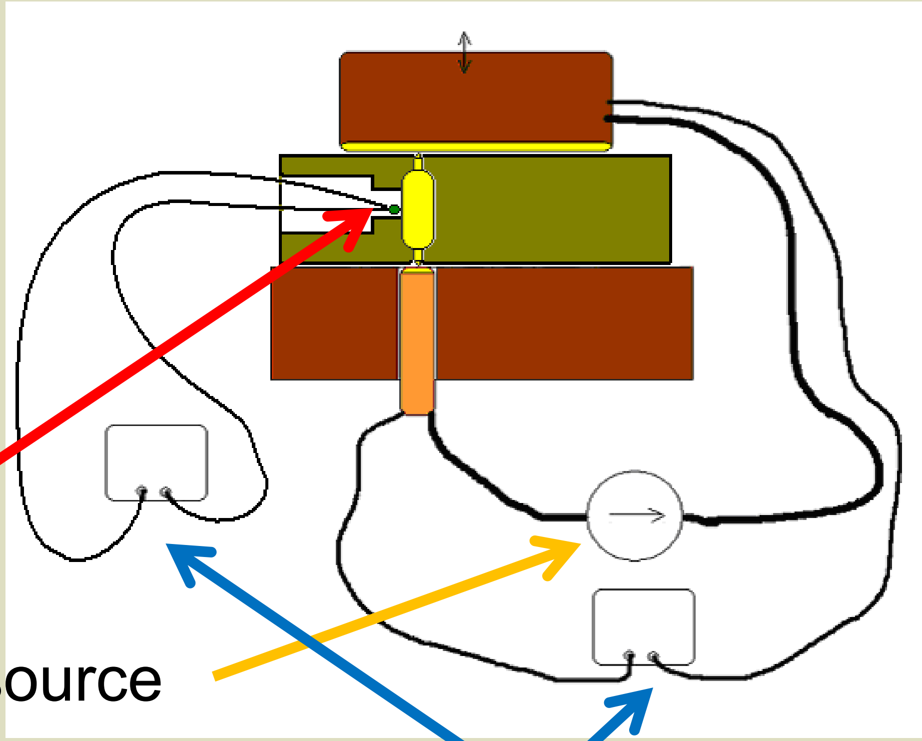
- Describe test environment and process.
- Collect data from a large number of tests performed on customer samples.
- Locate trends, commonalities and differences.
- Use several succinctly different contact types.

# Setup

## Standard DC test for I-V and R measurements:

Contact is held between Au plated surfaces at room temperature.

Measurement is performed in configuration of a 4-terminal (Kelvin) test



Thermocouple

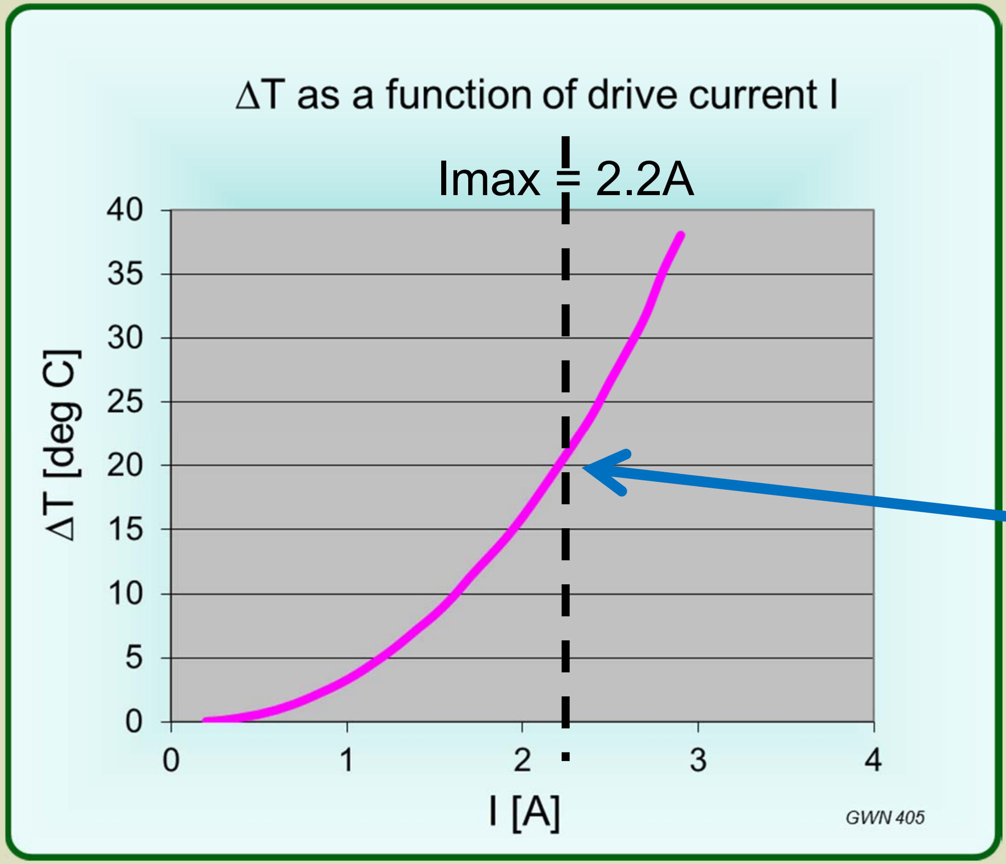
Current source

DVM / data acquisition

# Test method

- Apply incrementally increasing current levels
- Hold at each step for thermal equilibrium
- Evaluate for resistance R as a function of current
- Compute derivative of power dissipation as a function of current from acquired data

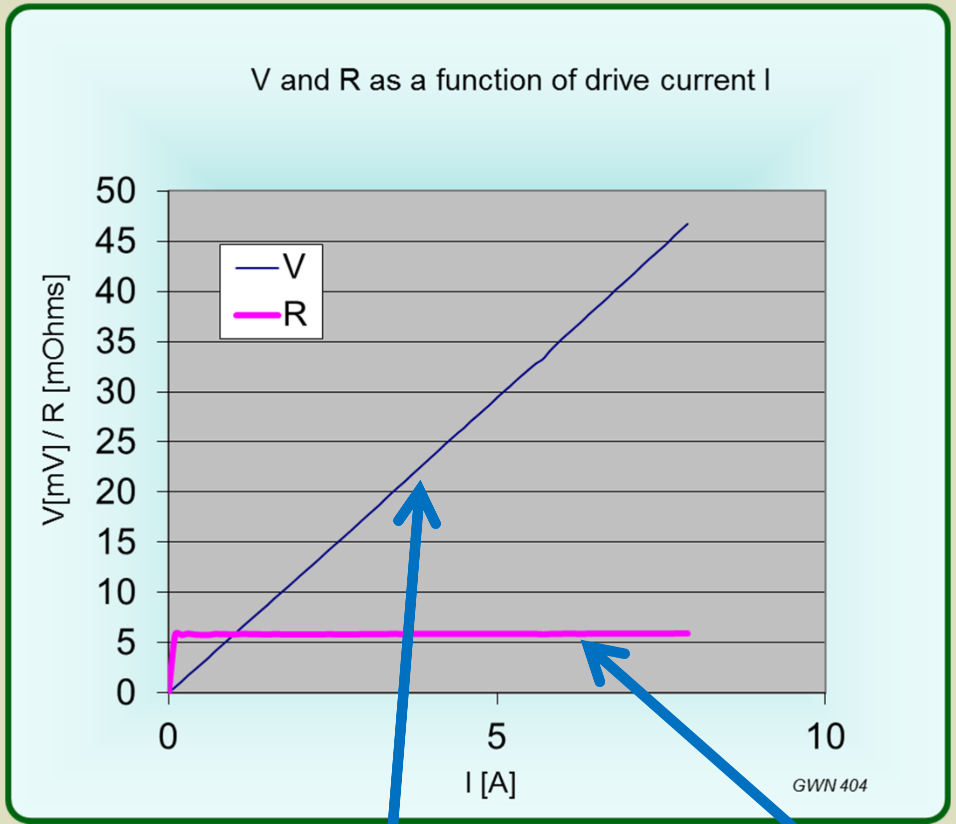
# Current Carrying Capability(CCC) by temperature rise

