The value of material characterization in product development

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Philips Innovation labs

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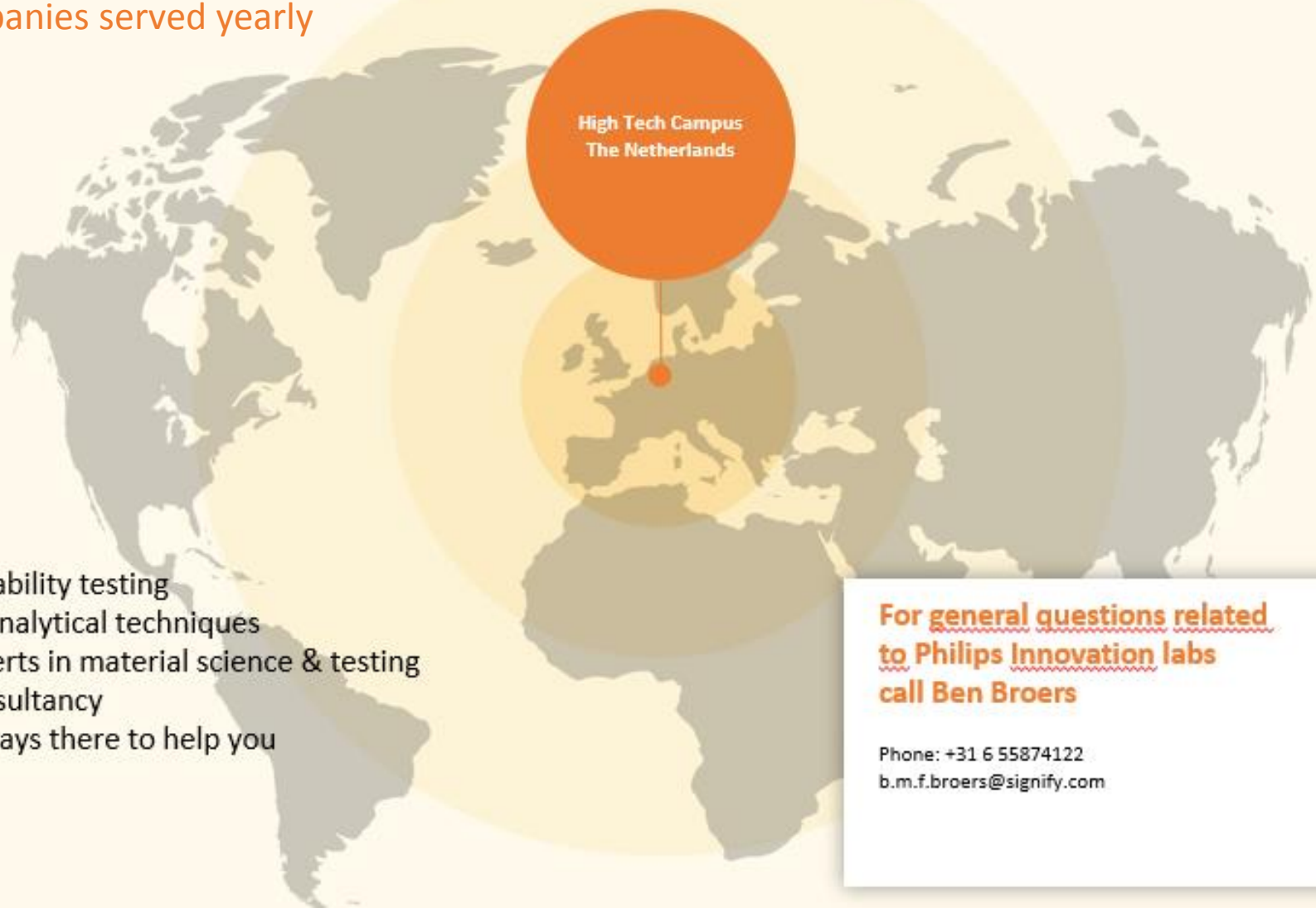
Local partner, **global reach**

>200 companies served yearly



- Reliability testing
- 35 analytical techniques
- Experts in material science & testing
- Consultancy
- Allways there to help you

For general questions related to Philips Innovation labs call Ben Broers

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Agenda

- Material characterization tools
- Examples material characterization in product development

  SEM-EDX, GC-MS, TOF-SIMS, FT-IR, µXRF
- Strenght of combining reliability testing & material characterization

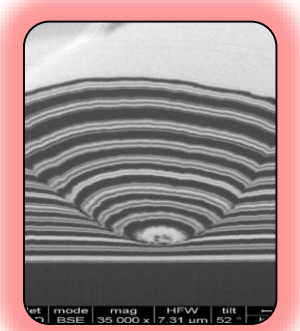
Overview material characterization tools

Ellipsometry, ToF-SIMS, XPS, XRD, Auger

Surface and thin-film

Atomic Spectroscopy, Elemental Analysis FTIR, Raman, GC, LC, NMR, XRF

Compositional analysis



SEM, TEM, FIB, XRT, AFM, profilometry, thermography

Advanced imaging

Particle size, BET, thermal analysis, rheology, mechanical testing

Physical characterization

Hot / Cold Storage, Damp Heat, Temperature Shock, Slow / Fast Cycling, Vacuum, UV Simulation

Environmental testing

Lifetime setup, Monitor (I/V/R vs time), Automated Power Supplies, Event Detection, PTC

