ALD
Atomic Layer Deposition
for space applications

PCB-Assembly protection

Dr. Marko Pudas 10/2018

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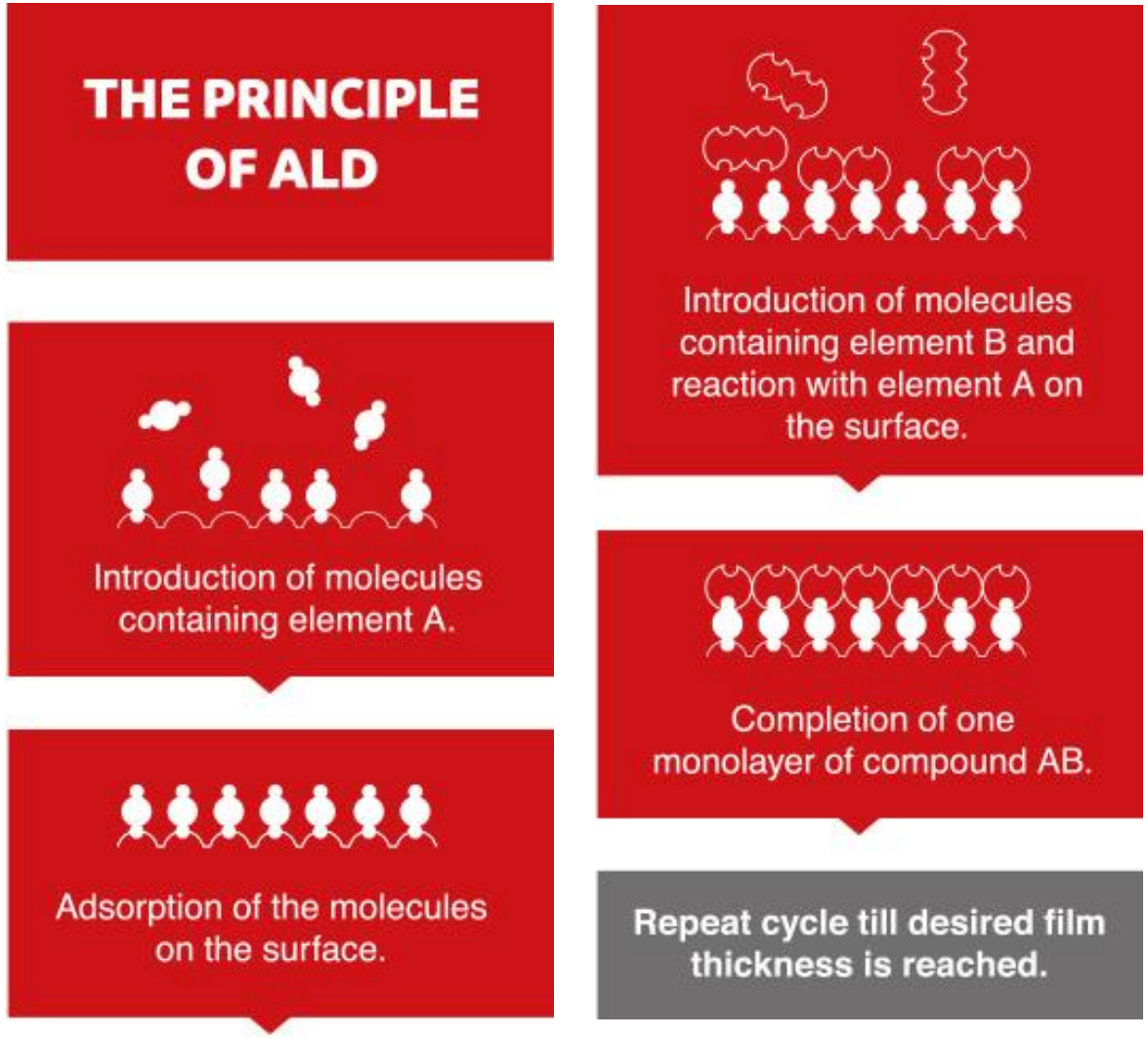
Workshop on High End Digital Processing Technologies and EEE Components for Future Space Missions, 1 October 2018, ESTEC, The Netherlands