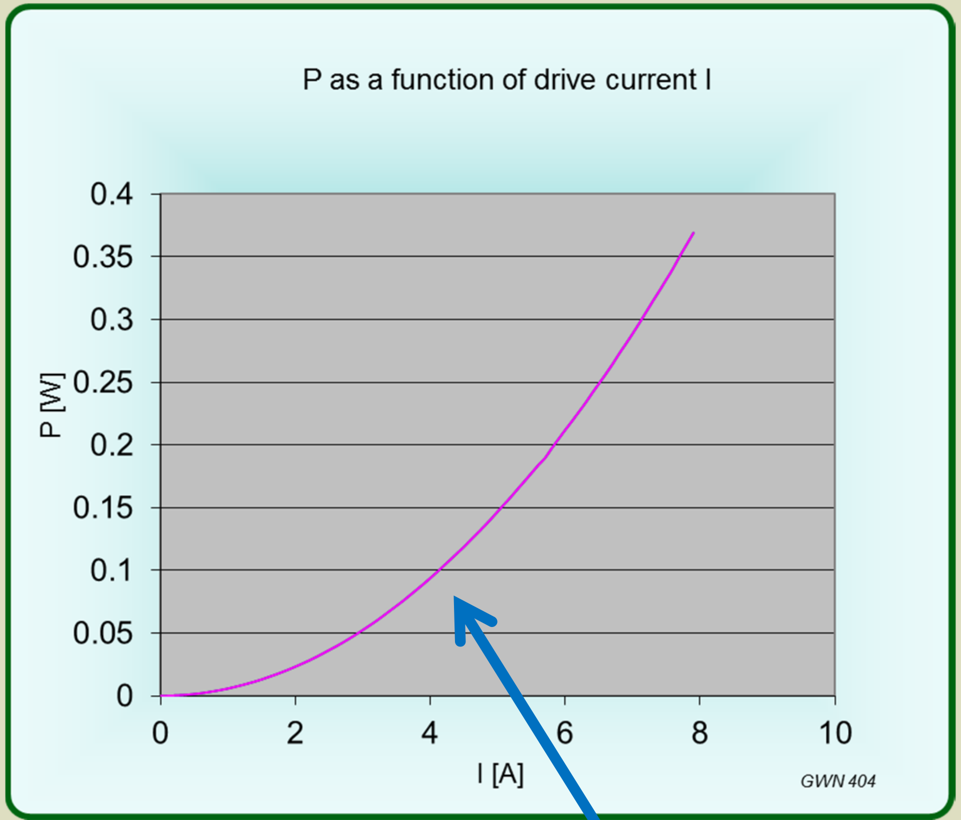



*CCC often defined as current required for a given temperature rise, e.g. 20°C*

Conventional assessment of maximum current ($I_{max}$, CCC) capability is often based on temperature rise associated with increasing current drive levels

# Processing of DC data acquired during test



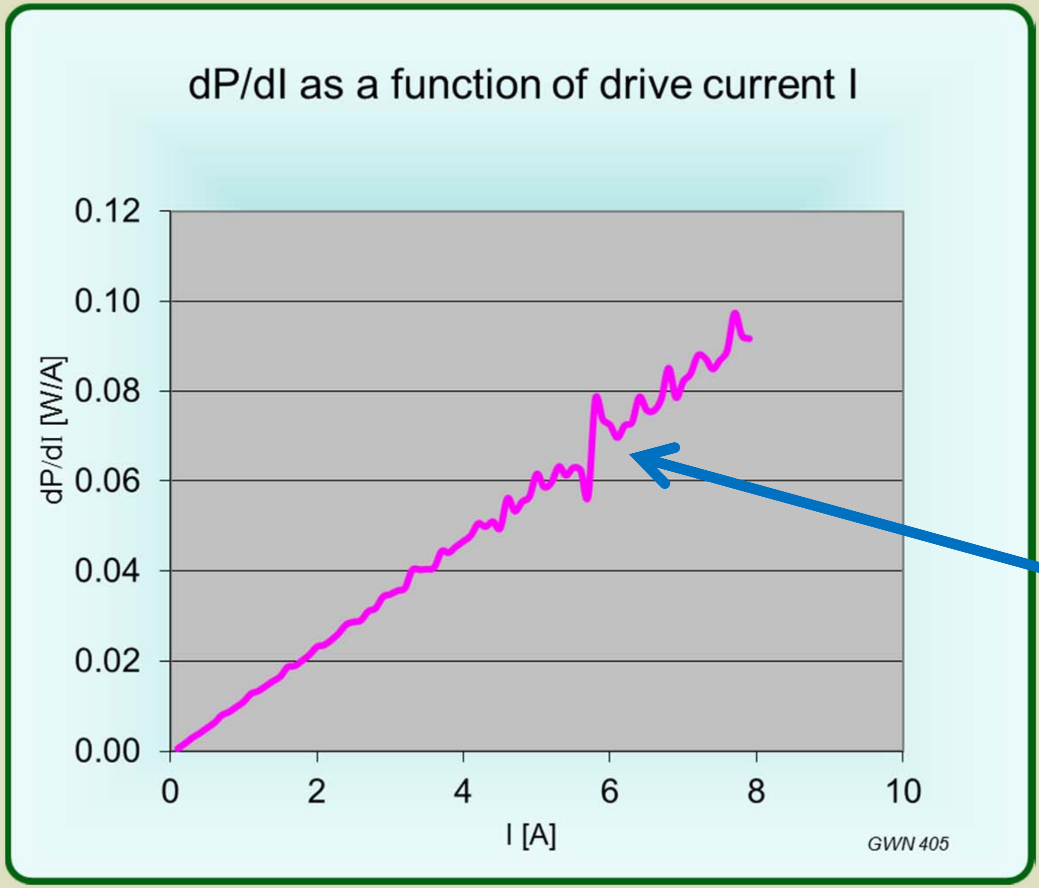

Measured V,I, - computed R

computed P = V*I

*There are no irregularities visible in this example*

# Enhanced processing for dP/di

*This graph is derived from the same data as shown on previous slide*

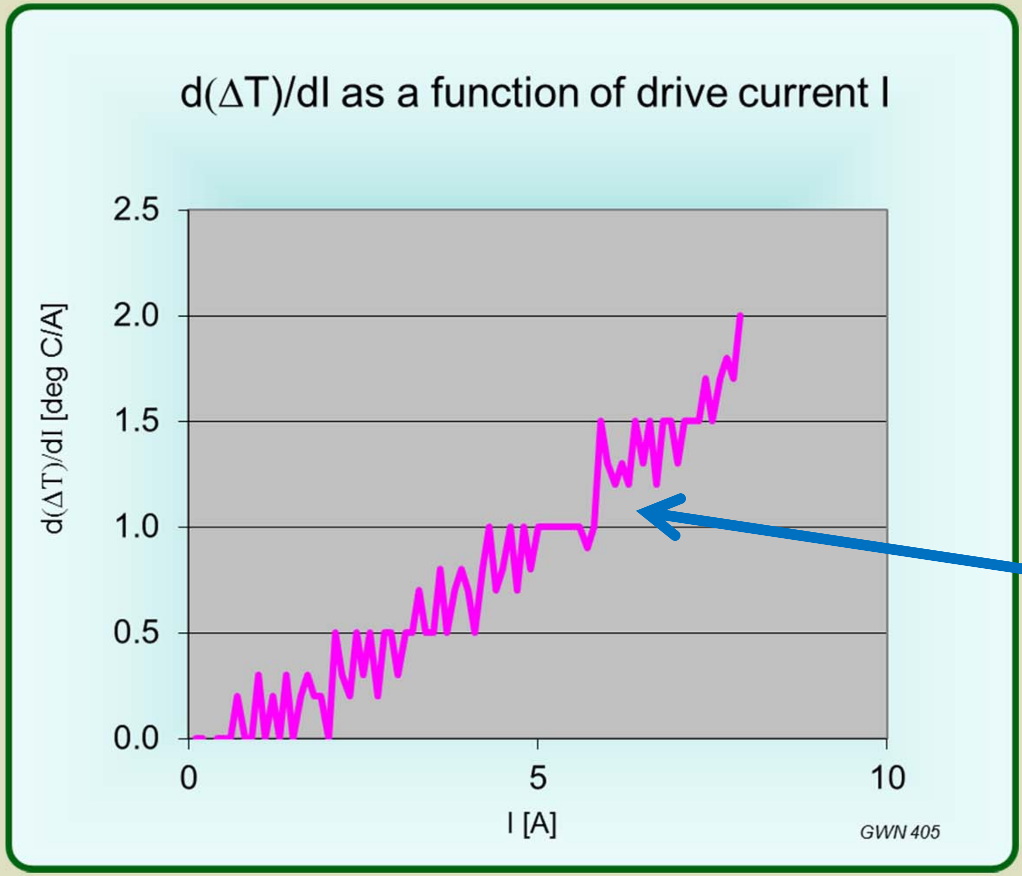



*irregularities become visible*

Computed dP/di - this should be a linear function of current but small non-linearities have become apparent