Insitu Testing

HALT, MEOST

Reliability

Some examples of material characterization in product development

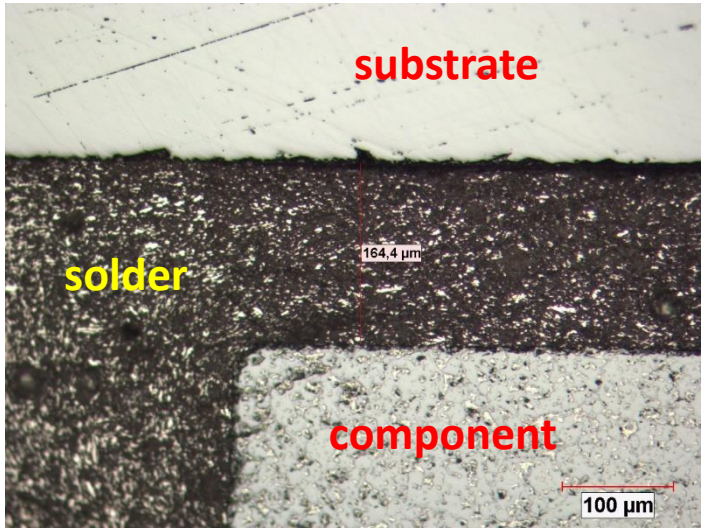
Interconnect thickness and composition control – electrical resistance increase

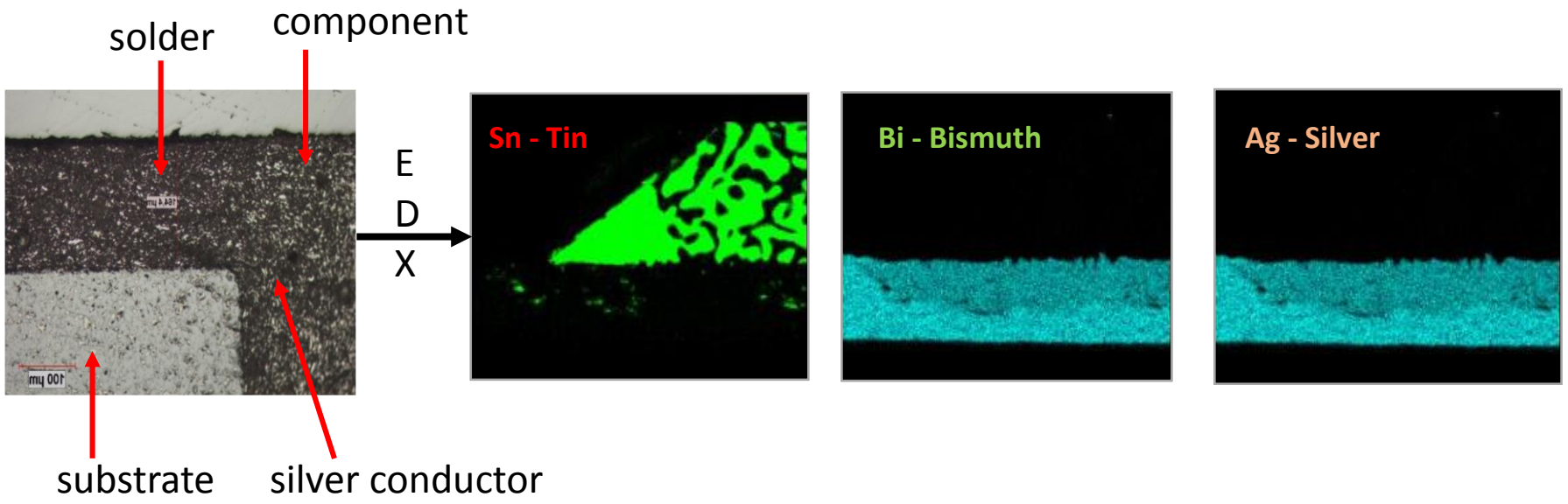
SEM-EDX (Scanning Electron Microscope)

- Compositional info (identification of elements & atomic %)
- Geometrical info (dimensions,..)
- Visual info (crack, voids, …)
- Magnification >100.000x

Backscattered electrons produce images with contrast that carries information on the differences in atomic mass
Secondary electrons give topographic information

X-rays are a *"fingerprint"* of each element; used to identify the elements that exist in a sample