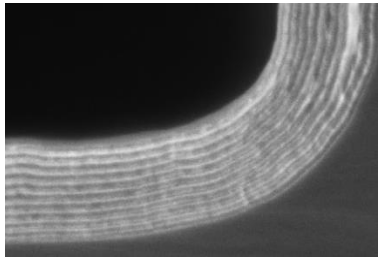
ALD – Atomic Layer Deposition

- Is a batch coating process with surface chemistry
- Wide range of material, e.g. Al_2O_3, TiO_2, M-, M-C,M-N
- Typical; **100 nm** up to ~0,5 µm
- True 3D down to nanopores, no pinholes
- **Vacuum** deposition process
  - Substrates are degassed & heated (degas analyzed)
  - ~40 C – **125C** – 400 C
- Mature IC manufacturing process
- Extremely repeatable in thickness & quality over time
- Chemically adhesion; will not peal off/flak
  - Dense,
  - Pinhole- and defect-free films
  - Digitally repeatable process

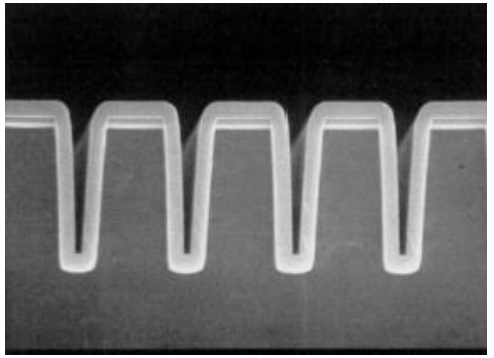


Benefits of ALD for different areas on space application

THIN FILM GROWTH BY CONSECUTIVE ATOMIC LAYERS



- Tin whiskers mitigation; Main objective for ongoing ESA-funded activity
  - Reworkable: Components can be changed and the substrate re-coated
- Corrosion protection; ALD or PVD+ALD – most durable corrosion resistance; *670 h/salt spray*
- Excellent gas & moisture barrier; 4 x10^{-5} g/m^2/d, (PEN/PET ~10^{-1} g/m^2/d);
  - Can be used for Sulfur & Creep Corrosion barrier, now used for coins; Creep corrosion or similar test needs ?
  - Prevent oxidation (of e.g. mirrors)
  - Degas COTS plastic packages / boards -> ALD coat -> No moisture intake, nor release
  - Tests to be carried out soon at ESTEC; any proposal for components and requirement?
  - Prevent gas leak from fuel/gas containers



- Optical filters, mirrors-layers, black-surfaces (~100 nm thickness)
- Possible mitigation of surface charging with (weakly) conductive transparent conformal coating

Widely applied for e.g. in IC industry, corrosion protection, moisture barriers…

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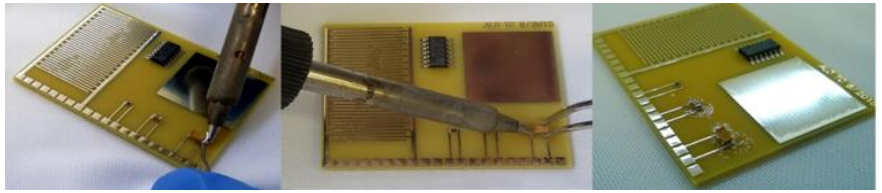
PCBA protection by ALD

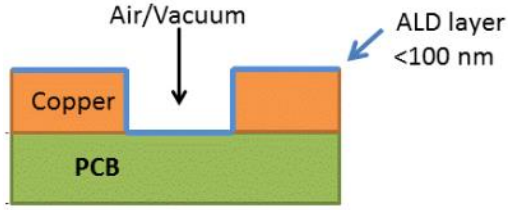
Conformal PCB assembly coating with a difference

- Blocks tin whiskers*
- Excellent moisture (&gas) barrier
- Corrosion barrier even against some liquids

- Can be reworked
- Can be patterned



  - and in some cases not needed for patterning for contacts
- Can be combined with other methods
- Ensuring high surfaces insulation resistivity, no RF changes
  - Obtain higher environmental reliability with even while decreasing conductor spacing (decreased side)
  - With "~0 added weight"

