



Improving seed layer adhesion and reliability through RIE pre-treatment

Evatec AG, Switzerland:

Scientist Mohamed Elghazzali, Roland Rettenmeier and in cooperation with GS Swiss

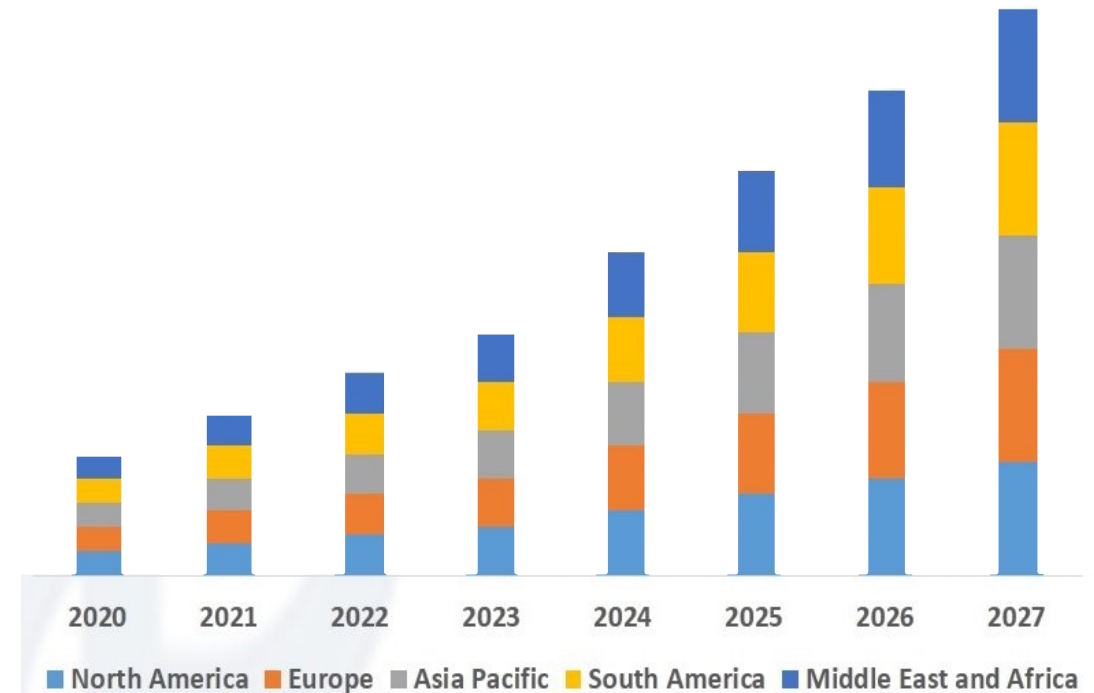


WIRELESS IMPLANTABLE MEDICAL DEVICES

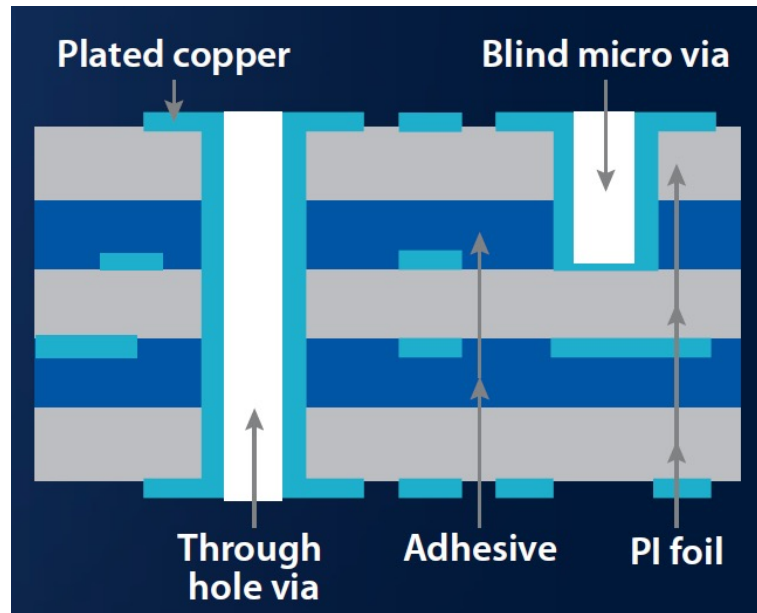


Source: MIT

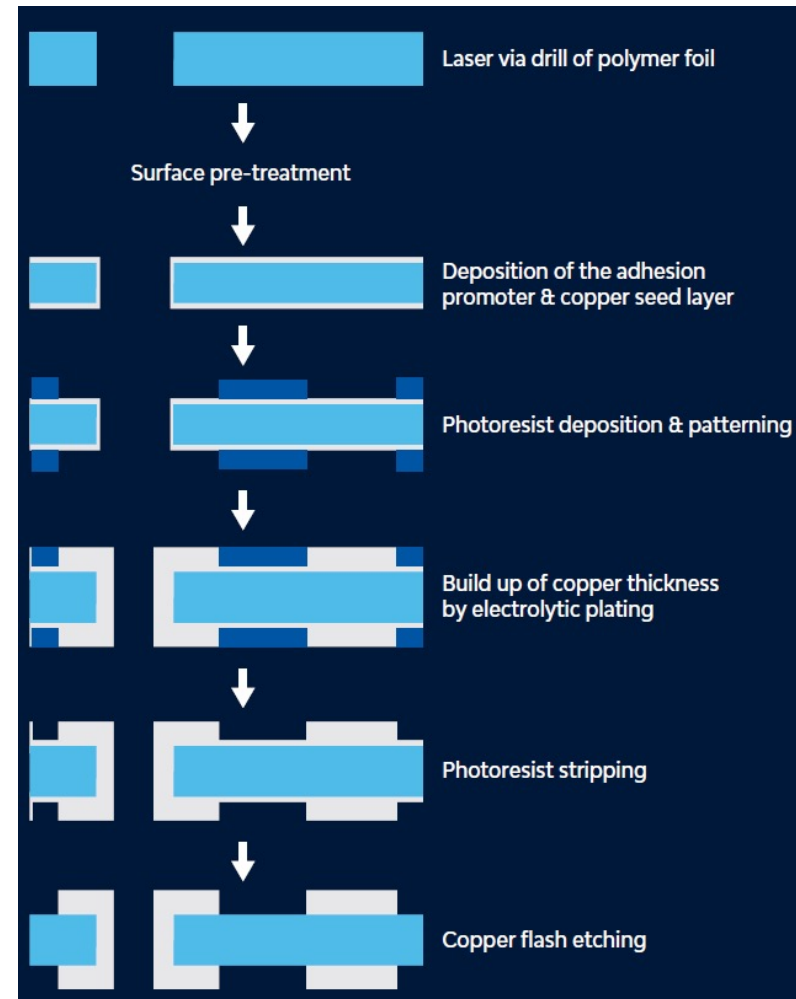
Expected to Account for USD 38.86 Billion by 2027



Source: Data Bridge Market Research Market Analysis Study 2020



The cross section of a typical flexible PCB structure



“Semi-Additive Process” (SAP)



**Handling
Unit**

**RIE pre-
treatment I**

**RIE pre-
treatment II**

Degassing

**PVD
adhesion**

PVD seed Cu

**Clusterline© 600
for Panel
processing**



SURFACE TREATMENT AND FILM DEPOSITION

Degassing

Emissivity independent

Precise temperature control

N2 laminar flow

Choose the right temperature and Time

RIE pre-Treatment I+II

Cleaning the surface

Removing native oxides

Polymer surface activation

Choose the right chemistry

PVD Sputtering Adhesion layer Cu seed layer

Enhanced layer adhesion

Lowest Rc in the industry

Low resistivity Cu seed layer

Low surface damage

- ✓ Low roughness, no surface damage
- ✓ Pristine polymer surface and remove contaminants
- ✓ Polymer surface activation to increase surface energy