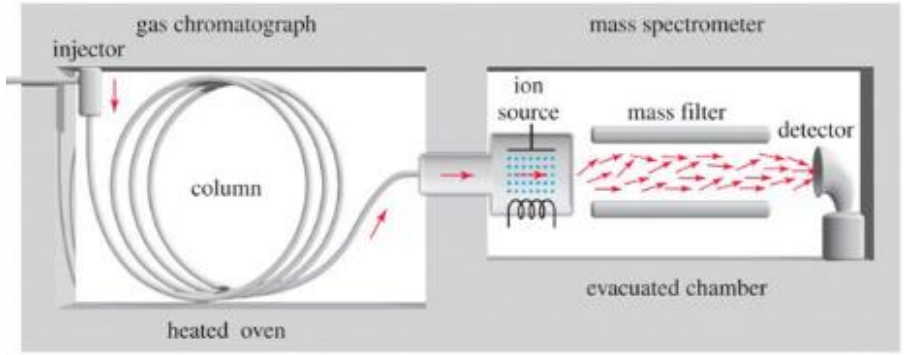


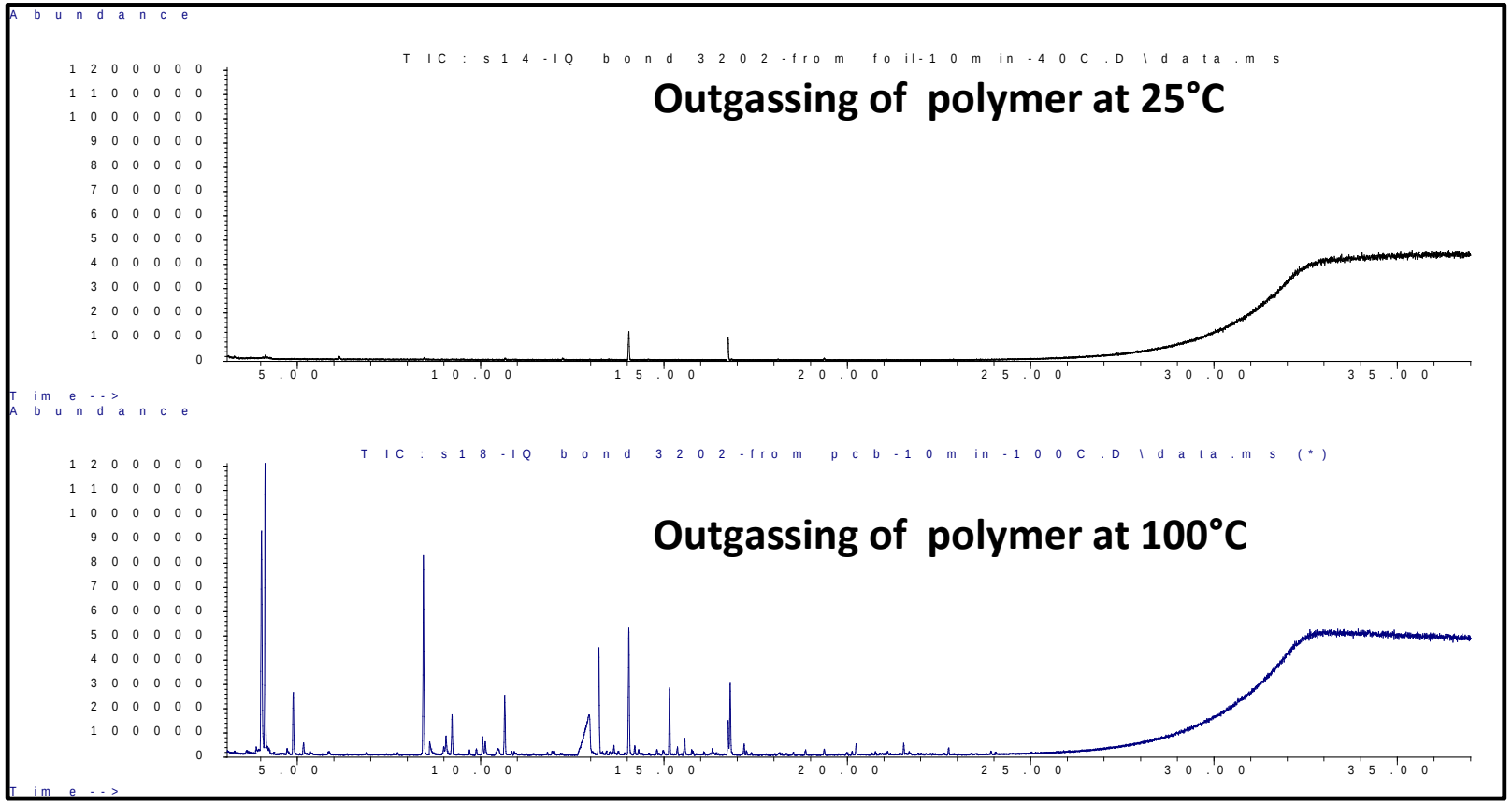
Polymer outgassing – unwanted deposition inside product

GC-MS

Gas Chromatography - Mass Spectrometry can separate, identify and quantify complex mixtures of chemicals

Degassed components during glue curing or product life can be measured





Very low outgassing glue at 25°C, only traces of silicon containing compounds (siloxanes) were detected.

The outgassing of the glue at 100°C:

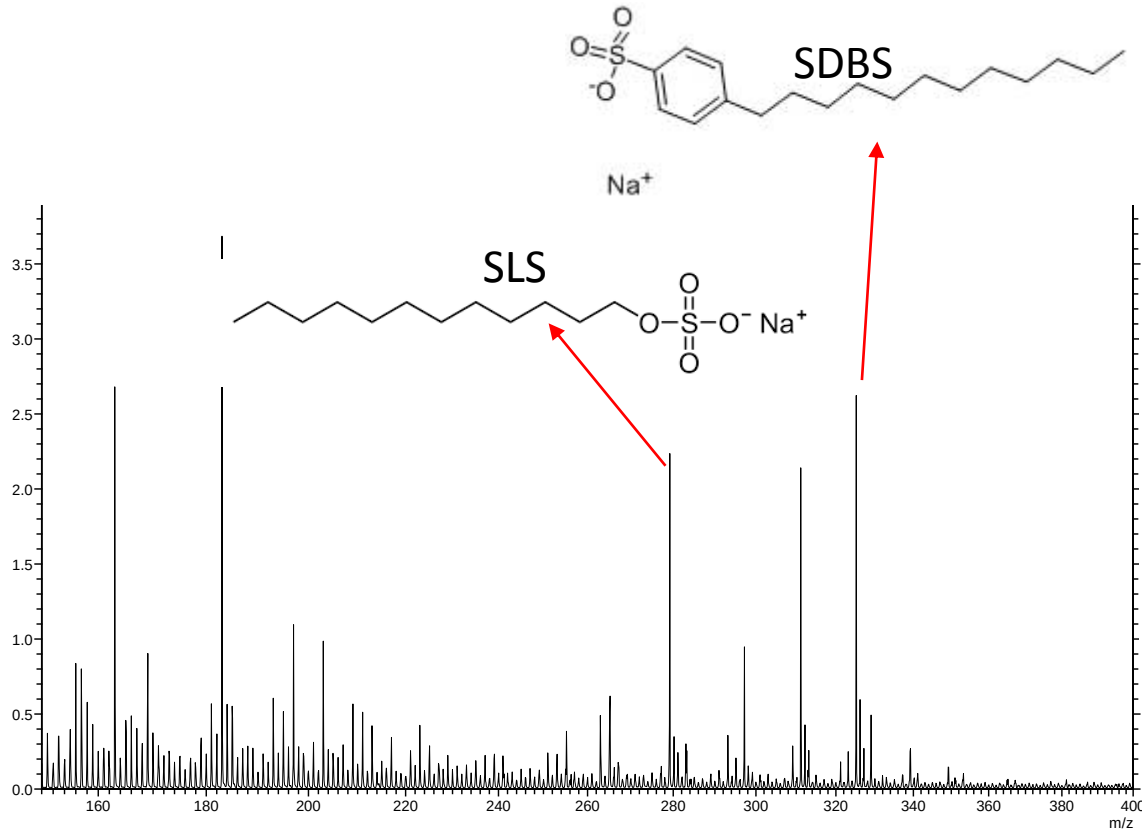
- solvents (e.g. 2-(2-ethoxyethoxy)ethanol)
- triethylphosphate (a flame retardant)

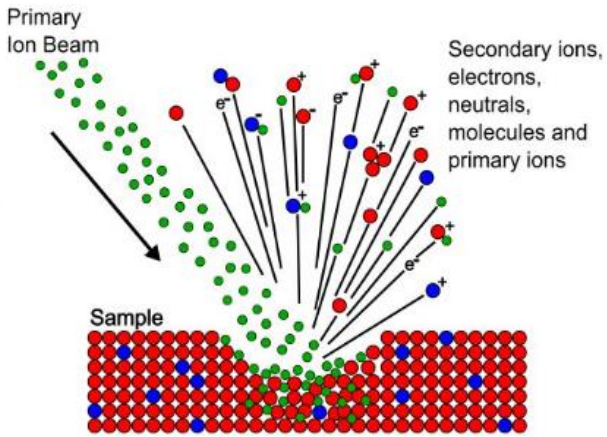
Surface contamination – adhesion problem even after cleaning

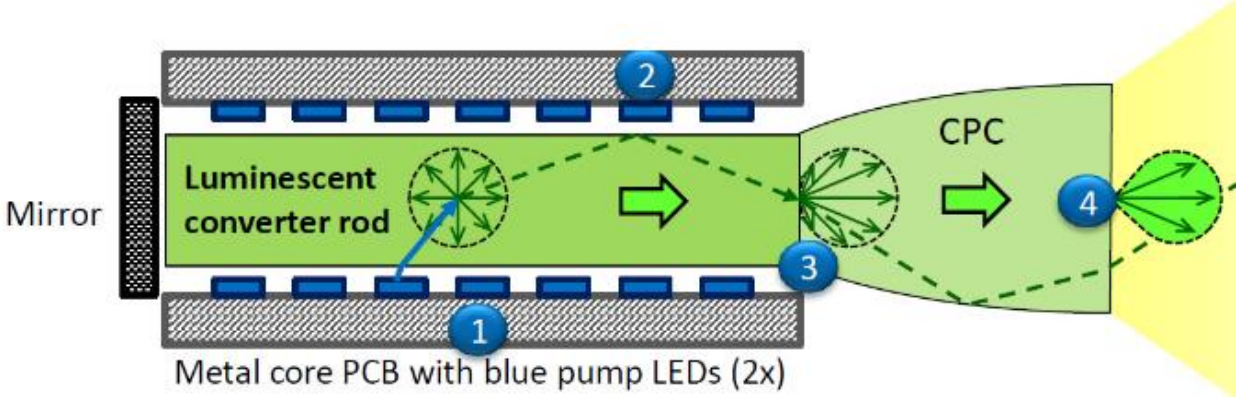
TOF-SIMS

TOF-SIMS provides molecular information from surfaces of solid materials

- Most sensitive surface analysis technique (ppm/ppb)
- Organic & inorganic contamination