# Enhanced processing for d$\Delta$T/di

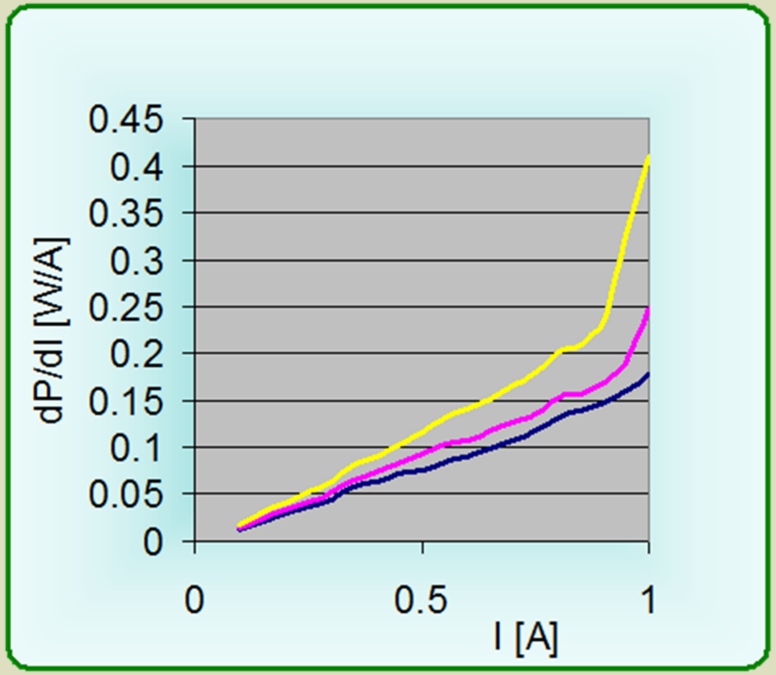
*This graph is derived from the same data as shown two slides ago*



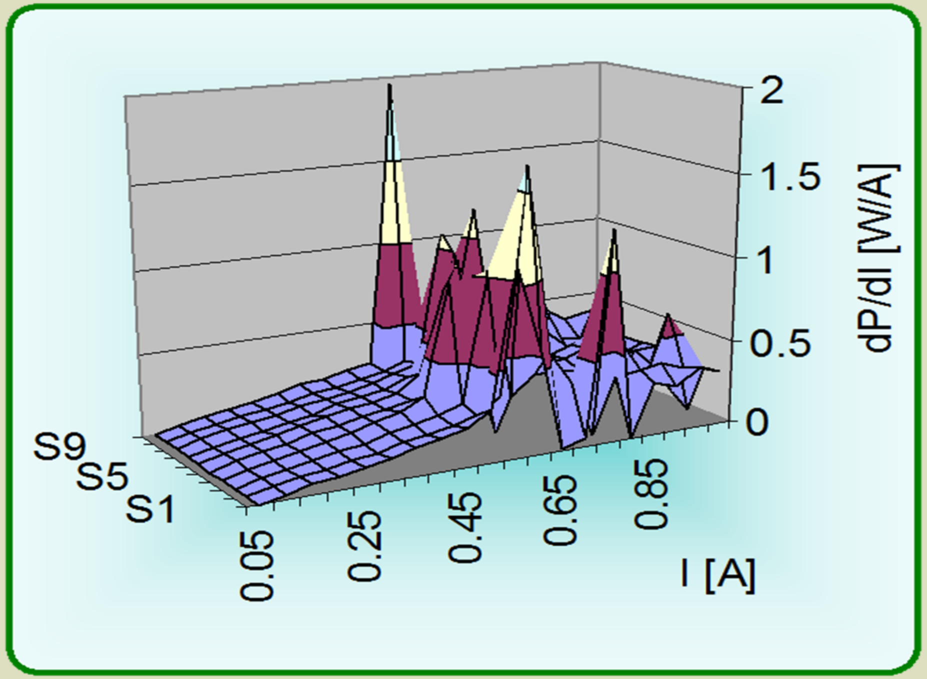

*irregularities are also visible in this graph*

Computed d$\Delta$T/di - change of temperature difference with increasing current also reveals small non-linearities

# More significant non-linearities in dP/di graph




3 successive measurements without any actuation, after 2nd cycle




10 successive measurements (S1-S10) after 3500nd cycles

Two different contacts

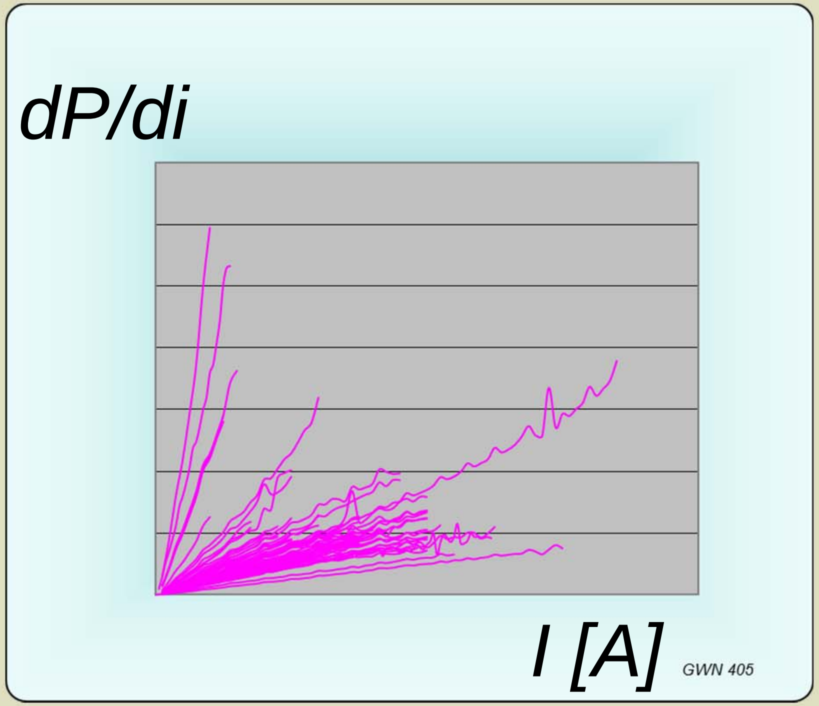
*Lead-free SAC105 compound contact surface*

*(from 2009 presentation)*

# Comments

- The previous slides show that at higher current levels irregularities in the current flow are in evidence.
- Enhanced processing via differentiation can be used to visualize these irregularities.
- A ‘low-noise-limit’ for the contacts can be defined in this manner.
- Perhaps this might also be used to determine CCC ?

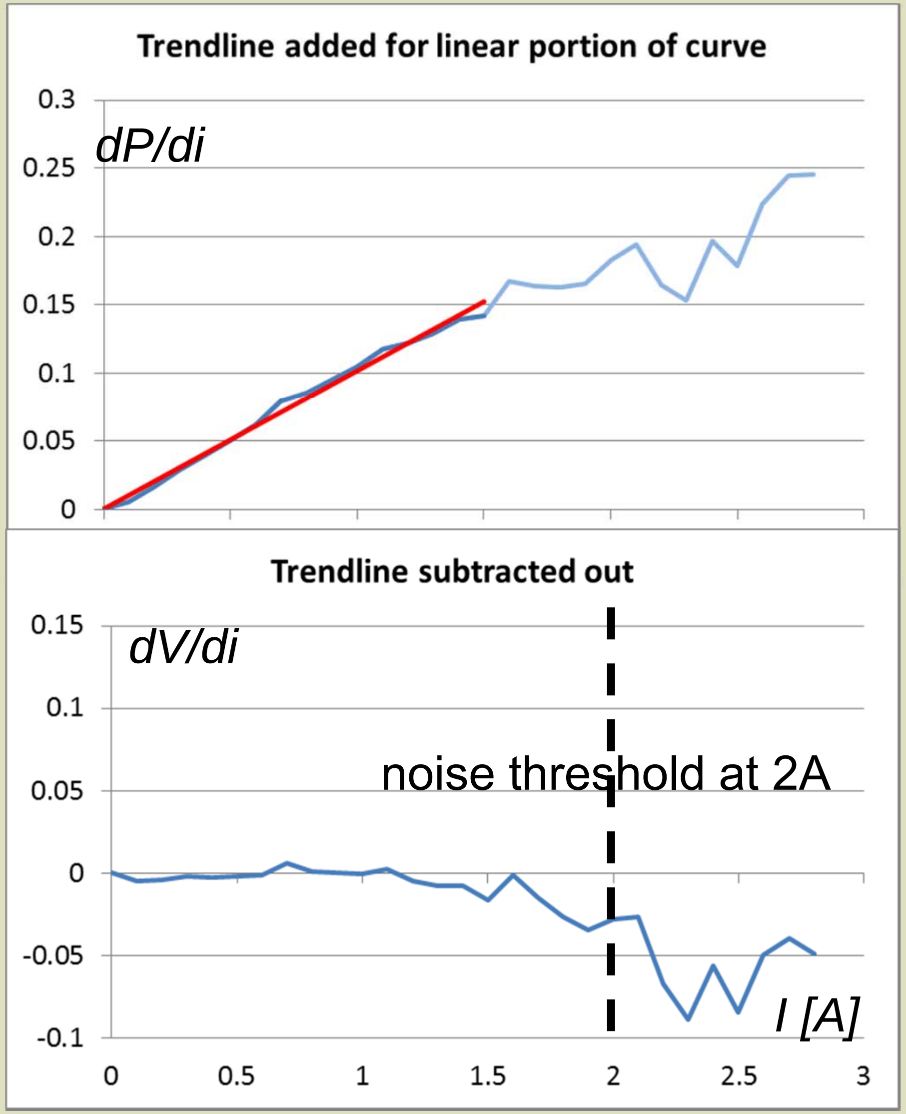
# How can dP/di be used to compare multiple contacts ?




