Parametric Study of Contact Fritting for Improved CRes Stability

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Dr. Christian Degen, Oliver Nagler,
Michael Horn, Dr. Florian Kaesen

Infineon Technologies AG, Germany
Communication Solutions – Test Techonolgy (COM TT)

Never stop thinking

??? Fritting ???
Electrical conditioning of contacts by ‘overvoltage’ / ‘overcurrent’

- Holm‘s theory of electric contacts

  Can fritting be utilized for contact conditioning of probe needles?

- Overview over evaluation setup

  PRobeFOrceInvestigationTool (PROFIT)

- Parameters under study:
  - A-fritting and B-fritting
  - Current level and polarity

- pro‘s and con‘s, conclusions

Never stop thinking

??? Fritting in theory ???
What happens during formation of an electrical contact?

Holm's theory of electric contact:

(Holm: *Electric Contacts,* Springer 1967)

•two conductors in mechanical contact, separated by thin insulating layer (e.g., probe needle on Al-pad separated by layer of native oxide)

•the insulating layer can be broken mechanically

•the insulating layer can brake-down locally due to electrical ***voltage*** (A-fritting), creating a channel for initial current flow (A-spot)

•the A-spot can be broadened by transport effects due to electric ***current*** (B-fritting), reducing CRes

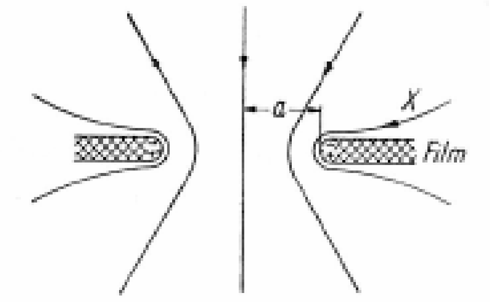


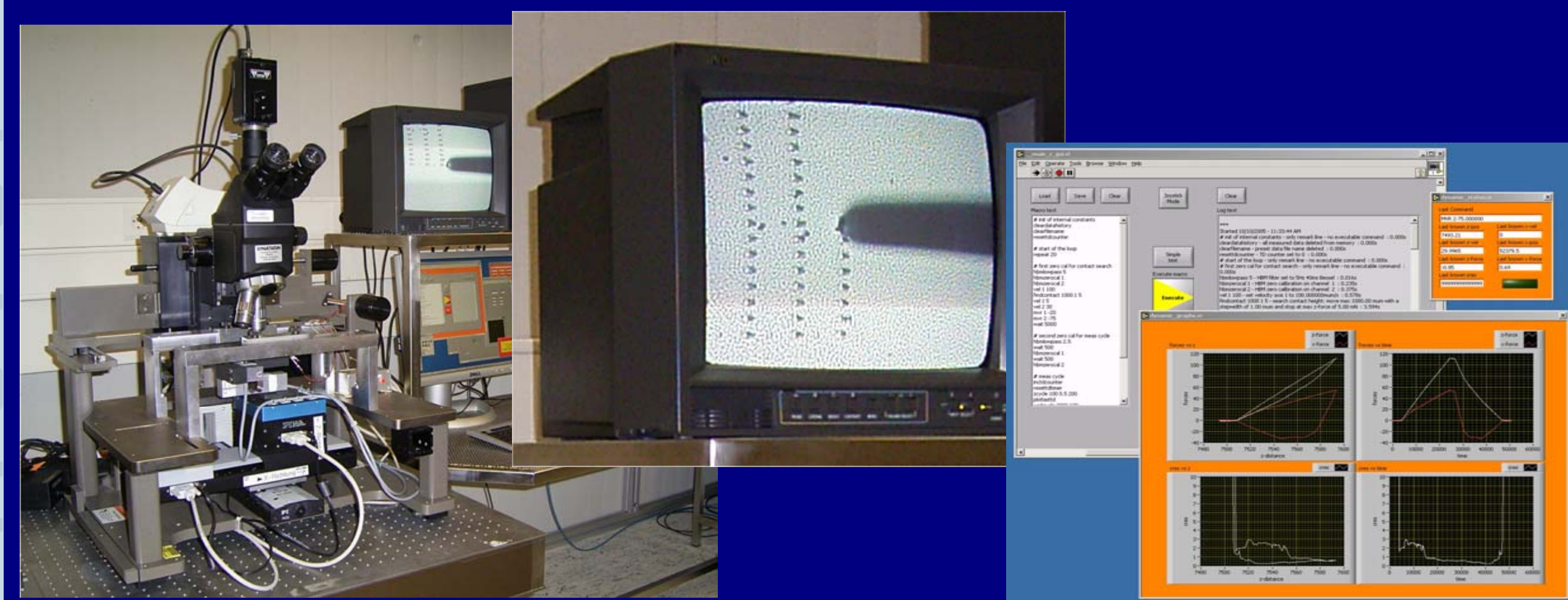
Fig. (27.01). Gradient lines of the field (strength X) bend through an a-spot surrounded by a film

How to study fritting of probe needles?

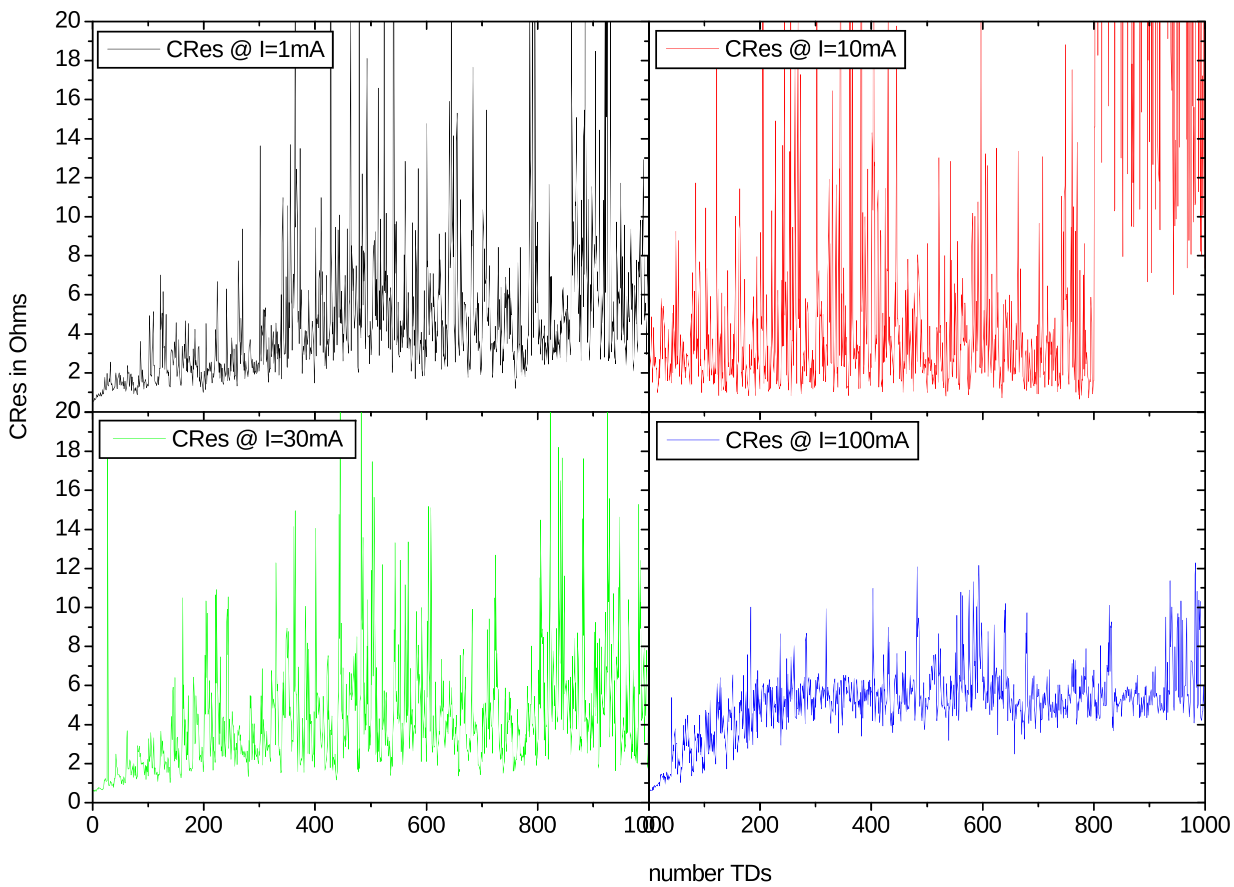
universal tool @ IFX probing lab: PROFIT = PRobeForceInvestigationTool