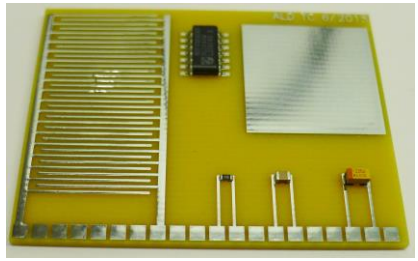


* Tin whiskers growth prevented in model substrates, see later

Atomic Layer Deposition for conformal coating of PCB assemblies and components

esa - funded; Evaluation of Atomic Layer Deposition (ALD) Conformal Coating to Mitigate Tin Whiskering - 4000113005/14/NL/PA, 2015

- Testing and validation planning of ALD for complete PCB(A) conformal protection
- 1st stage has demonstrated *
  - **Mitigation** of tin whiskers
  - **Conformal** applicability ALD for PCBA, >80 V breakthrough voltage;
    - *even higher voltage with increased layer thickness; Reworkable*
  - Deposition and testing **processes** were evaluated; best in use, ALD tool available



esa funded; Atomic Layer Deposition for Tin Whiskers Mitigation and Cure on Space Electronics Manufacturing (4000122745/18/NL/LvH/gp), 2018

- 2nd stage started 1/2018 *
  - Verification of 1st stage experiment & Route planning to establish validation of ALD coating for suppliers
  - Testing of ALD-encapsulation of plastic packages for space use and increased lifetime in ambient
  - Test boards with relevant space grade AND off-the-shelf components (polymer packages)

What are your critical components to be validated? Your required test board?

Parallel B2B projects have stated for automotive, medial…

* In collaboration with Loughborough Univ. and Poltronic

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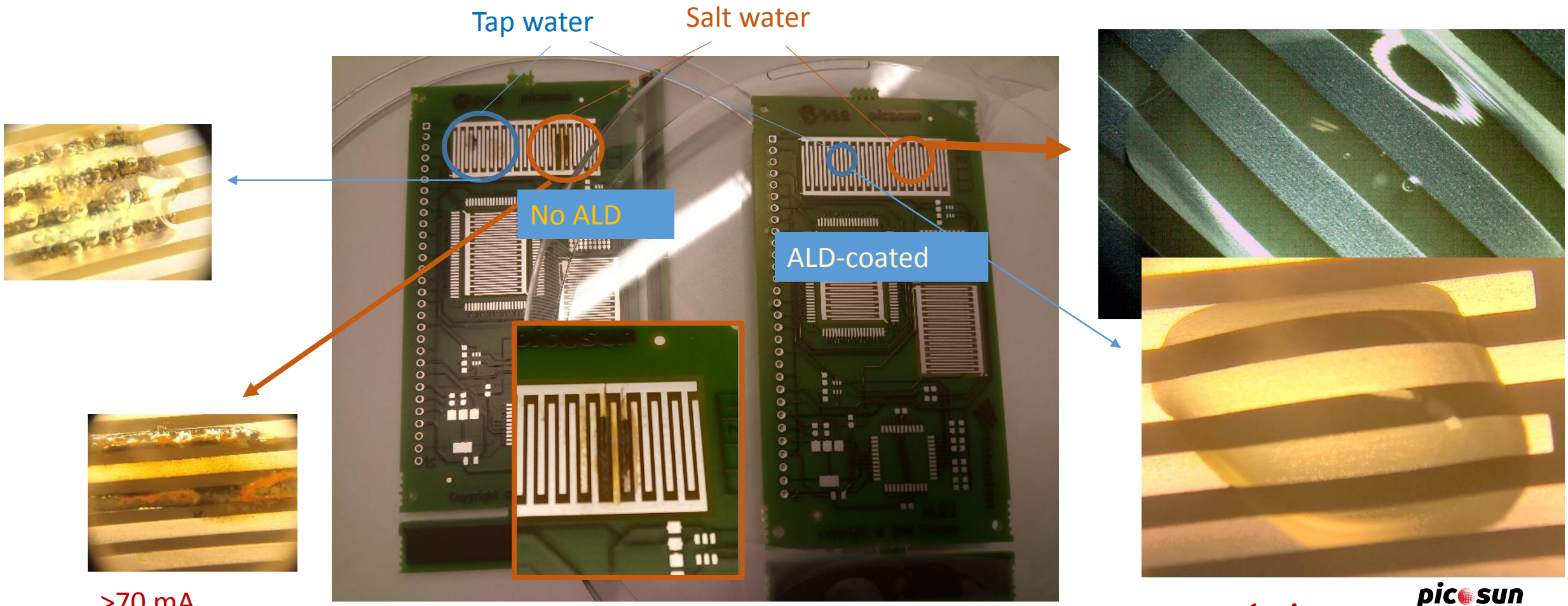
ESA-funded; Atomic Layer Deposition for Tin Whiskers Mitigation and Cure on Space Electronics Manufacturing (4000122745/18/NL/LvH/gp), 2018