dP/di graph for >70 different contacts

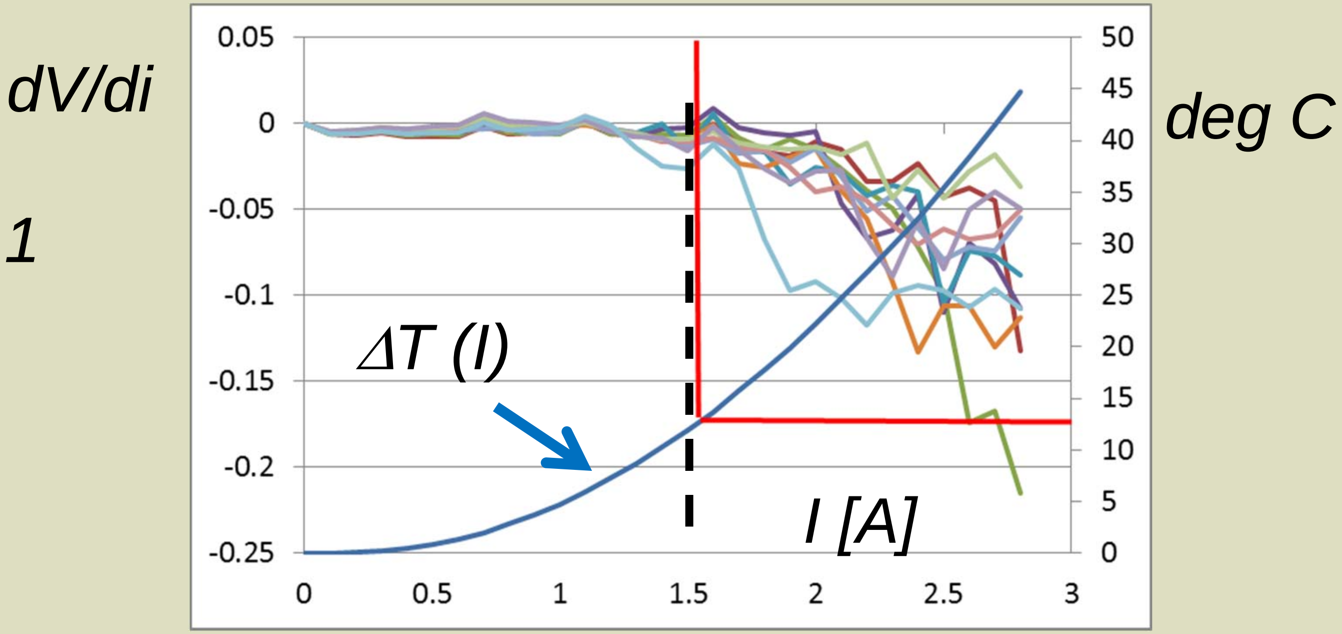
*dP/di by itself is not useful for comparison*

Removing slope results in a zeroed dV/di (I) display and allows for definition of threshold



# dV/di compared with ΔT (I)

*Example:*
*Measurements for 1 contact with 10 successive actuations*

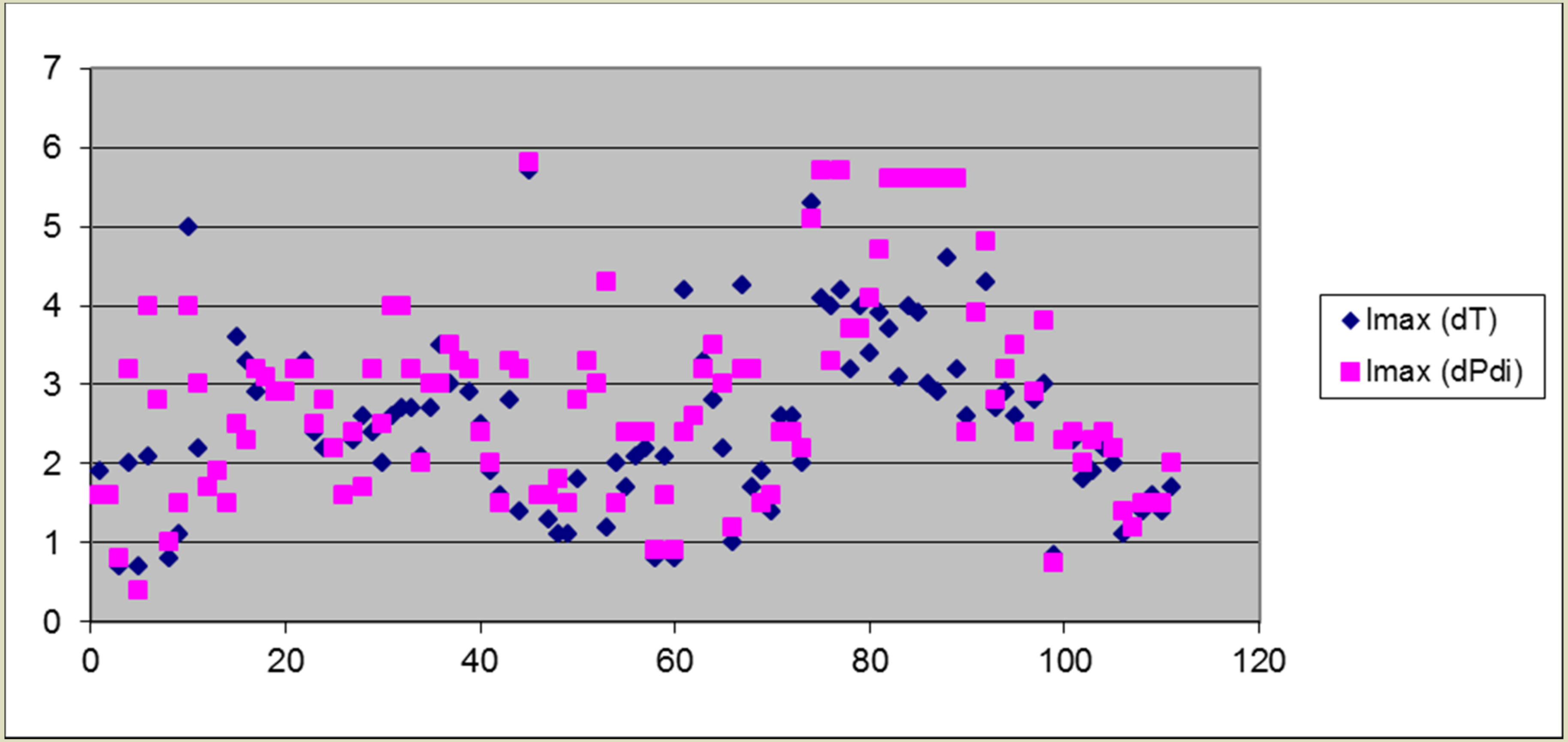



Graph shows both ΔT(I) and dV/di.

The onset of excess noise threshold corresponds to a 13 degree temperature rise. Typical DC characterization uses a 20 degree temperature rise limit.