(SWTW2005: Nagler et al / 'An Advanced Probe Characterization Tool for Online Contact Basics Measurements')

- motorized x-y-z stages, x-z force sensors, top-view microscope
- standard PCBs for mounting various ***single probes***
- substrates with standard pad material (Si-wafer pieces, coated with Al, Au, …)
- LabView based custom-made software for ***automatic multi-TD investigations***
- ***high precision SMU*** for parametric tests
- capabilities: probe force, current/voltage dc, RF, leakage, S-parameter, …



How stable is a probe contact?
TungstenRhenium cantilever 20µm tip on Aluminum, OD=20µm, 1000TDs



- CRes degrades after several 100 TDs without cleaning
- probes accumulate Al-oxide -> isolating layer between tip and pad

Why are electric contacts bad? -> Conductors separated by isolating layer!
(here: high current relay contact, from literature)

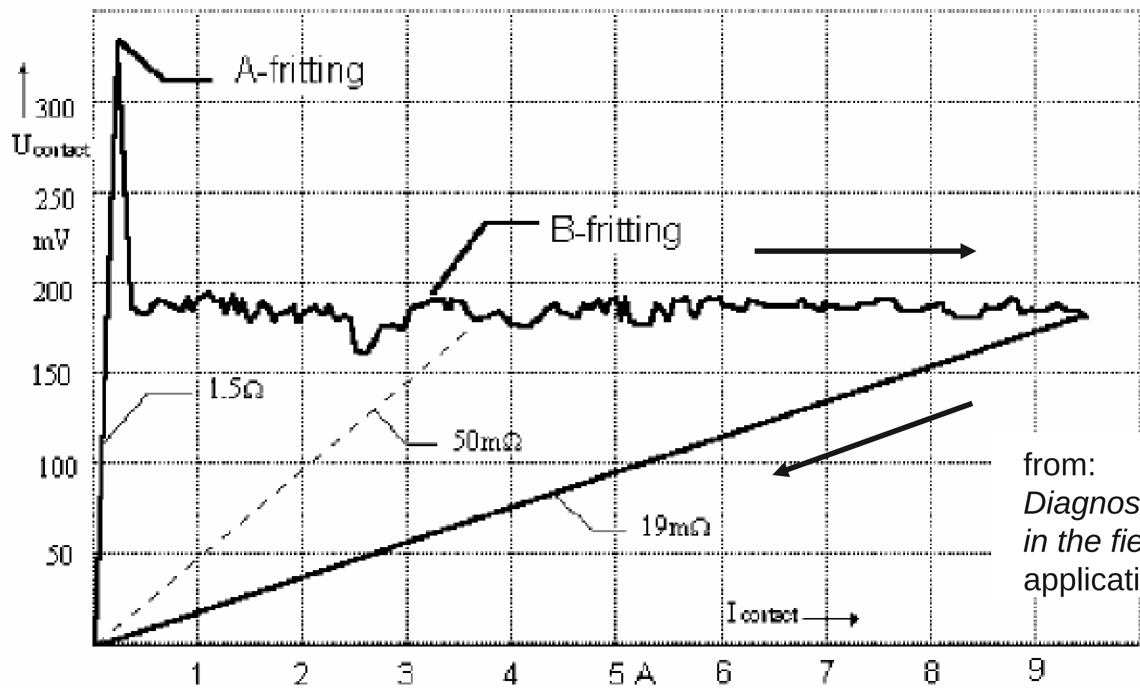


Fig 2: Fritting of a relay contact

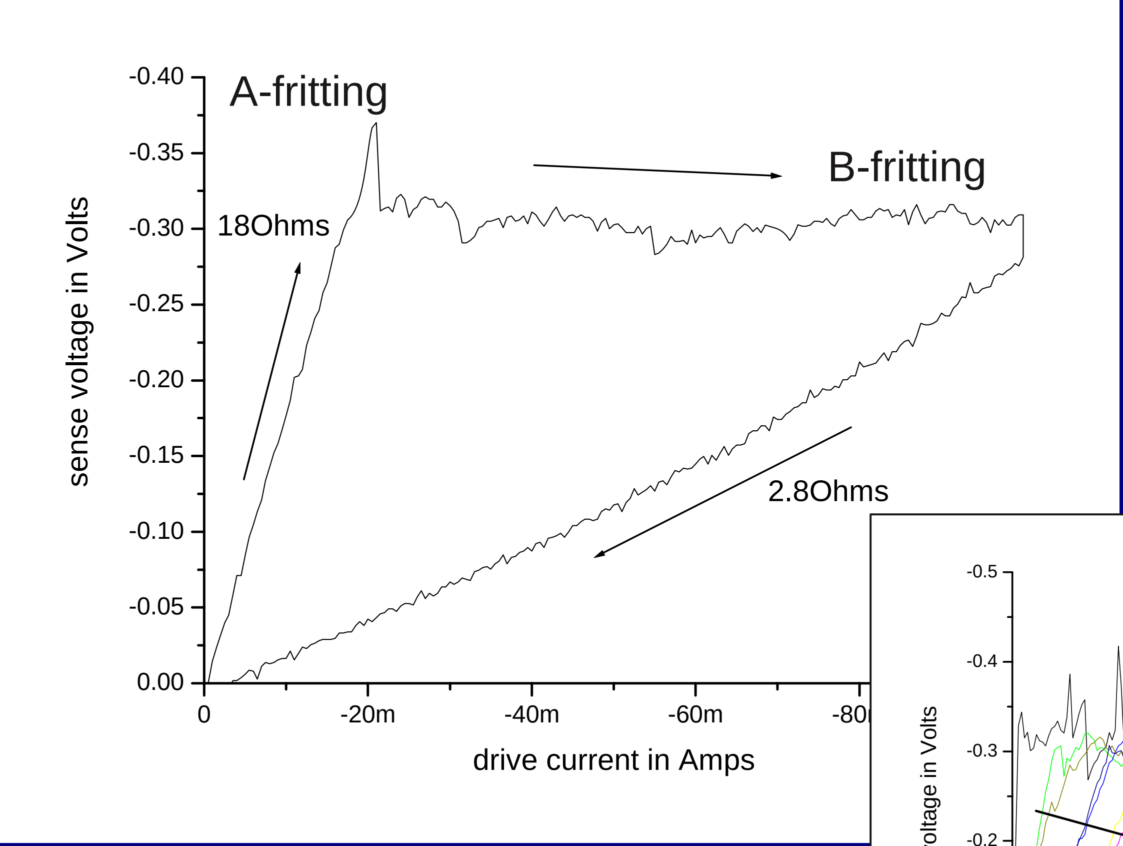
from:
Diagnostic routines for automotive relays in the field, IC- and EOL-tests, application note by Tyco Electronics