BIASED CORROSION

Drop of salt water on *1mm*-Ag coated electrodes, 3.3v bias



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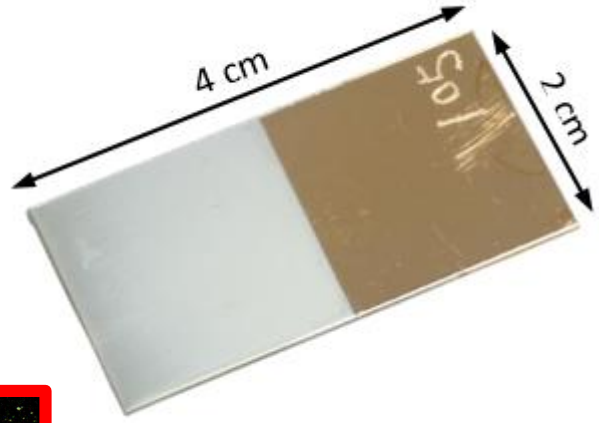
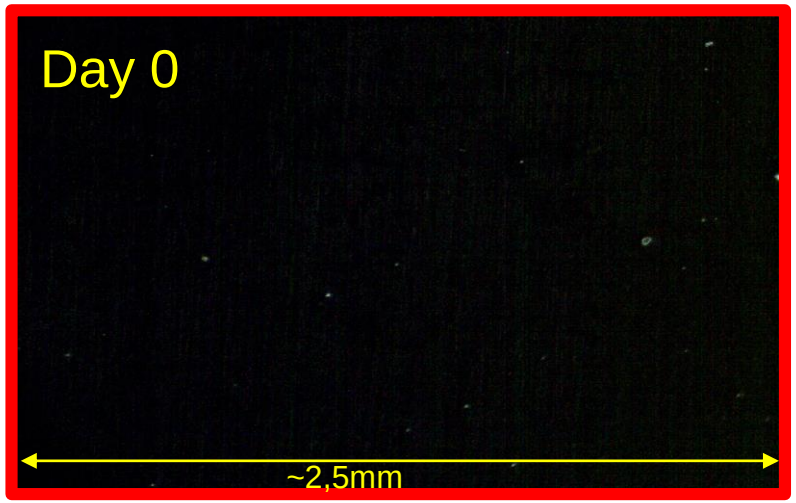
ACCELERATED SN-WHISKERS GROWTH PROCESS