# dP/di and ΔT(I) maximum currents for a collection of 110 different contacts

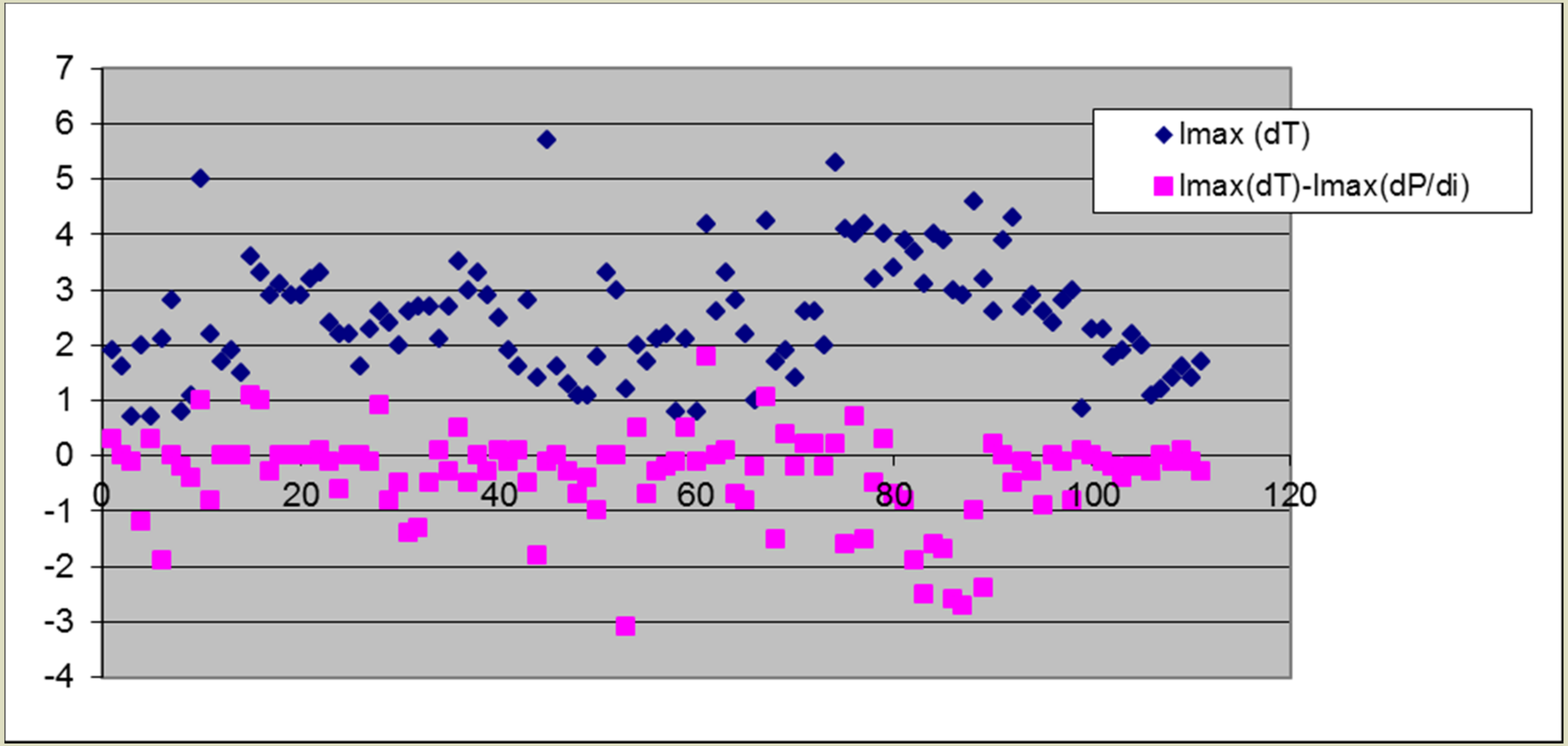
3 different contact types




*$I_{max}$ as defined by dT(20$^{o}$C) and dP/di deviation from linear*

# Maximum ΔT currents and difference to dP/di

g6



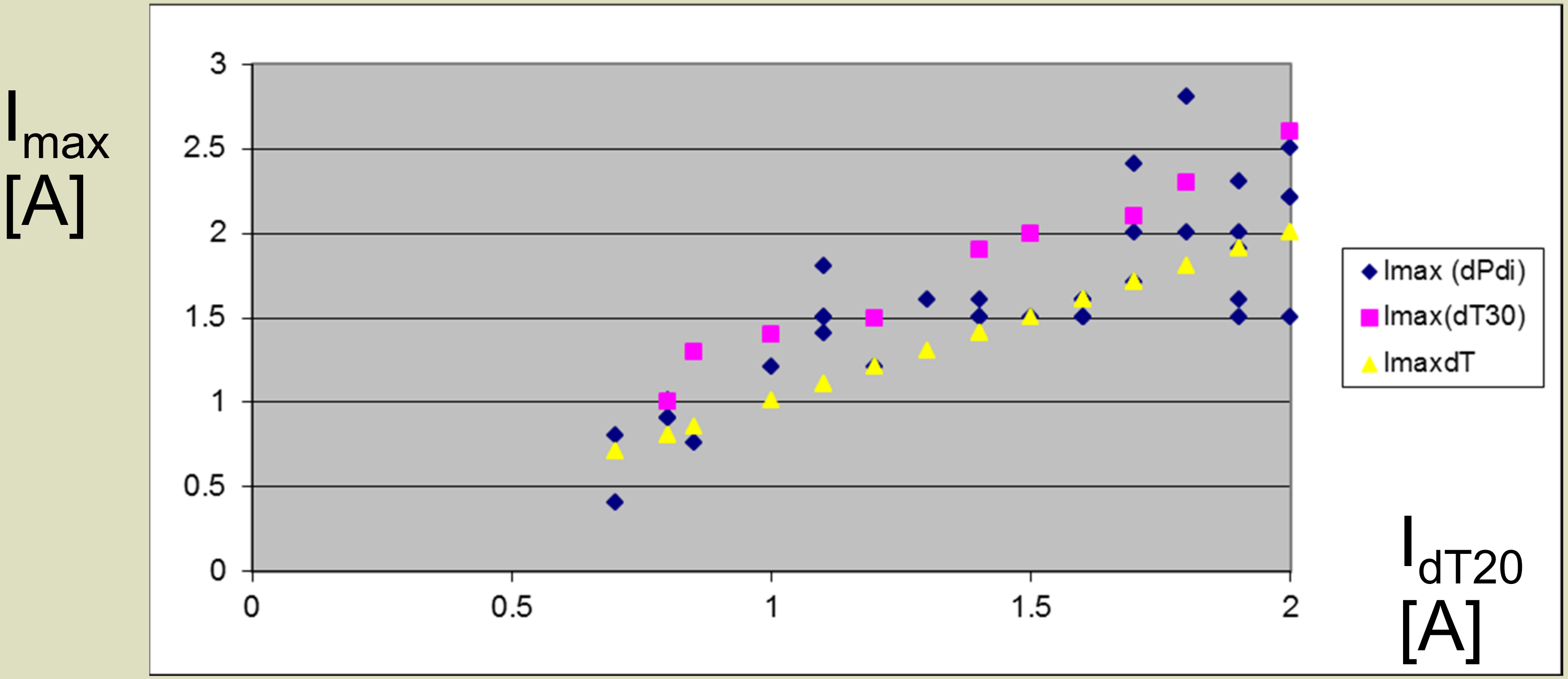

$I_{max}$ as defined by dT(20°C, blue) and difference to that from dP/di $I_{max}$ (pink)

If correlation was perfect all pink data points should be at 0

## Slide 17

**g6** what's to be expected - 0 deviation, pink)
gkgh, 4/19/2021

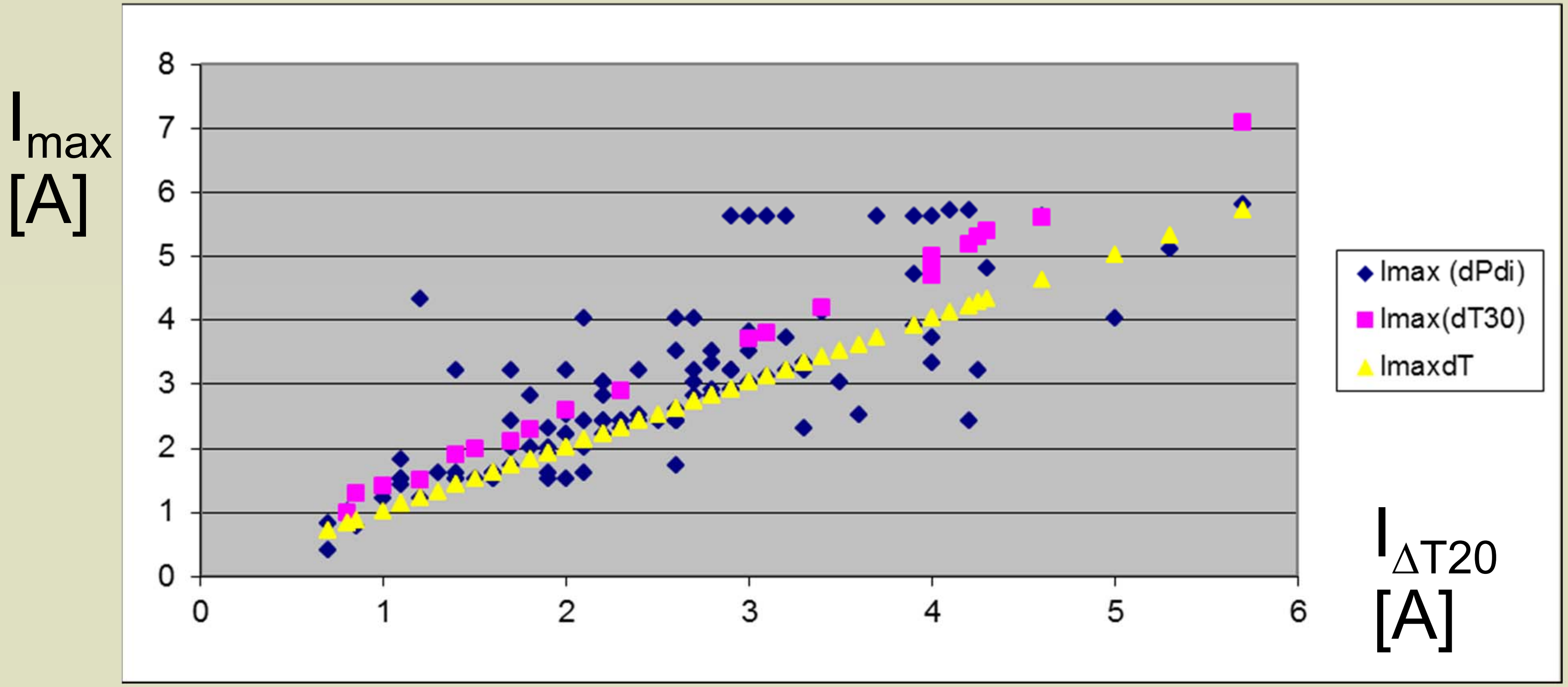
# dP/di for low current levels




Graph shows $I_{max}$ as defined by dT of 20 $^oC$ and 30 $^oC$ as well as defined by dP/di as a function of max. current value for 20 $^oC$ temperature rise

Many dP/di CCC values fall between 20 deg and 30 deg CCC limits.