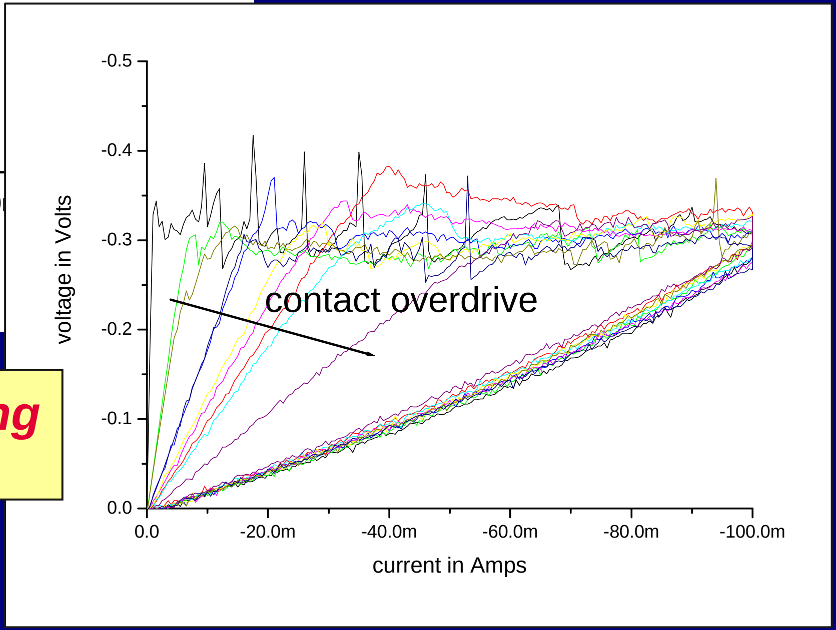
I-U characteristics during fritting cycle
- ***A-fritting*** is voltage induced formation of initial conductive channel
- ***B-fritting*** is current induced broadening of existing channel

(for details see Holm: *Electric Contacts,* Springer 1967)

Formation of electric contact: cantilever TD on Aluminum pad

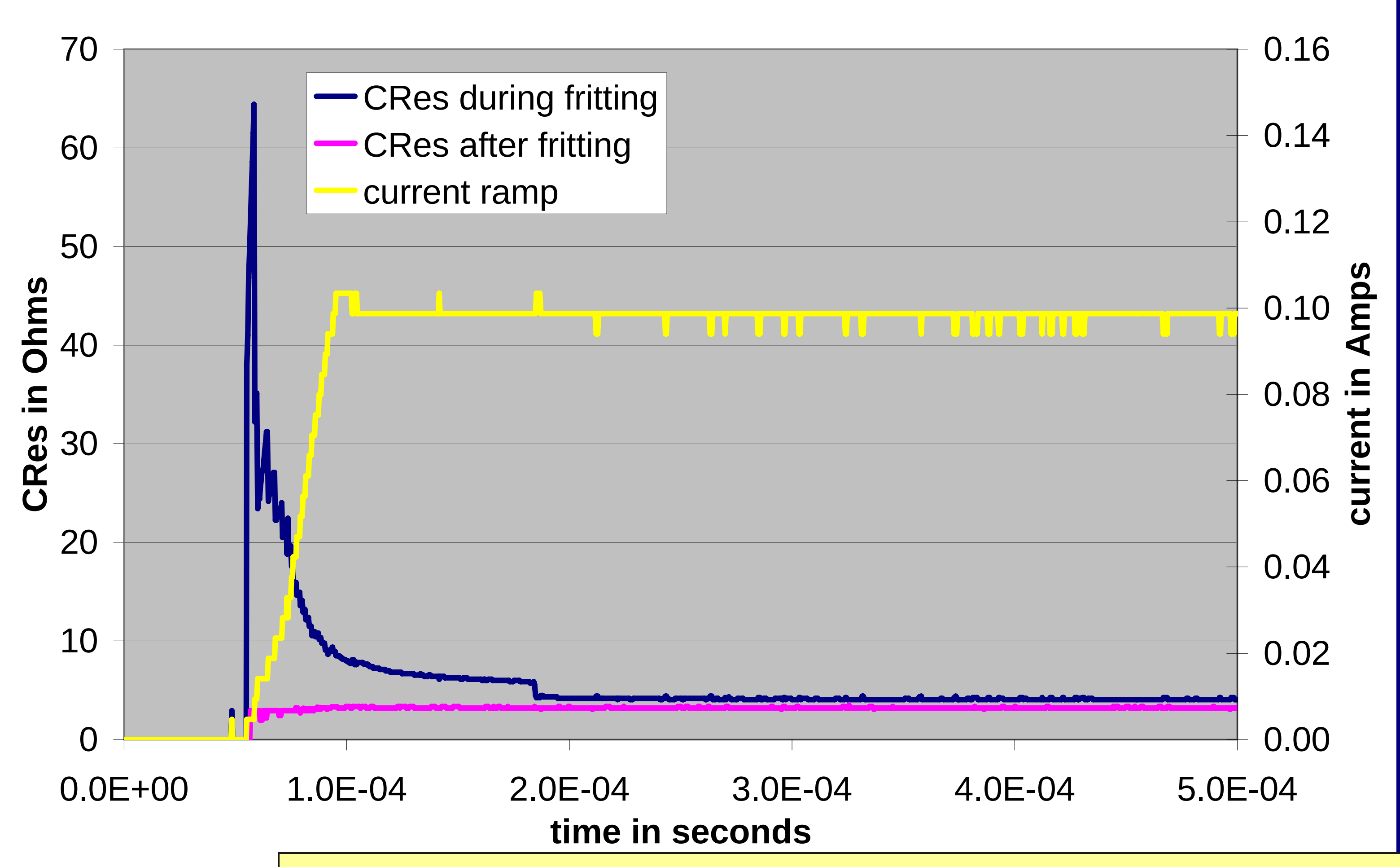
(high precision quasistatic measurement / full trace ~1sec)





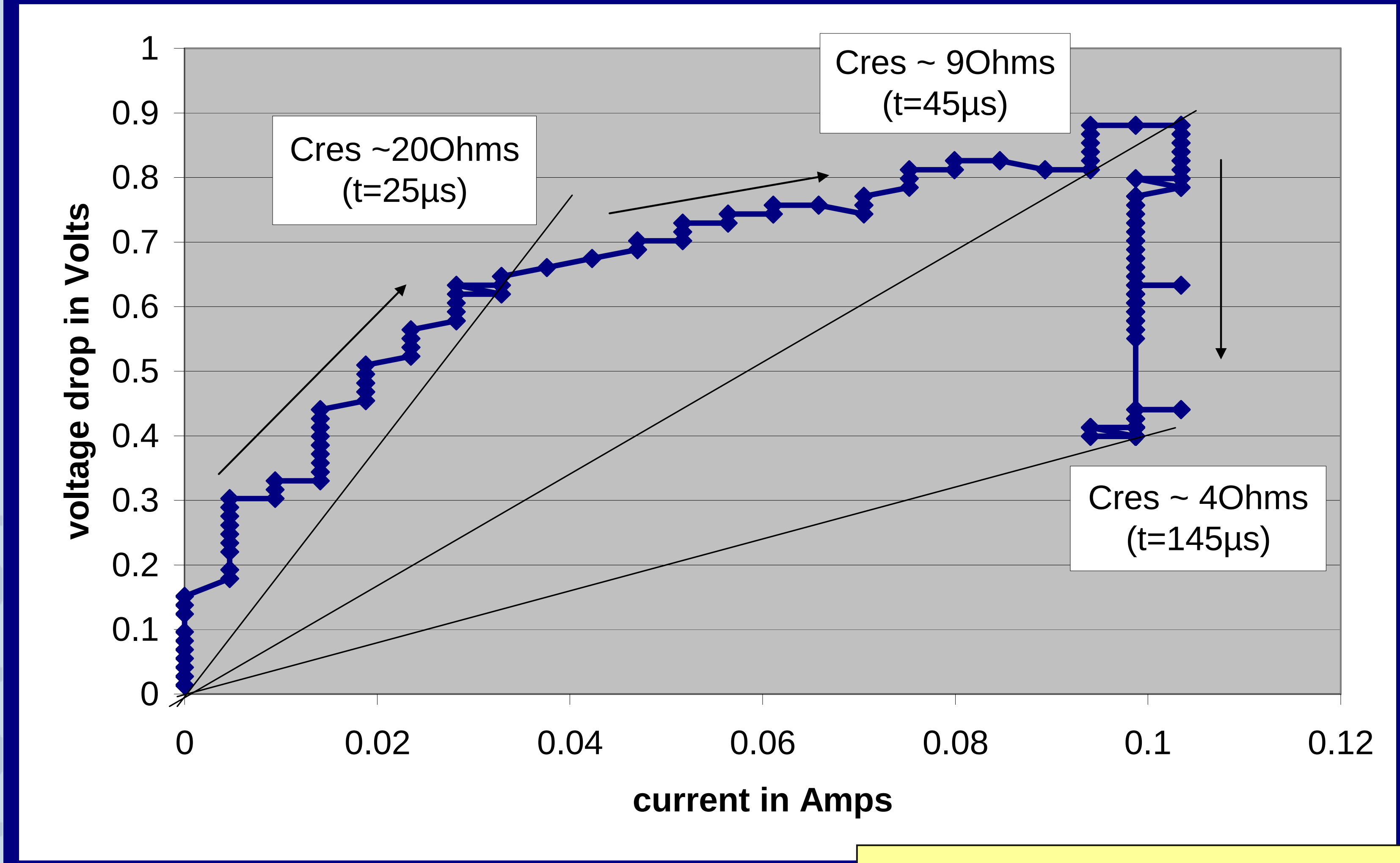
•observation of ***A-fritting*** and ***B-fritting*** for probe needles on pad material