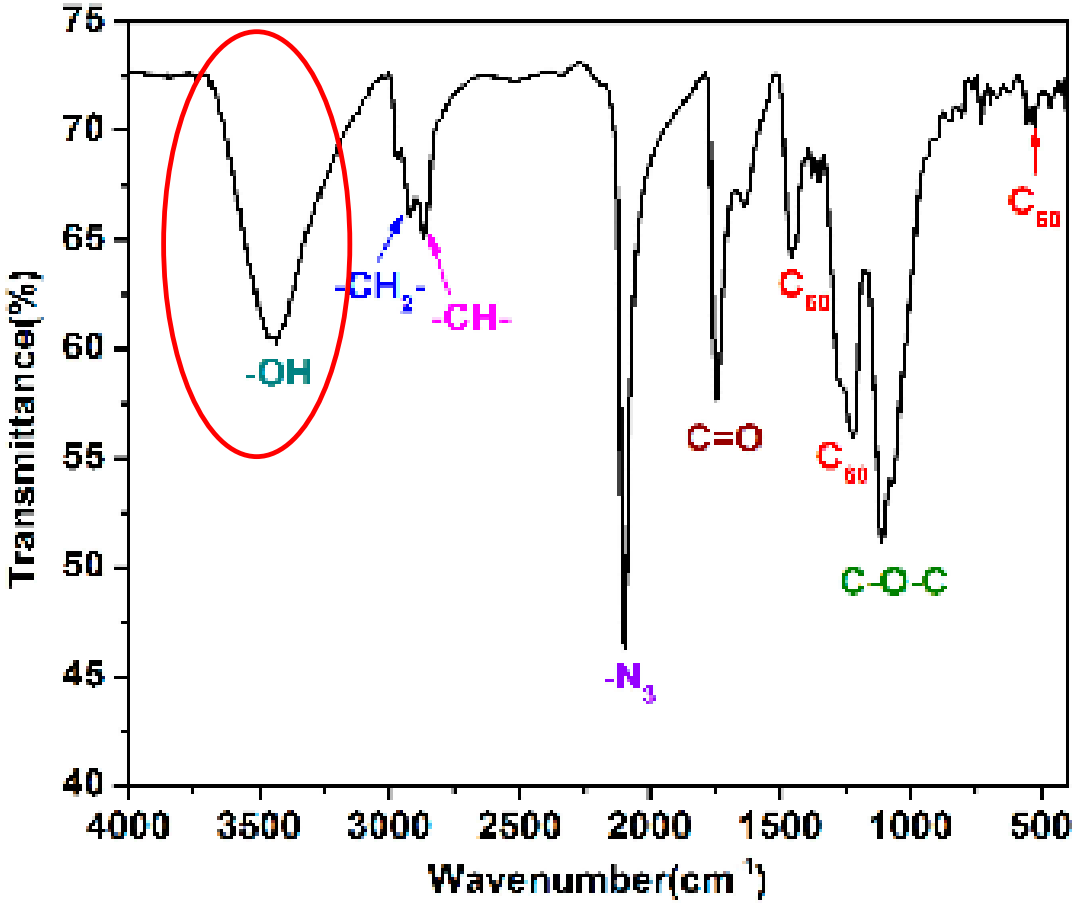


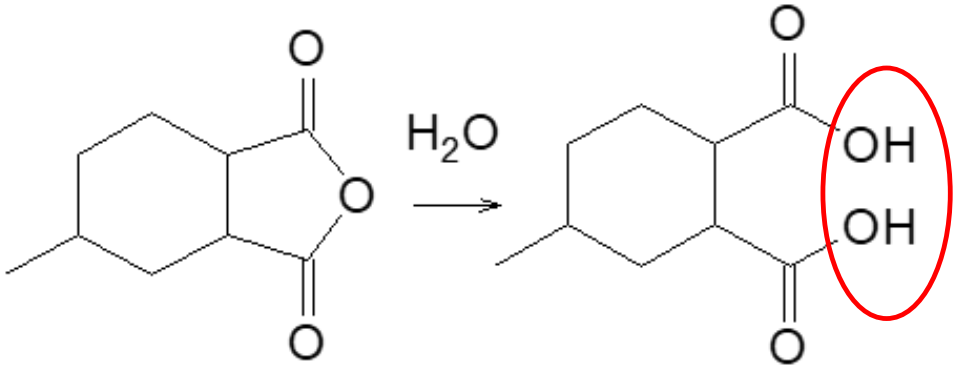
SDBS & SLS are surfactants present on cleaning wipes

FTIR

Fourier Transformed Infra Red spectroscopy

IR spectroscopy is the spectroscopic technique which uses the Infrared light and studies its interaction with the molecules. The spectra generated can give a lot of information about the molecule, especially about the functional groups associated.





*Epoxy **degradation** reaction*

Black electrical insulator layer – degradation @ high%RH

FT-IR

Functional parameter: Break Down Voltage (kV/mm)
Disadvantage : BDV test is a destructive test (large nr of samples needed / expensive)

It was discovered that the FTIR peak height at 1500cm-1 correlates to decreasing break down voltage