THE SUCCESS FACTORS FOR GOOD DEGASSING

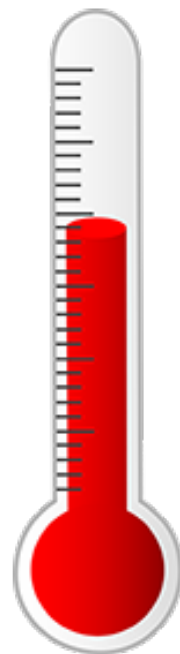
Degassing

Emissivity independent

Precise temperature control

N2 laminar flow

Choose the right temperature and Time



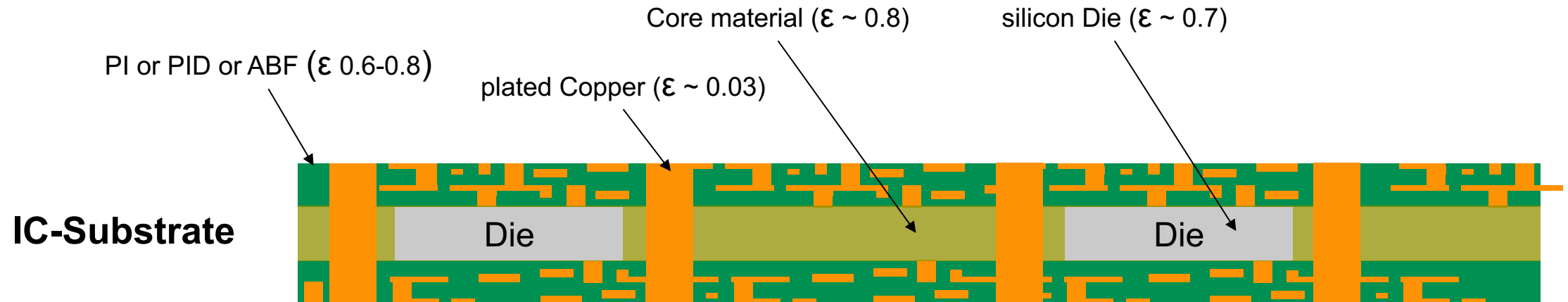
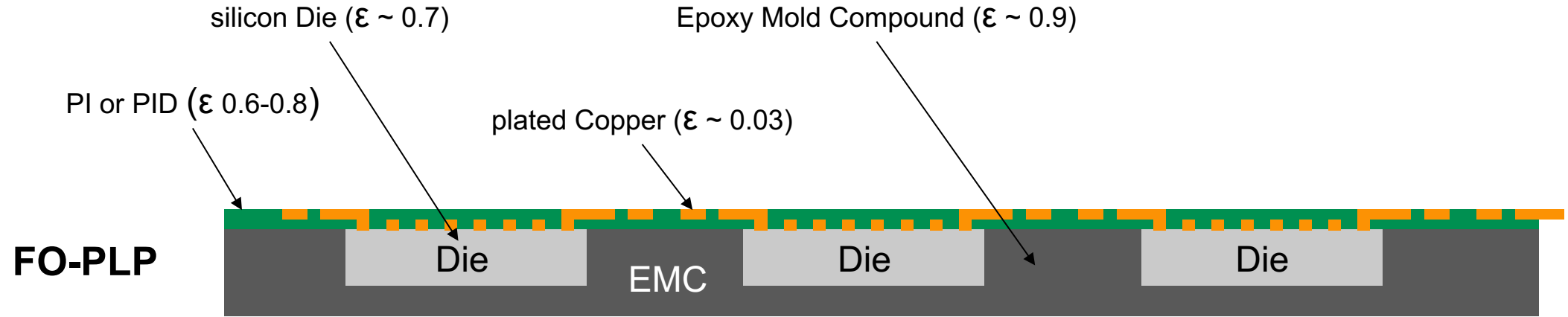
**precise
TEMPERATURE
control**