What are the typical timescales for contact fritting?
-> investigation of voltage drop across contact during current step



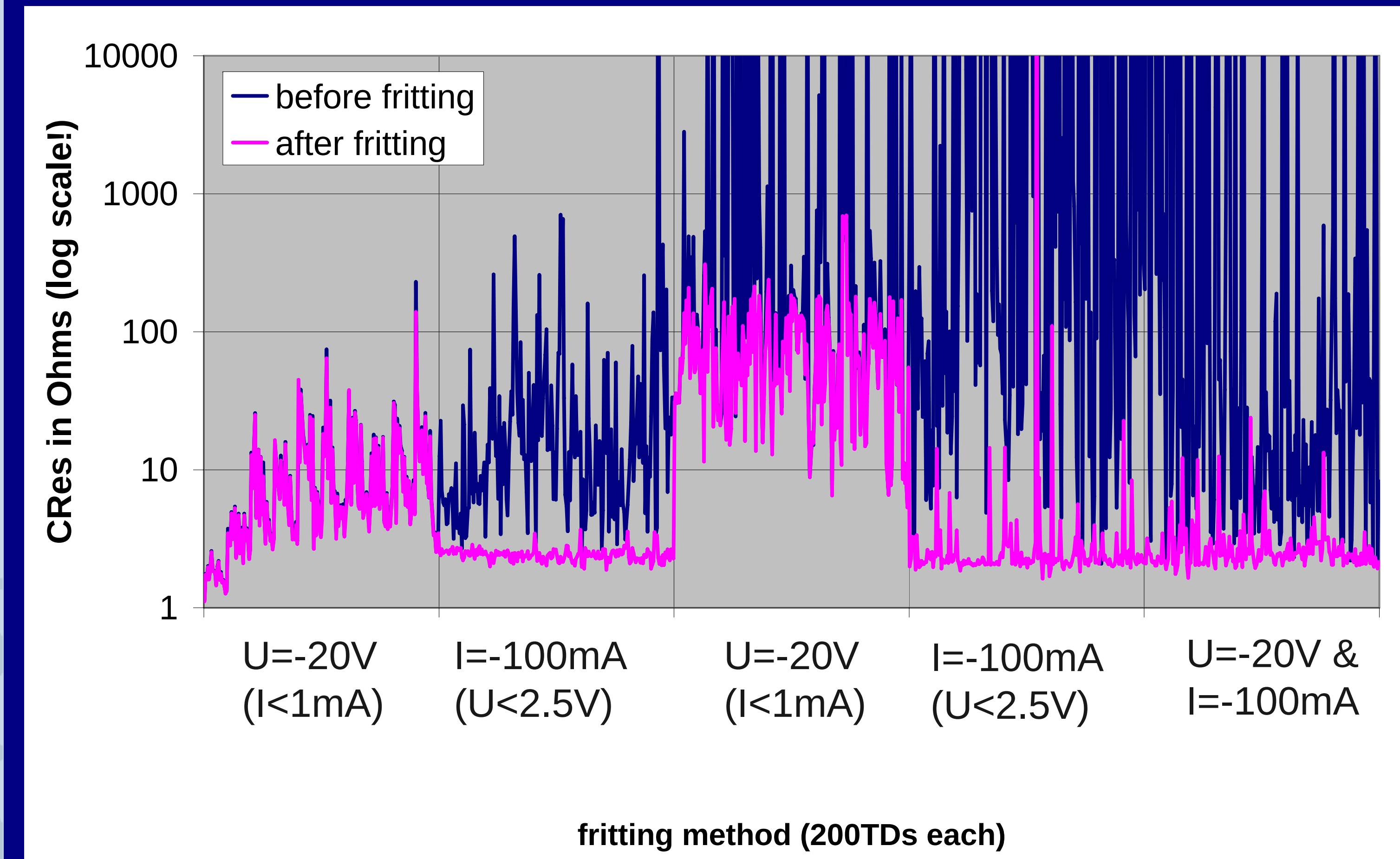
- current step <50µs
- full breakdown of insulating layer after ~150µs (typ. <<1msec)
- instantaneously low CRes for 2nd cycle (after fritting)

Characteristic curve of contact fritting:
voltage drop across contact during current step



•typical timescale ***<<1msec***

What is dominant for contact fritting of probe needles?
voltage effects vs current effects



- Is the effect always initiated @ U<2.5V ? -> ***YES***
- Or do higher voltages assist conditioning? -> ***current is crucial***

summary part1 – contact fundamentals

contact formation and fritting:

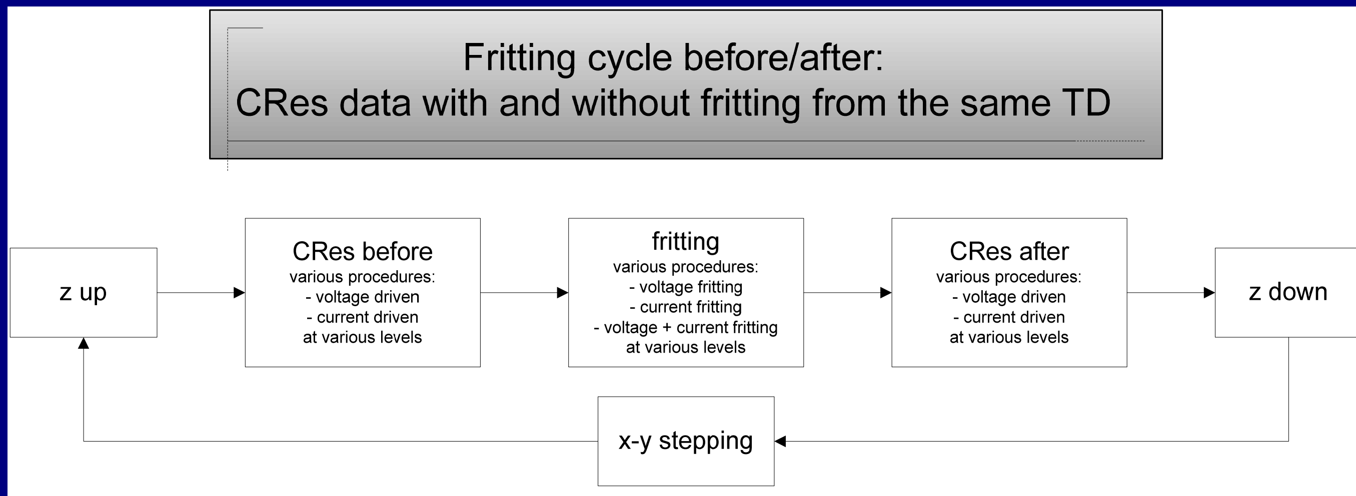
•fritting cycle observed on probe-pad-contacts
•fritting cycle typically ***<<1msec***
•A-spot prepared by A-fritting at ***voltages <2.5V*** (assisted by mechanical scrub)
•current fritting (B-fritting) significantly lowers CRes