Sensitivity of %RH investigation with a damp-heat storage test two levels

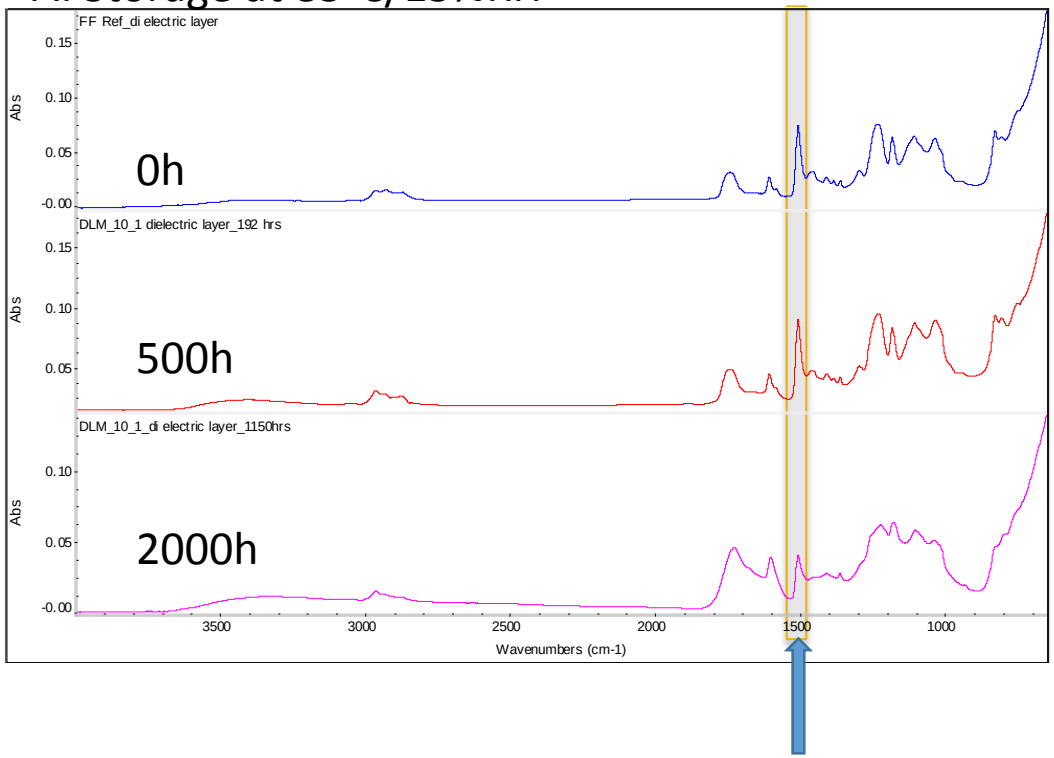
Test condition A: Storage at 85°C/15%RH

Test condition B: Storage at 85°C/85%RH

Black electrical insulator layer – degradation @ high %RH

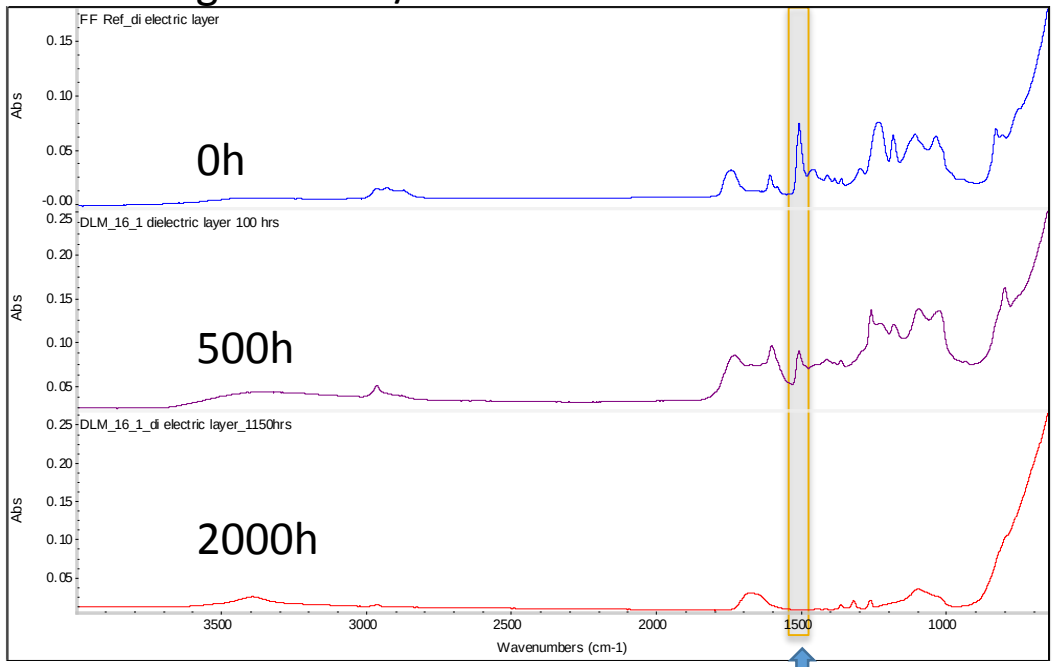
FT-IR

A: Storage at 85°C/15%RH



1500cm-1

B: Storage at 85°C/85%RH



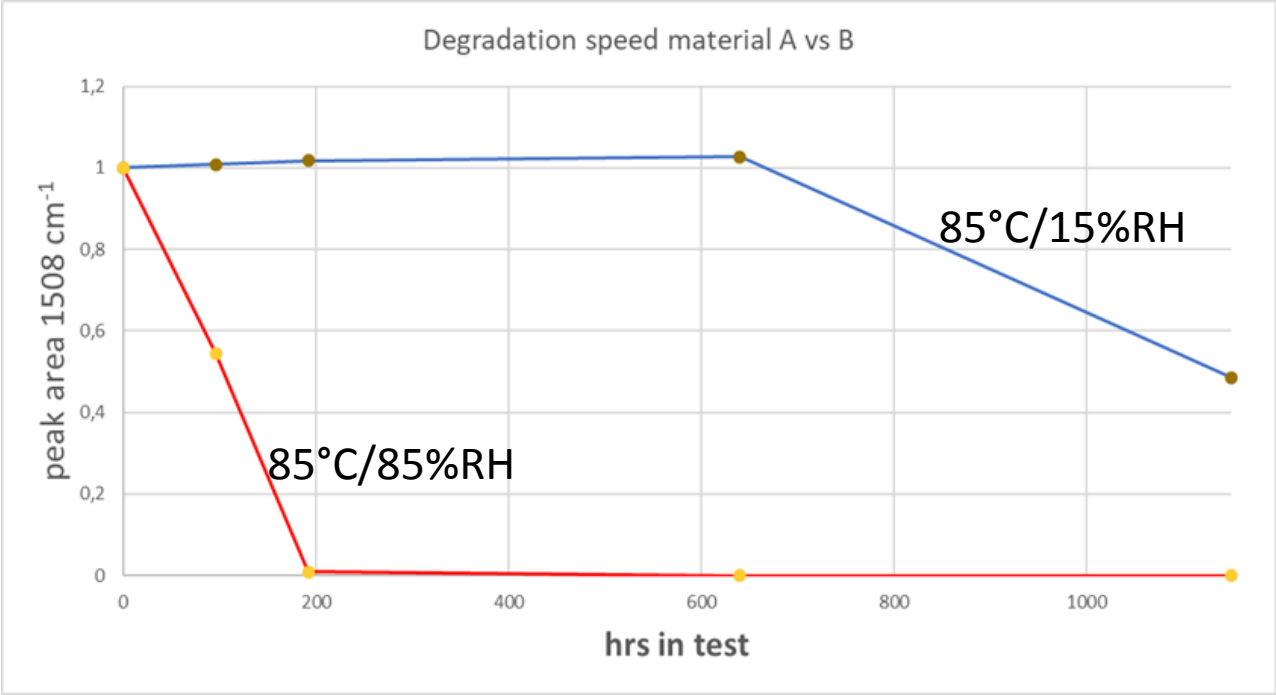
1500cm-1