# CCC for all contacts as a function of $\Delta T\ I_{max}$

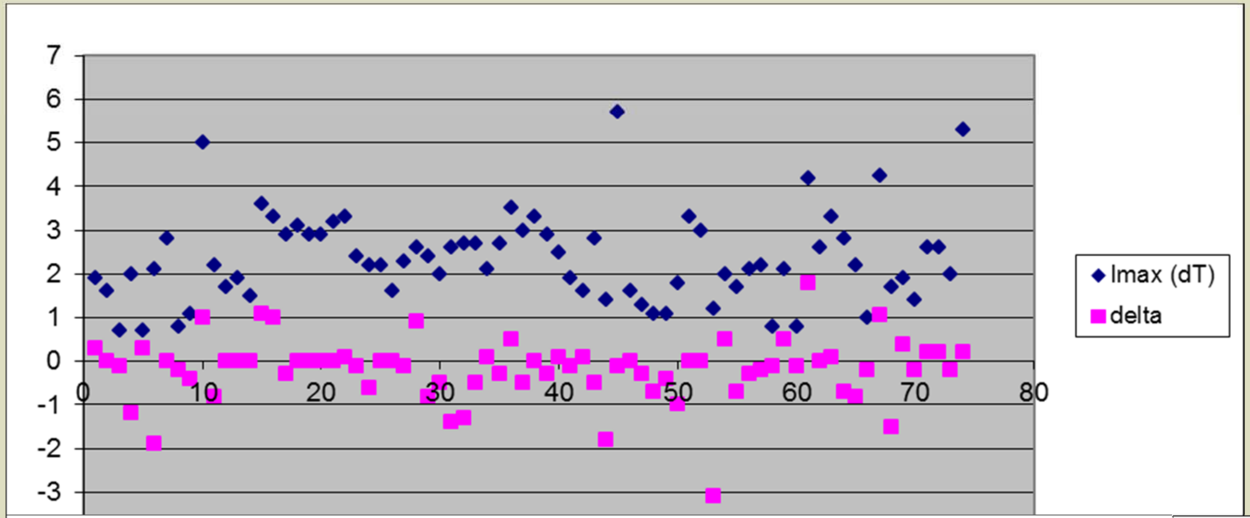



Graph shows $I_{max}$ as defined by dT of 20 °C and 30 °C as well as defined by dP/di as a function of max. current value for 20 °C temperature rise

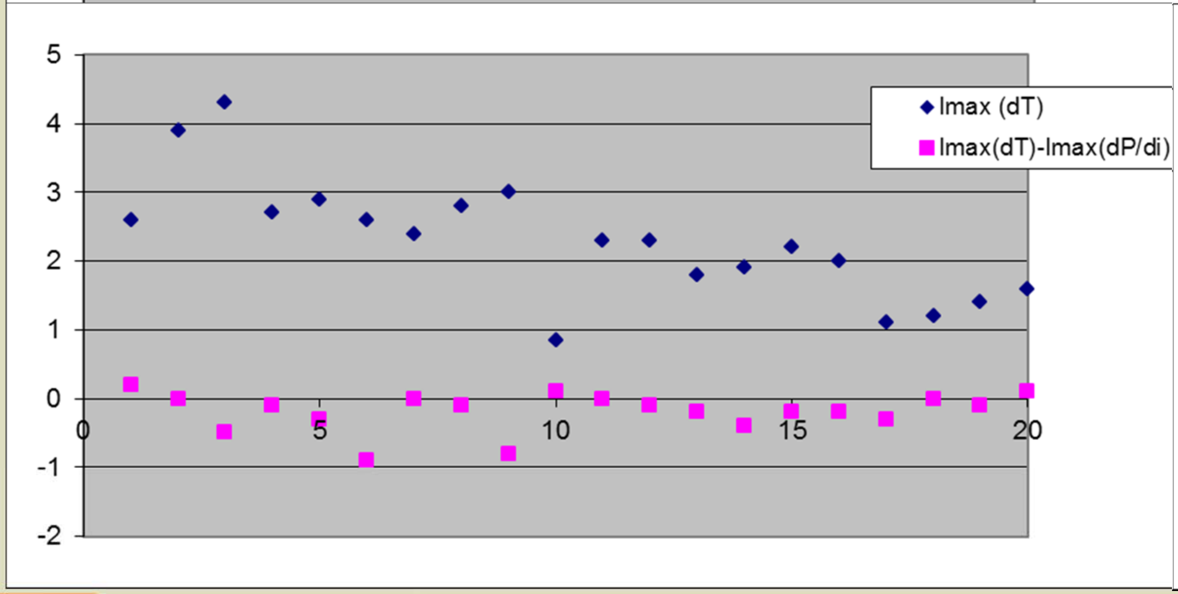
# Comments

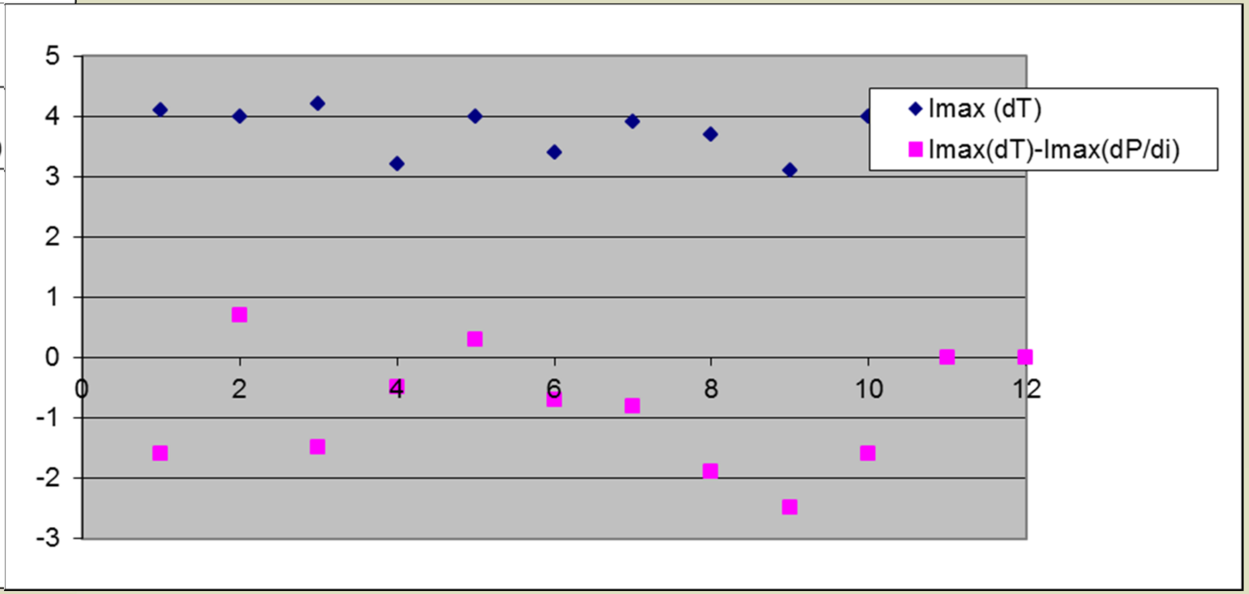
- The previous slides show a degree of correlation between $I_{max}$ from dT and $I_{max}$ from dP/di.
- The mathematical value for correlation is 0.77.
- While this value is encouraging the accuracy achieved is not sufficient to warrant replacing $I_{max}$ values obtained with dT.