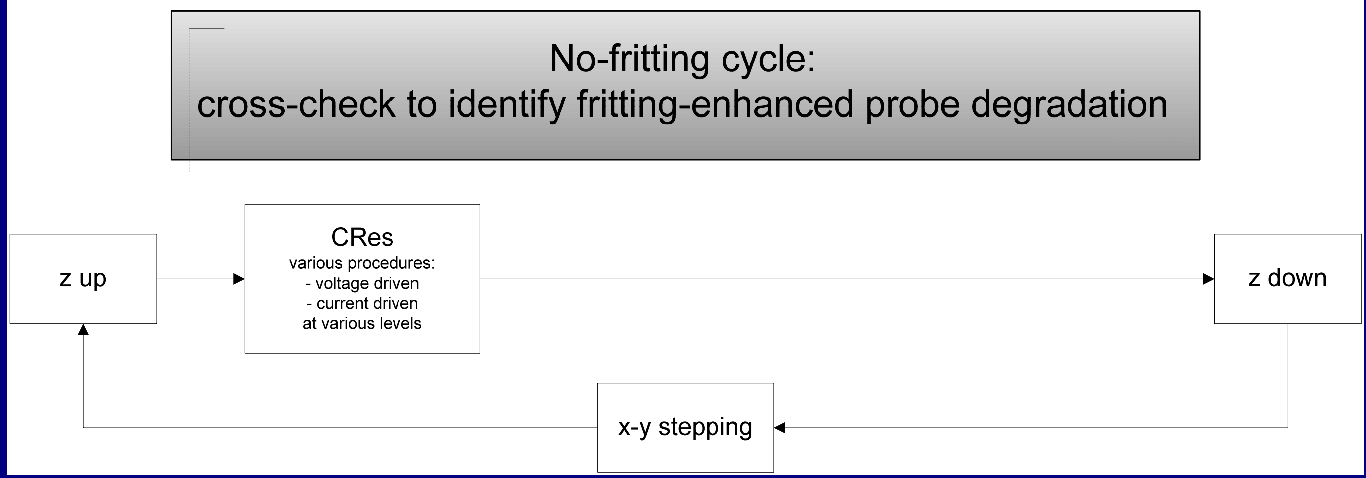
next questions:

•polarity of fritting current ?
•level of fritting current ?
•multi-TD test ?

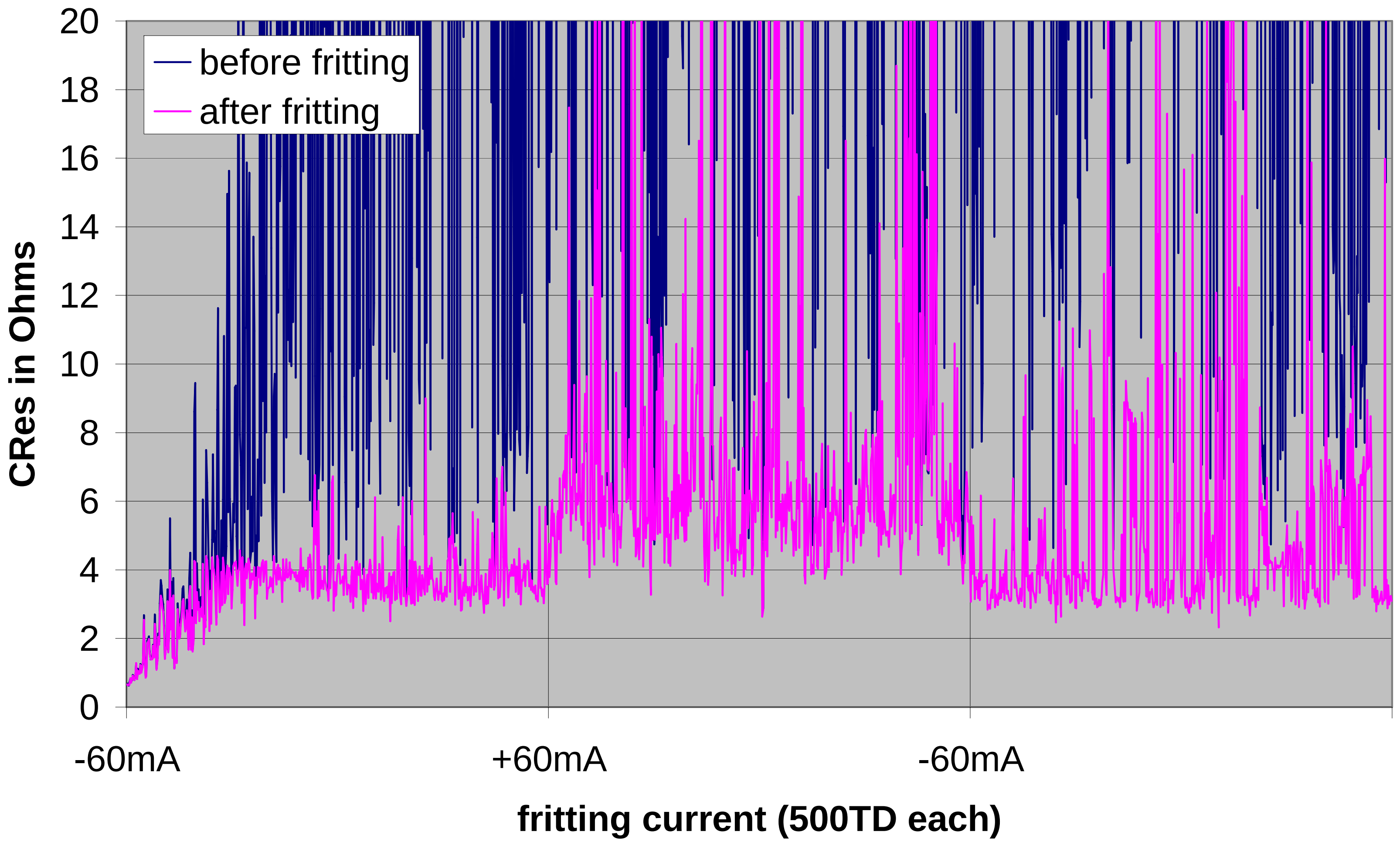
Flow of multi-TD experiments:

1. meas. CRes before – do fritting – meas. CRes after -> all the same TD
2. no fritting, only meas. CRes -> reference without any fritting effects