- Peak height at 1500cm-1 decreases in time (= correlated to decreasing break down voltage)

Black electrical insulator layer – degradation @ high %RH

FT-IR

Plotting peak height 1508cm-1 against test duration

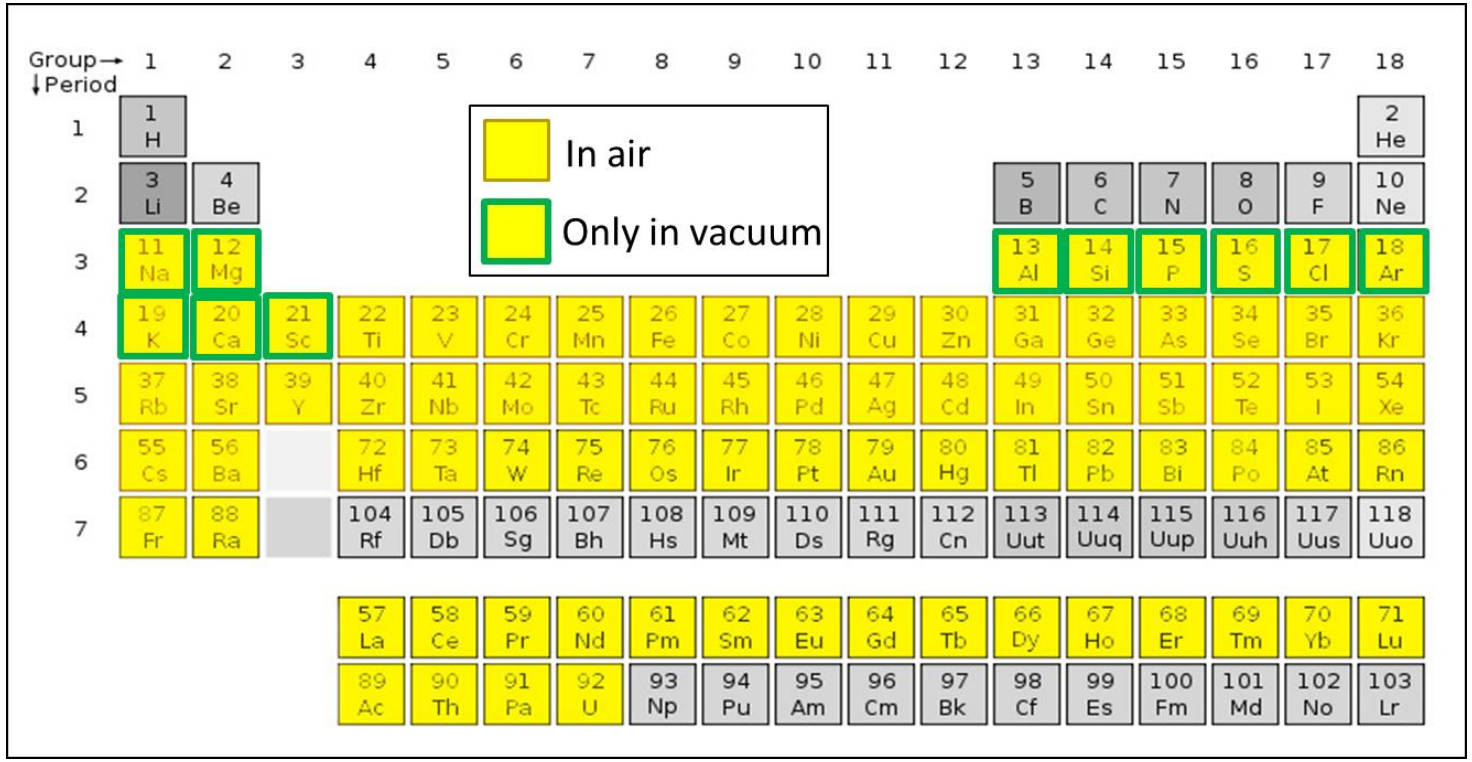


- FTIR / Raman can make degradation visible in an early stage
- Molecular understanding of chemistry leading to failure
- Input for modelling the application window / determination of acceleration factors