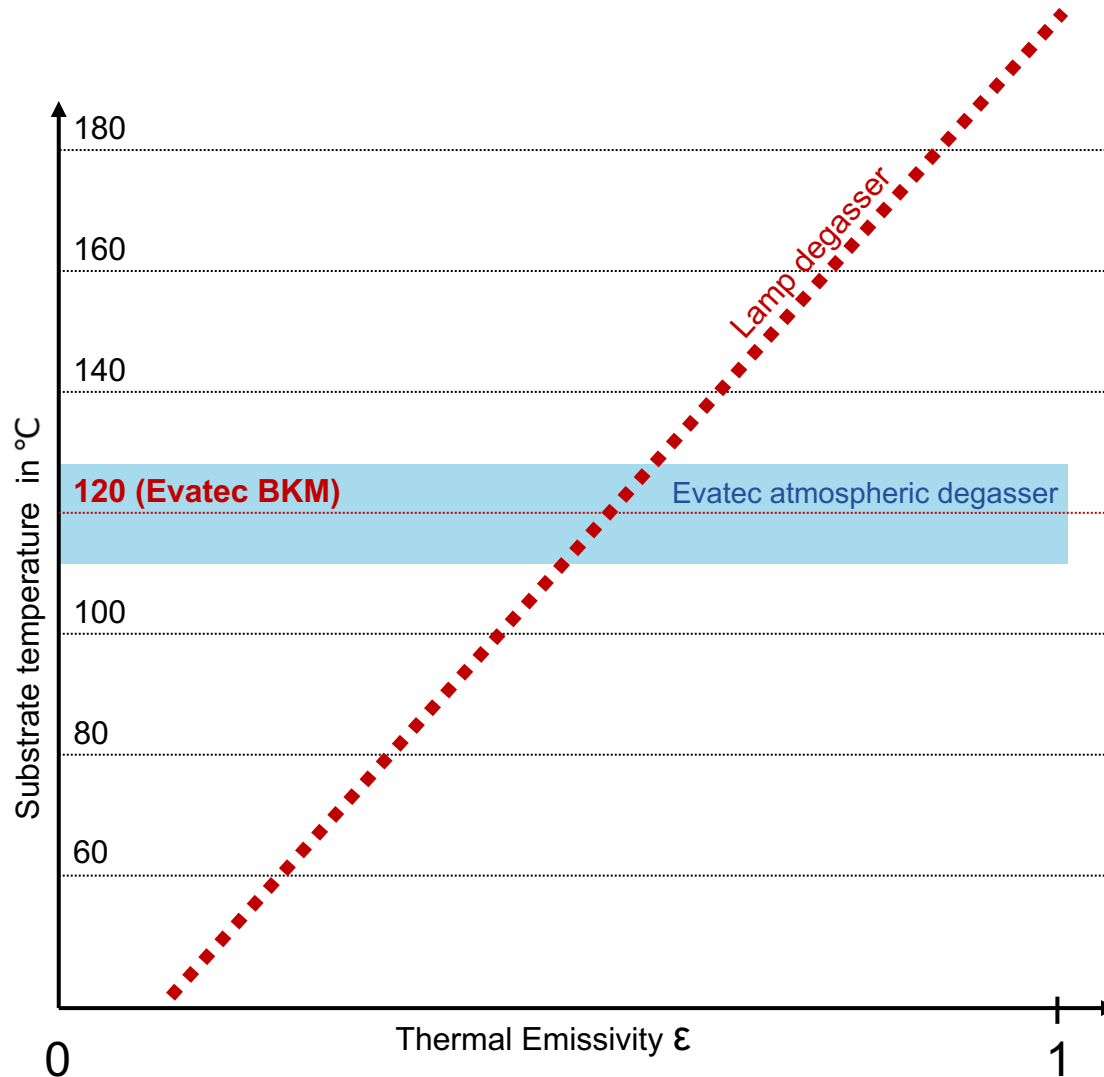
&



TIME
0.5 - 1 hours







No temperature control due to emissivity mix with lamp degassing

- Lower emissivity → cooler → no degassing !
- Higher emissivity → hotter → hot spots !
- Surface recontamination