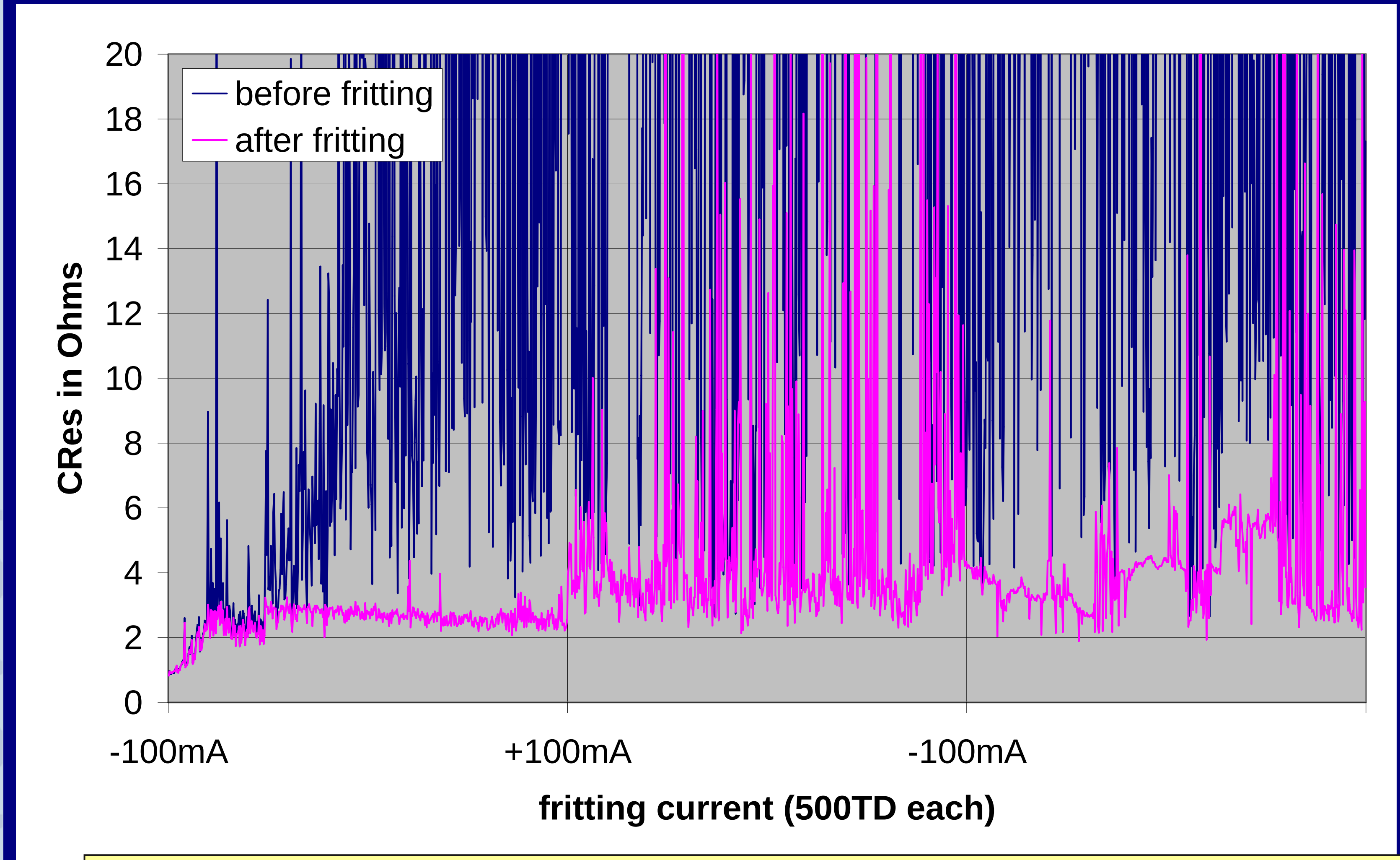


Which polarity of fritting current gives better stability?
(cantilever probe, OD=20µm, I=60mA changing polarity)



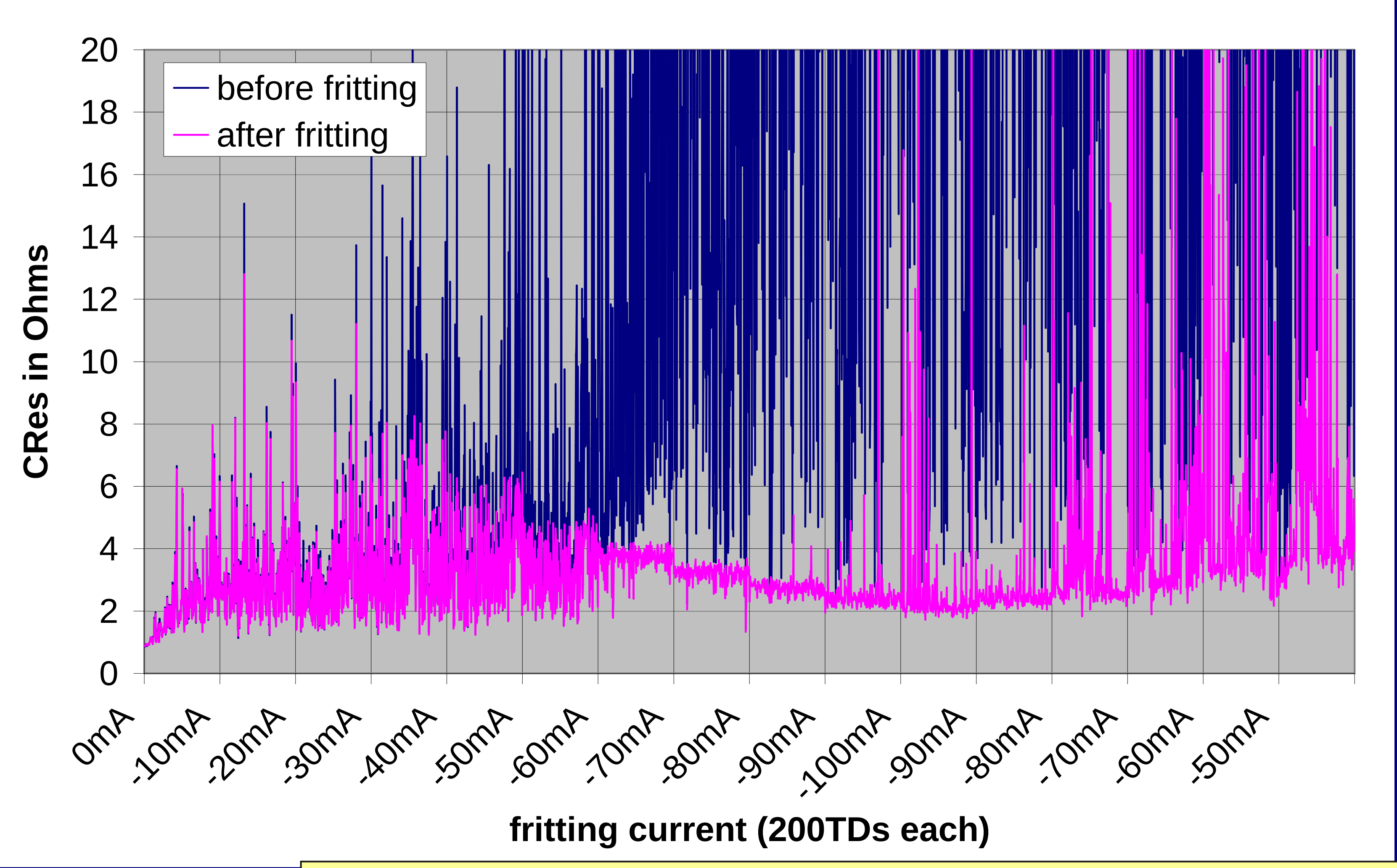
•***negative current*** = better CRes stability (pad=ground, probe=negative)

Which polarity of fritting current gives better stability?
(cantilever probe, OD=20µm, I=100mA changing polarity)



•***negative current*** = better CRes stability (pad=ground, probe=negative)