Micro-XRF

X-ray fluoresence

- Elemental analysis technique
- No / minimal sample preparation needed
- Non destructive

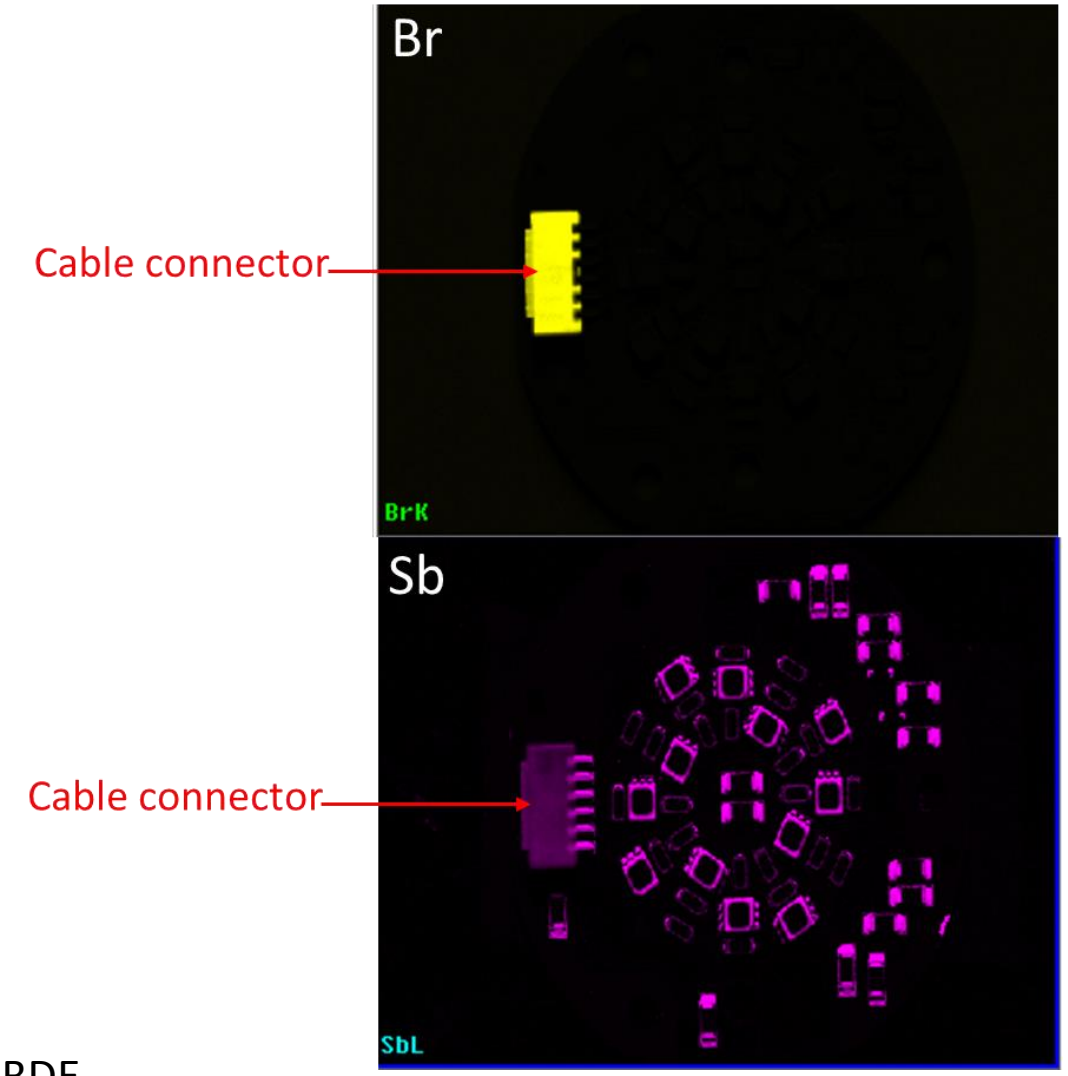


Restriction of Hazardous Substances (RoHS) – Check sourced BOM parts

Micro-XRF

The *Restriction of Hazardous Substances Directive* restricts the use of *6 hazardous materials* in electronic equipment

RoHS restricted substances	Limits
Lead (Pb)	1000 ppm
Mercury (Hg)	1000 ppm
Cadmium (Cd)	100 ppm
Hexavalent chromium (Cr6+)	1000 ppm
Polybrominated biphenyl (PBB)	1000 ppm
Polybrominated diphenyl ether (PBDE)	1000 ppm



PCB mapping of RoHS elements (Br and Sb)

PBB and PBDE are flame retardants and contain 50-85w% Br.
Br in combination with Sb is an indication for the presence of PBB or PBDE

Reliability tests & material characterization

- Feedback loop to material characterization enables identification of failure mode & to follow the degradation process in time *(determination of acceleration factor using multi level tests)*

- Prediction model for degradation speed

- Damp-heat test
- Temperature shock test
- Temperature cycle test
- UV / light radiation
- HALT
- Salt-mist test
- Humidy-freeze test
- IP testing
- Chemical resistance test

operational & non operational

The value of material characterization in product development

Lower risk for:

- Delay in market introduction / product release
- Product quality & reliability issues
- Last minute BOM changes
- Cost uplift
- Supplier “issues”
- …..

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