# Results for 3 different contact types




$I_{max}$ (dT) and difference to dP/di $I_{max}$ for three fundamentally different contact constructions



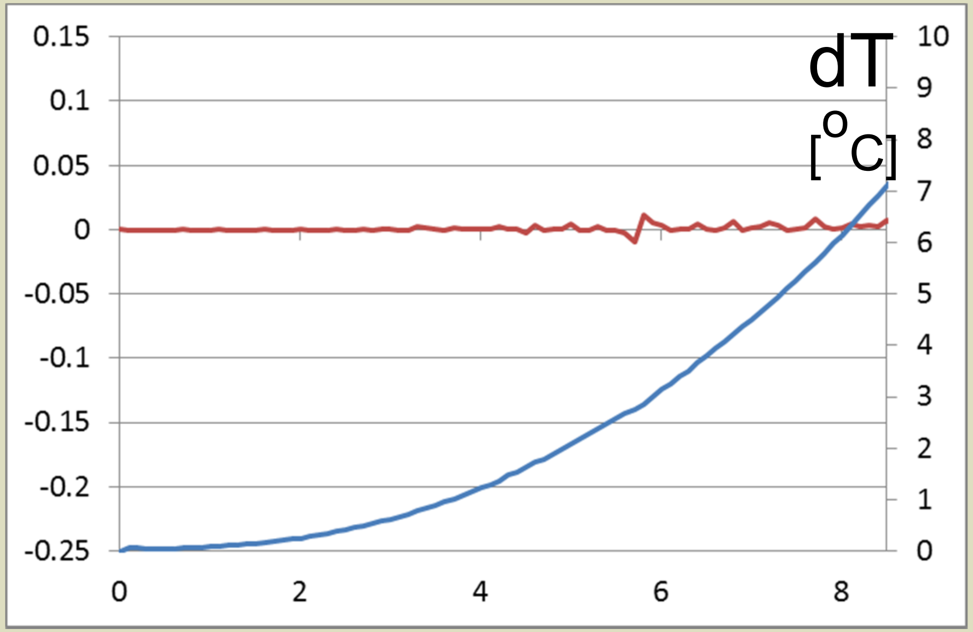



# Calibration and actuated pins

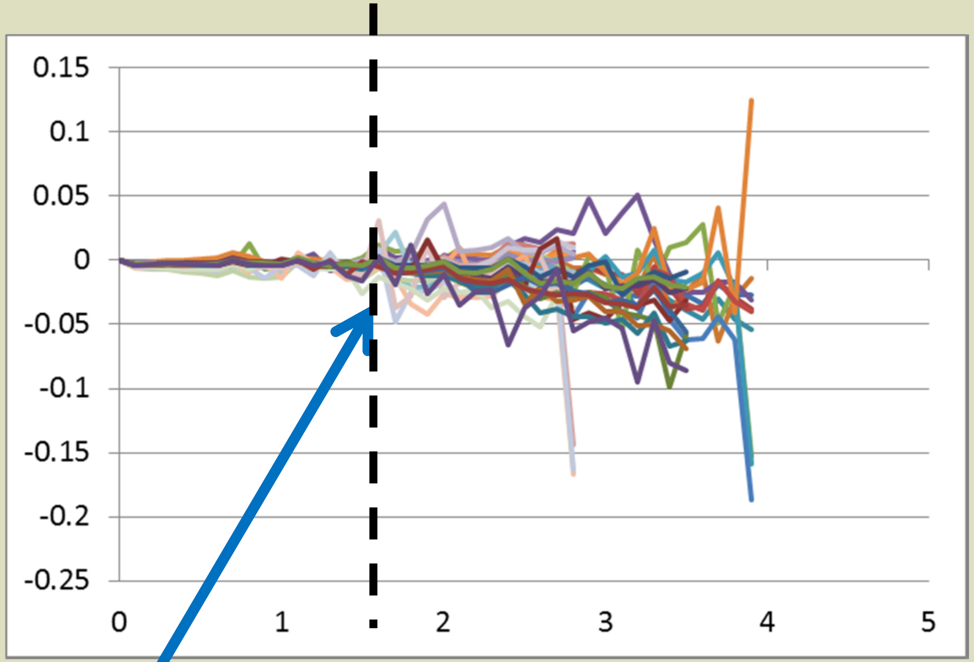
g7

dv/di

[mV/A]




noise threshold at 1.5A




I [A]

Fixture cal

10x actuation of 5 different pogo pins

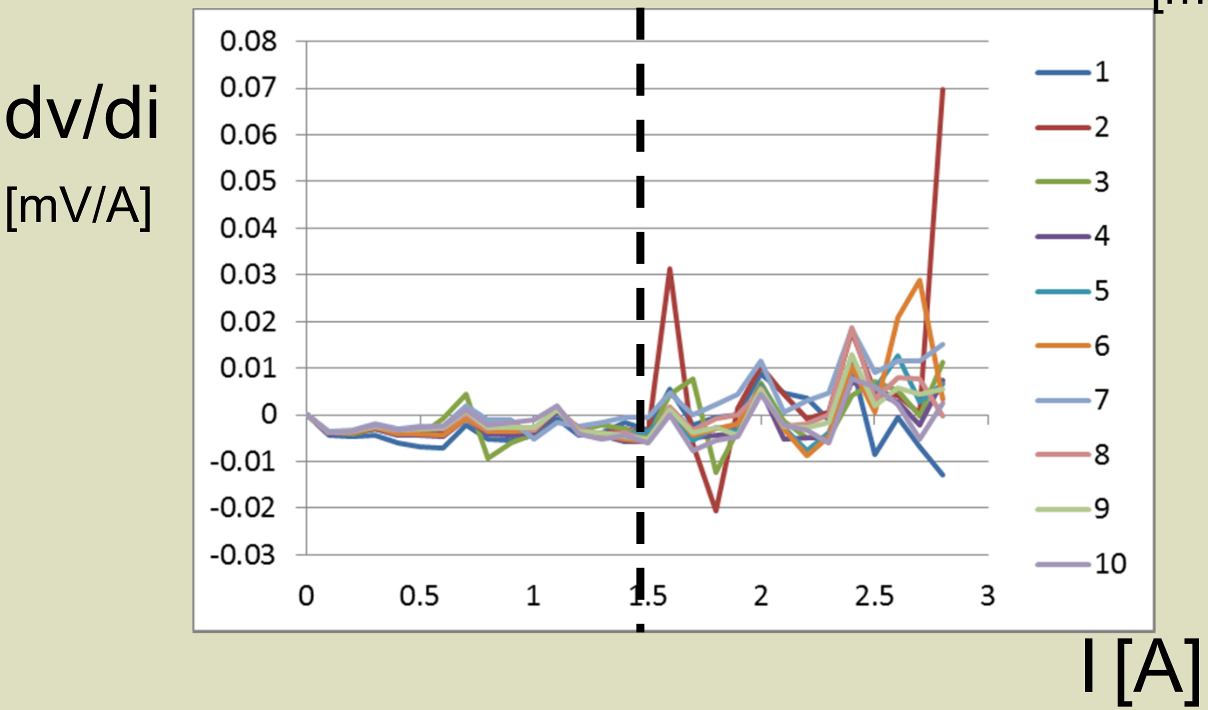
*Sensitivity measurements can give stability forecasts for contact applications.*

## Slide 22

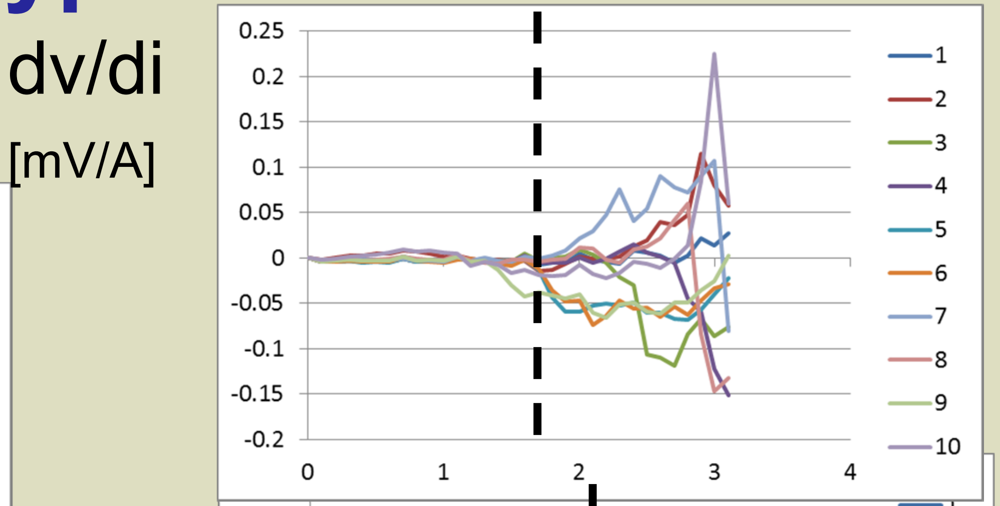
**g7** this proves feasibility of using this for contafct qualifications
gkgh, 4/19/2021