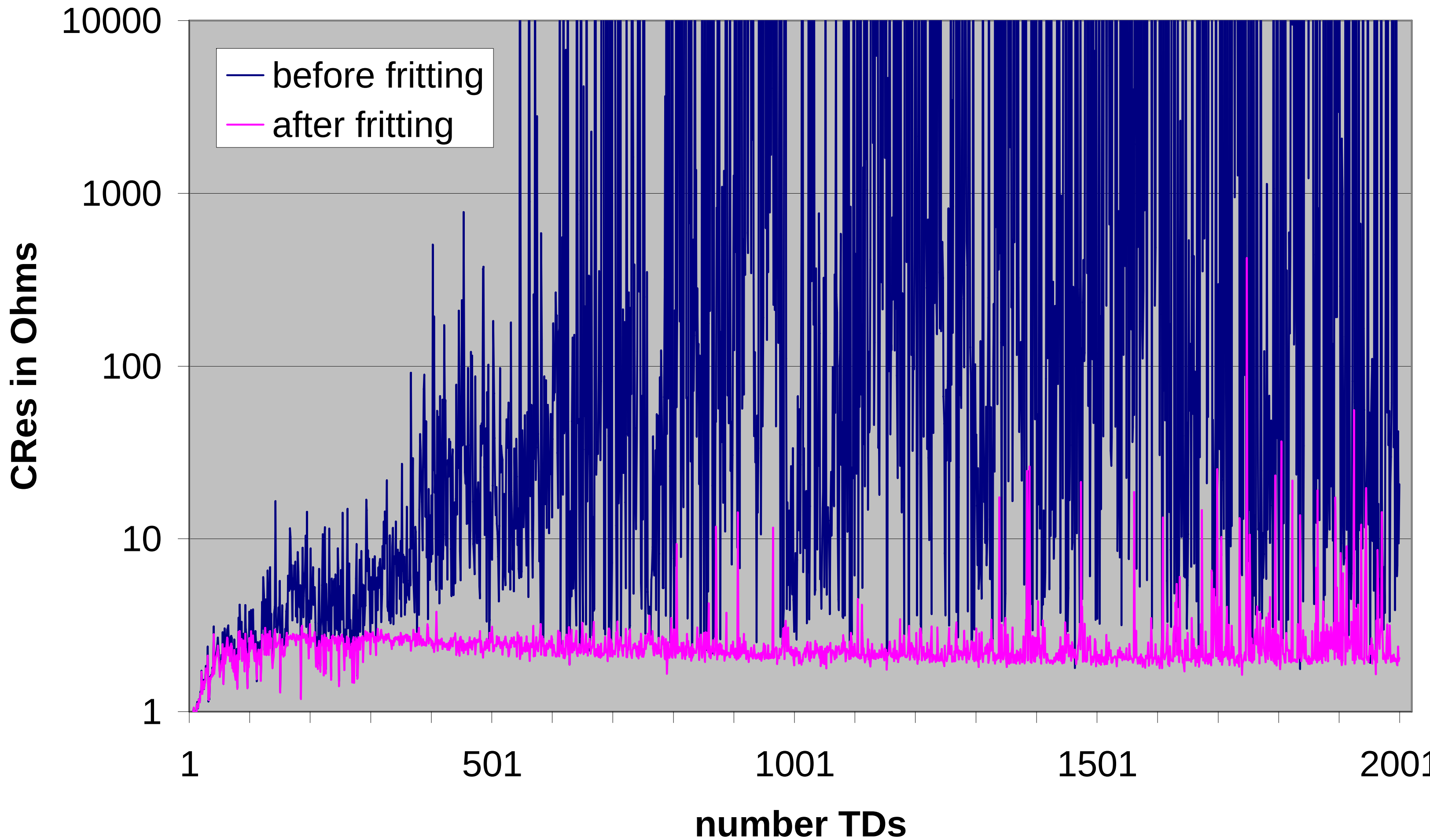
How much current is necessary for CRes stabilisation by fritting?



•significant improvement from ***I > -40..-60mA to I=-100mA***

So fritting works – are there any drawbacks?

•2000TDs, fritting ***I=-100mA***, CRes @ U=1mV (i.e., no current load)

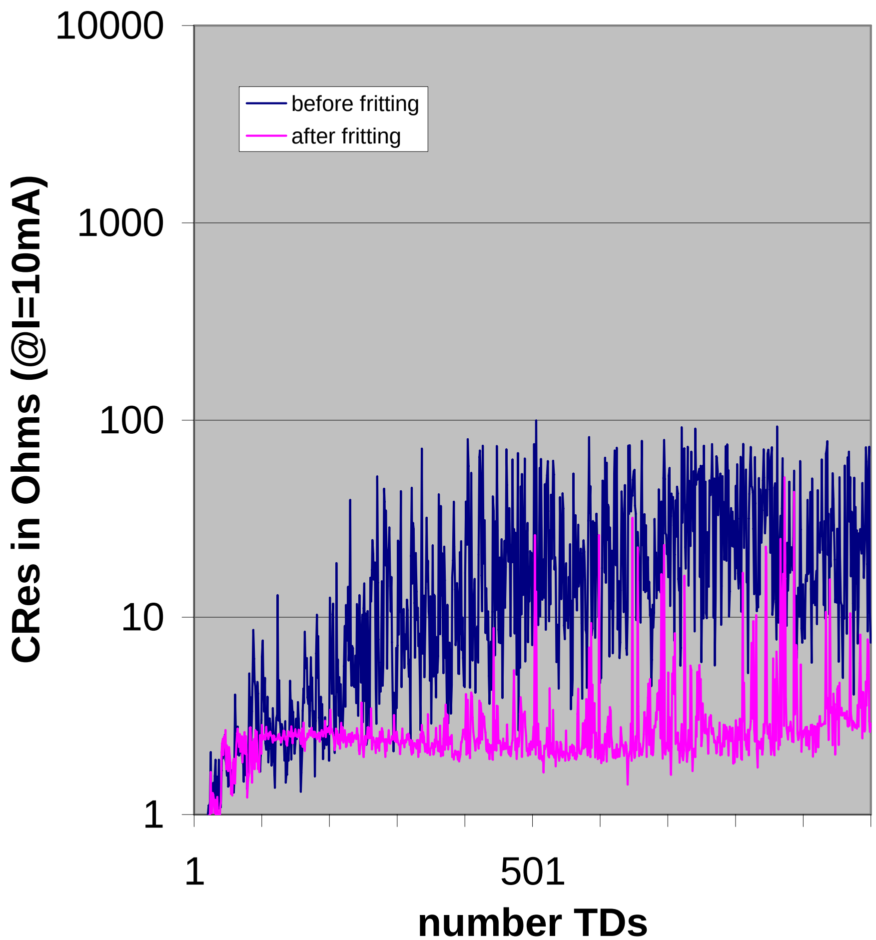


•Very stable CRes ***2.0 .. 3.0 Ohms***

•High fritting current enhances probe pollution -> probe gets ‘addicted’ to fritting

Once more about drawbacks

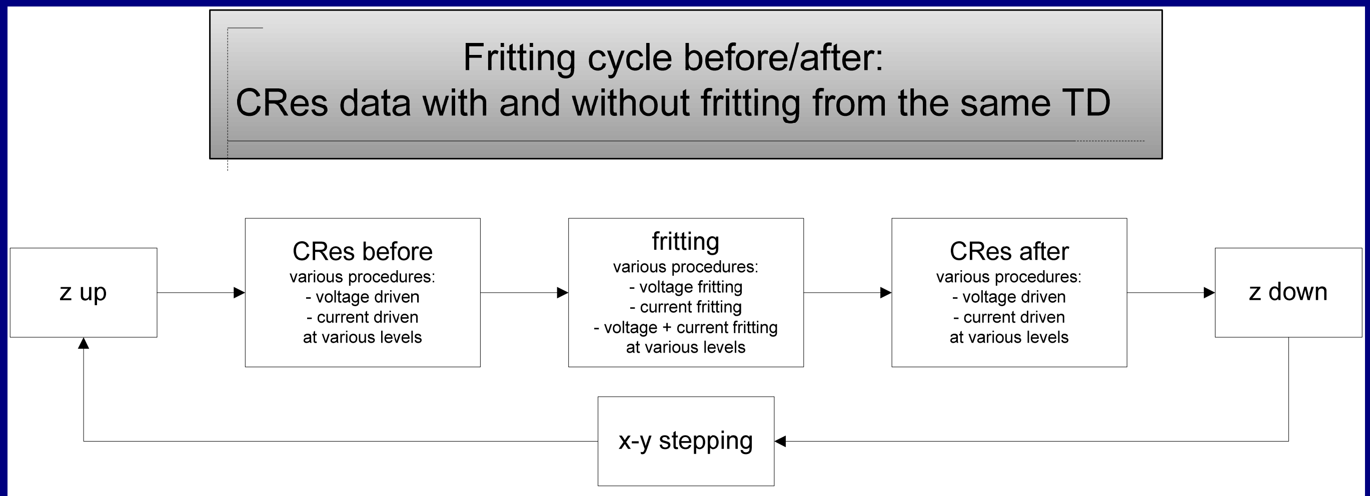
- 1000TDs, fritting I=-100mA, CRes @ ***I=10mA*** (i.e., ***with*** current load)
- less degradation ('before fritting') than CRes @ U=1mV