ALD prevents the growth

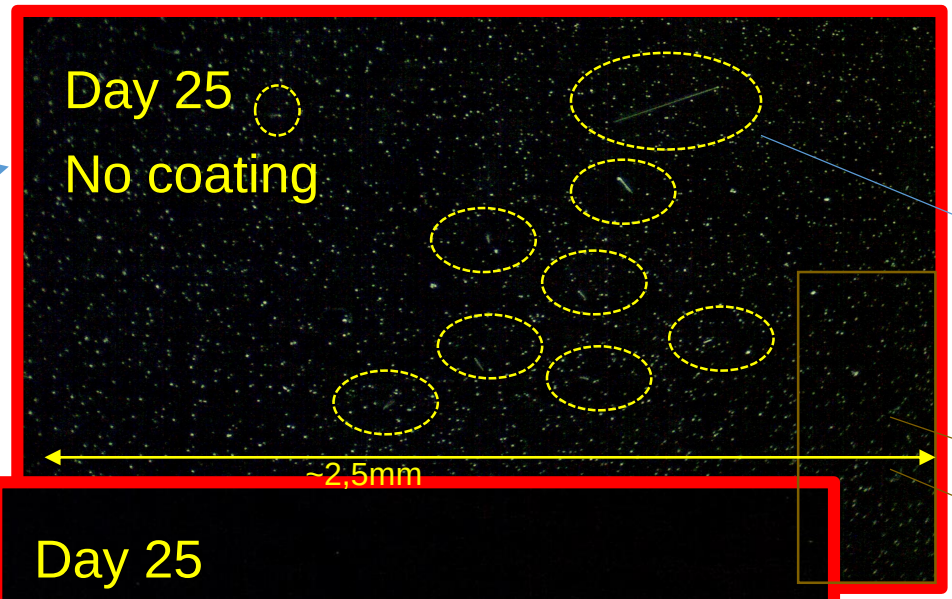


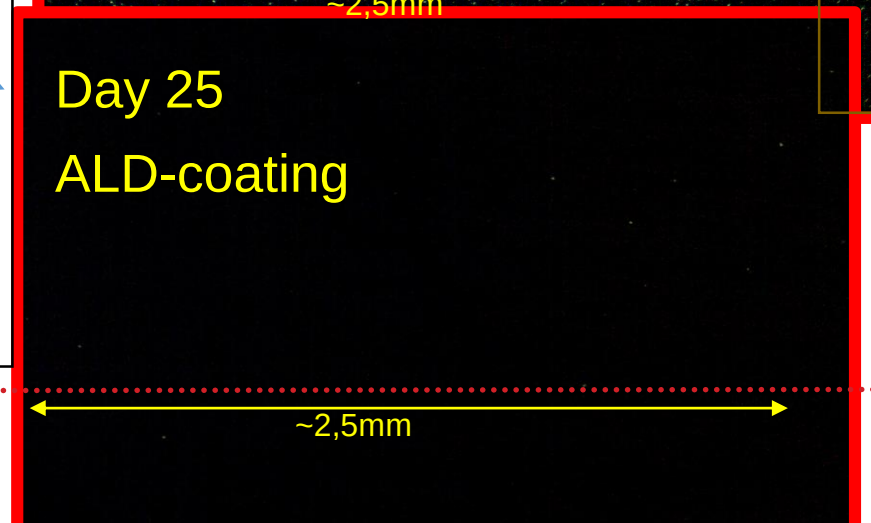
After electroplating;

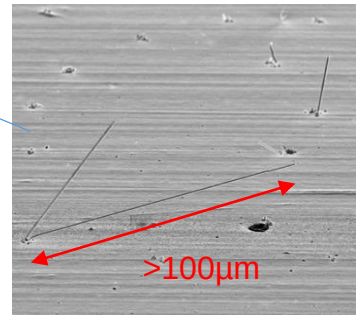
Only ‘dirt particles from plating’



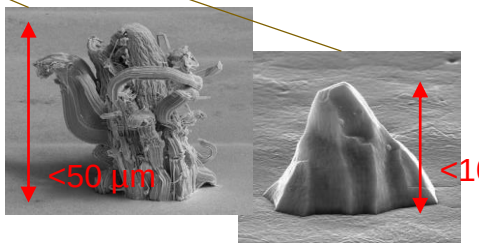
Whisker density (cm-2)
100-1000
0







Tin whisker



Eruption, Hillock/nodule formation

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How to do it

Roadmap

Tool examples

P300; 27 x 27 x 27 cm3

(other, **P1000**; diam 60cm, h70 cm)

- Tin whiskers mitigation preliminary demonstrated and evaluated, now repeating experiment using a wider test matrix
  - Equipment available
- Plastic package encapsulation now demonstrating
- 3rd Phase; Validation
  - Validation planned, expected to start in ~1 year
  - Real (Flight representative) PCBs for validation – proposals for boards / components? Interested partners?
  - Parallel use for down to earth applications (reliability), aka. industrial drivers – We are searching partners!
- Demonstration / development now in process; next (e.g. EMS) collaborator, who can provide the coating service *(should be requested by 'OEM')*

Quick questions?

More detailed discussion & material tomorrow
2nd Oct. (pref. before noon)

Marko.Pudas@Picosun.com

Thank you!

MAIN HEADQUARTERS
Tietotie 3
Micronova building
FI-02150 Espoo
Finland

Phone: +358 50 321 1955
Fax: +358 9 297 6116
E-mail: info@picosun.com
Web: www.picosun.com

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