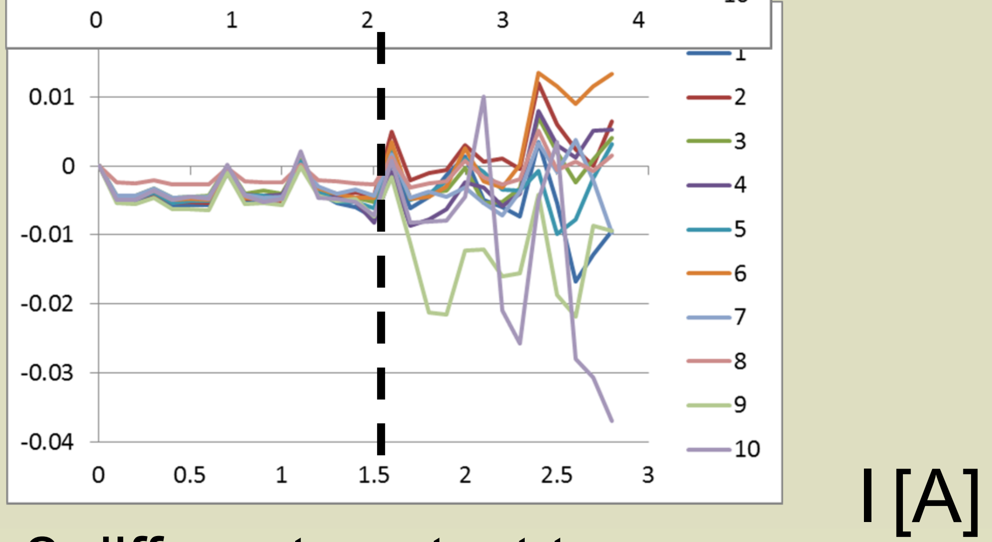
# Different contact types and conditions

noise threshold at 1.5A




10 measurements without any actuation of contact




2 different contact types each with 10x actuation

# Conclusions

- Examination of dP/di and dV/di is capable of providing stability forecasts for contact applications.
- Replacing the $I_{max}$ definition via temperature rise with that from dP/di does not appear advisable. However, the latter can provide a tool to assess current carrying capability for contacts where direct measurement of temperature rise is not possible.
- Variations of $I_{max}$ derived from dP/di vs. those derived from dT should be seen in light of general variability for this type of measurements
- Use of dP/di as a CCC gage should be accompanied by an effort to establish correlation for the particular type of contact.

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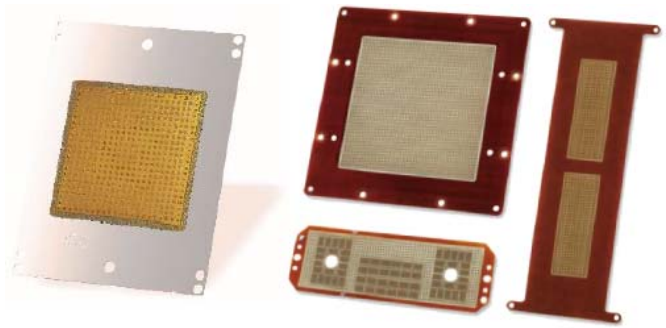
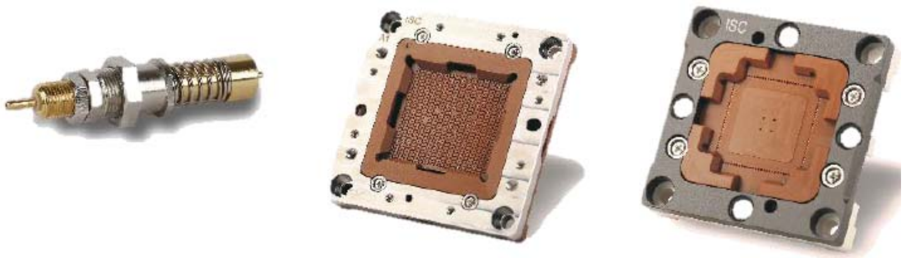
- High performance and competitive price
- High speed & RF device capability
- Various customized design to meet challenge requirement



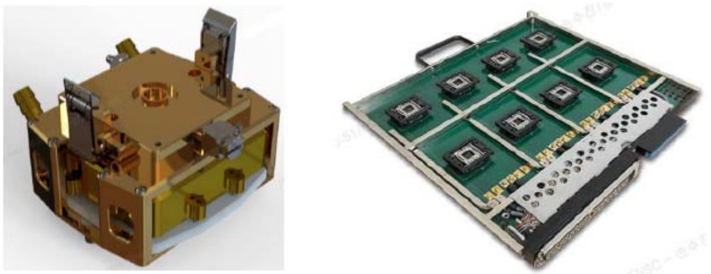
## POGO SOCKET SOLUTIONS

- Excellent gap control & long lifespan
- High bandwidth & low contact resistance



## THERMAL CONTROL UNIT

- Extreme active temperature control
- Safety auto shut-down temperature monitoring of the device & thermal control unit
- Full FEA analysis & Price competitiveness



## BURN-IN SOLUTIONS

- Direct inserting on the board without soldering
- Higher performance BIB solution


**CONTACT**
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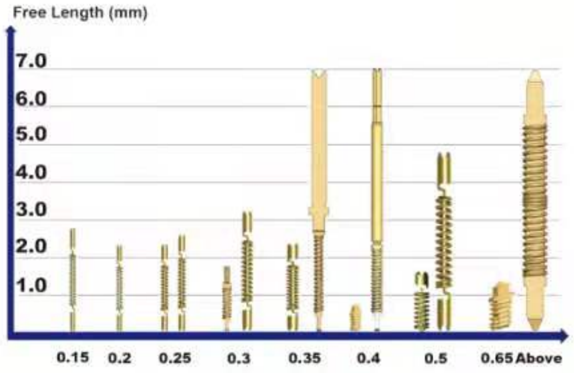
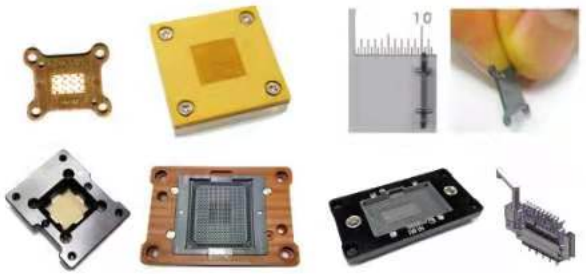
# IWIN Co., Ltd. The test probe for high signal integrity at extremely high speed test

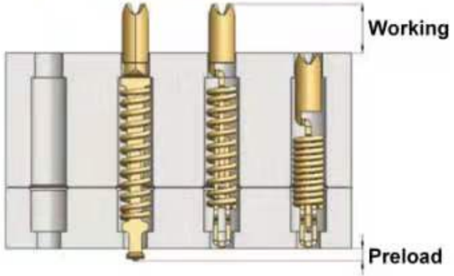
## Spring probe by stamping




250 kinds of spring probe pin
300 kinds of test socket (44,000 Pin count socket possible)
One piece spring probe
Three piece spring probe
High speed product → 0.63mm free length spring probe pin available
Finest Pitch → 0.15mm Pitch



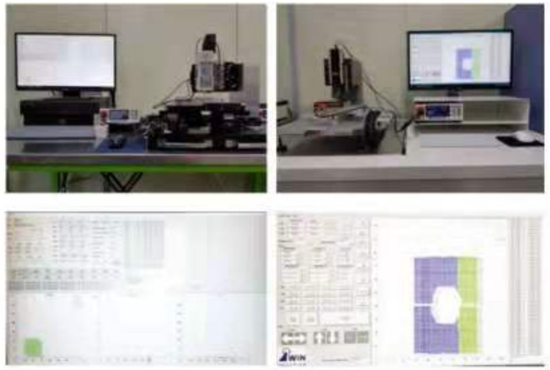
## Spring probe by stamping




**Patented**

| Pitch(mm) | Free Length(mm) | Current Carrying(Amps) |
|---|---|---|
| 0.15/0.2/0.25 | 2.17~ | 0.5~ |
| 0.3 | 1.5~ | 1.5~ |
| 0.35 | 2.08~ | 1.8~ |
| 0.4 | 0.8~ | 2.5~ |
| 0.5 | 1.5~ | 3.0~ |
| 0.65 | 1.13~ | 9.0~ |
| 0.8 | 3.14~ | 3.0~ |

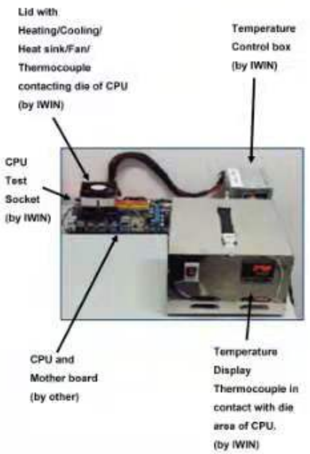
## Automation
### Pin assembly and Quality control



Top Figure: Socket CRES, Force, Stroke test
Bottom Figure: Data displayed

Top Figure: Socket CRES test
Bottom Figure: Data display 5,903 pins socket

### Socket and Lid




### Pin assembly
(Fully automated machines)

- Stamped piece parts attached to a reel fed into the assembly machine

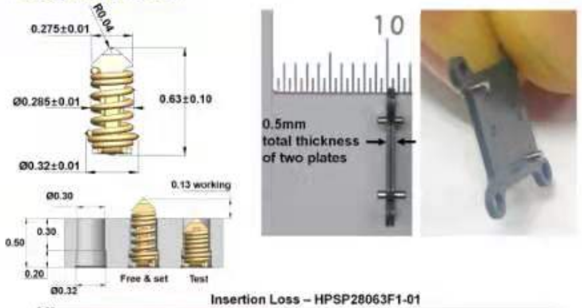
- Assembled pins can be attached to a reel, or, supply in separate for socket assembly.

## Spring probe pins for High speed

### Extremely short spring probes by stamping

One piece spring probe
Three piece spring probe

### Design approach



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**High Performance Probe solution**

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