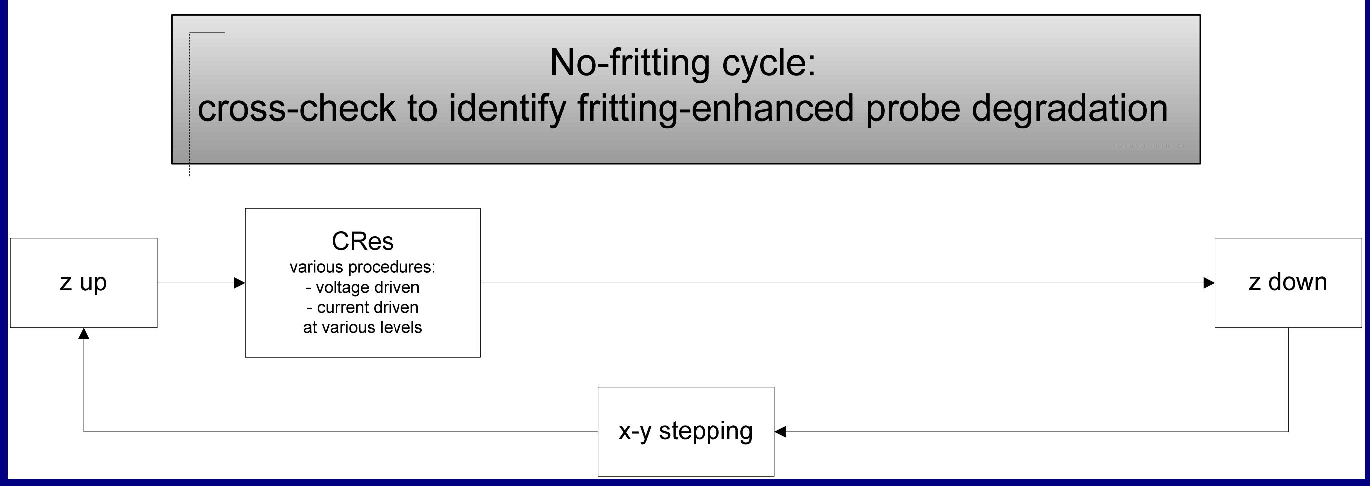


- susceptibility for degradation (contamination) depends on load, i.e., power dissipation or current across contact point
- CRes stability and fritting may vary between IO and power pins
- tests with low current values are more sensitive to poor contacts
- test applications need to be evaluated individually

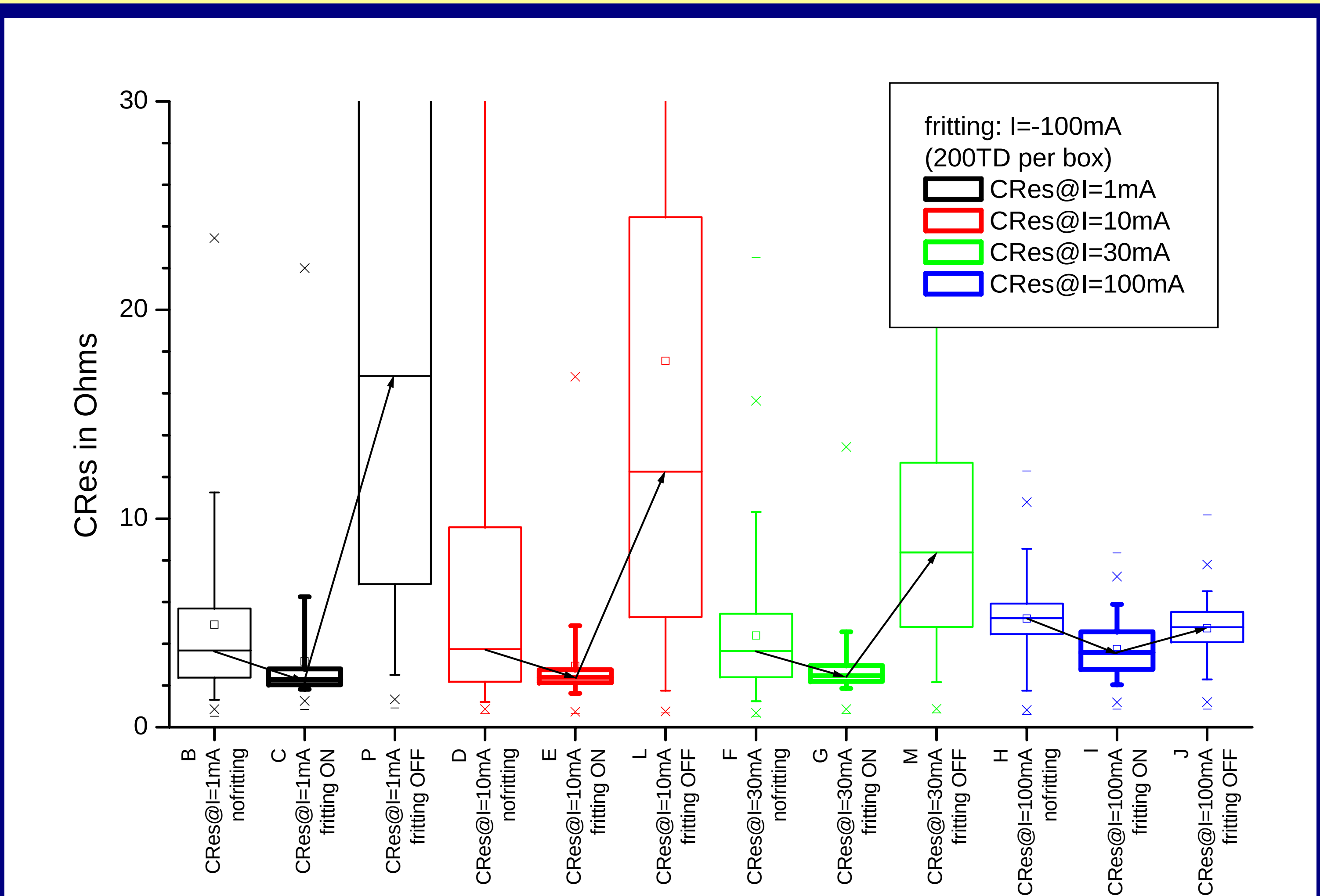
- Again very stable CRes ***2.0 .. 3.0 Ohms***
- Enhanced pollution is less significant if standard testing current is higher!

How significant is fritting enhanced contamination?
-> Comparison of fritting OFF / ON / OFF





Fritting OFF-ON-OFF:
contact conditioning and subsequent probe degradation



- fritting improves contact stability but makes probes 'addicted' to current
- negatives effects become negligible for higher testing currents (power pins)

summary / conclusions

FRITTING WORKS!

•A-fritting starts at voltages <2.5V (Tungsten-Rhenium on Al)

•B-fritting significantly lowers CRes
•currents >40mA required (with negative polarity)

•fritting makes ‘addicted‘: after turning fritting off, CRes is higher than before (current assisted contamination)

•amount of CRes improvement depends on current level during testing (operation) mode

☺ fritting is suitable to reduce CRes for power pins where negative effects due to enhanced contamination are less significant
😐 fritting very efficiently reduces CRes also for IO-pins – but probe cleaning / maintenance strategy must be adjusted accordingly in order to control enhanced contamination
☹ fritting cannot substitute online cleaning – but it can stabilize CRes in between cleaning executions

perspectives

FRITTING WORKS!

currently used in IFX production

- fritting used in several test programs but so far only limited productive experience
- application in front-end and back-end test
- observation of both, yield improvement and enhanced probe wear out

future tasks

- adjust fritting parameters according to new findings
- re-evaluate yield improvement vs probe wear out
- unified recommendations for test development groups

Thank you for your attention !