Substrate temperature range (120°C $\pm$ 10°C)

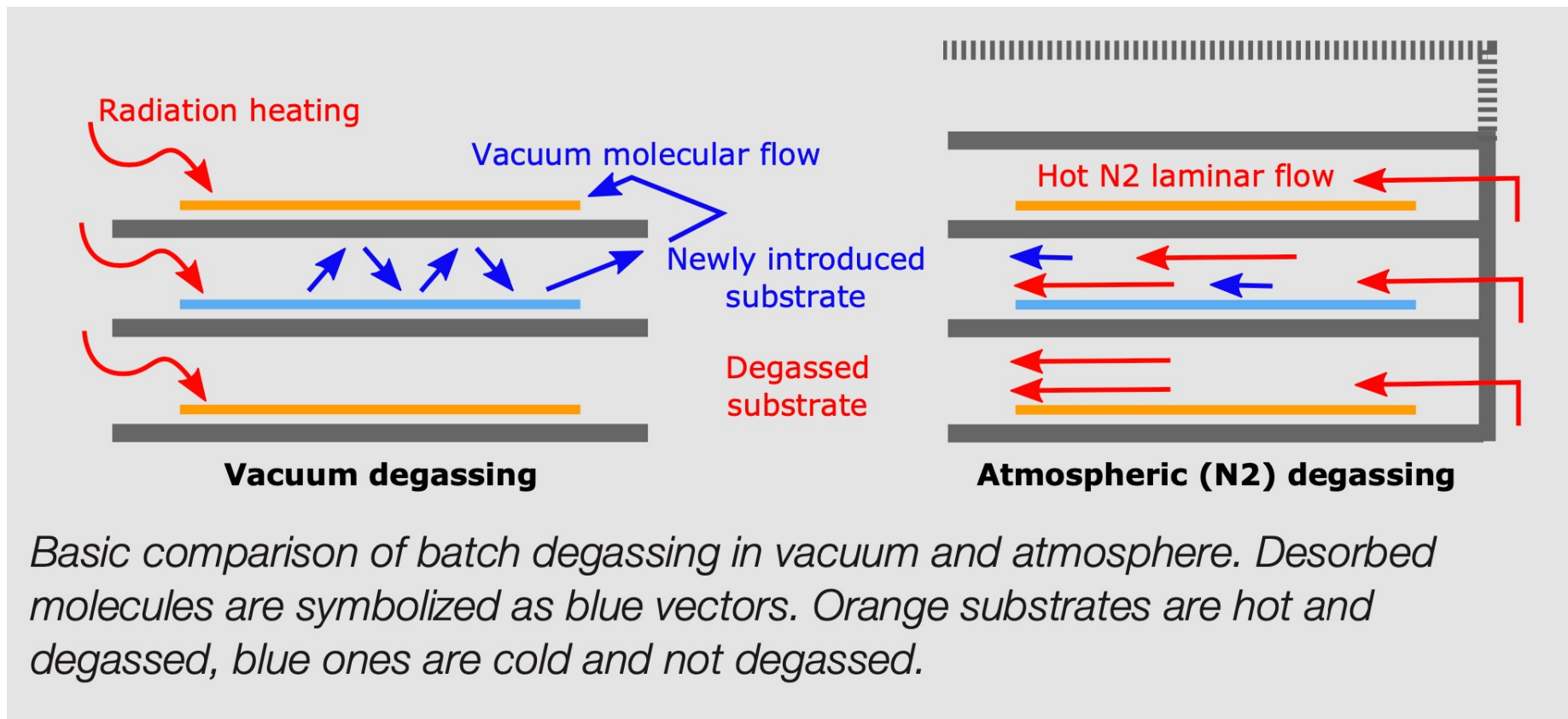
with **evatec** atmospheric degassing

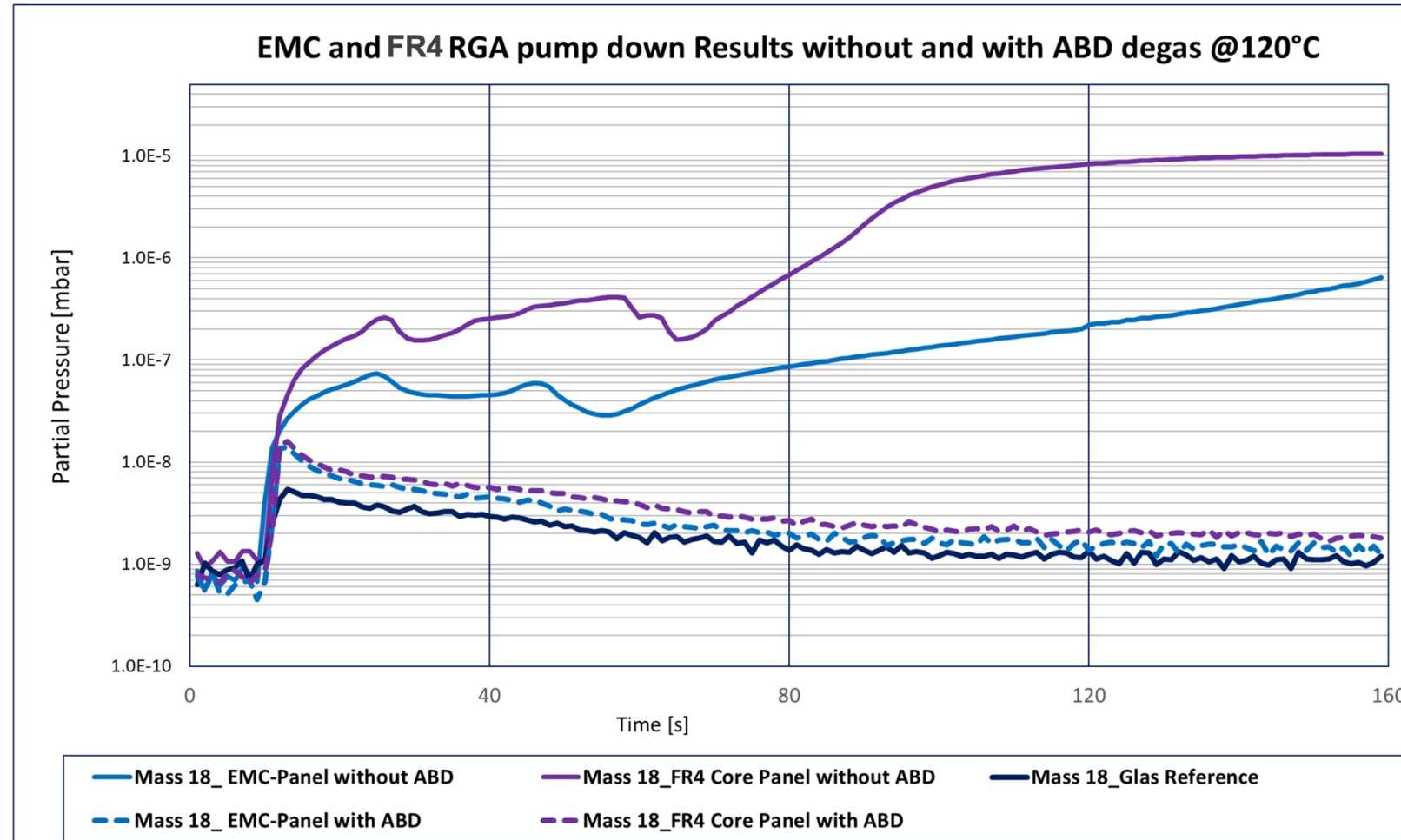
- Emissivity independent temperature control
- Volatile component pumped out



Every Substrate has it's individual N2 laminar flow.

- for transporting the degassed volatiles and moisture to the exhaust
- for avoiding “crosstalk” between the substrates

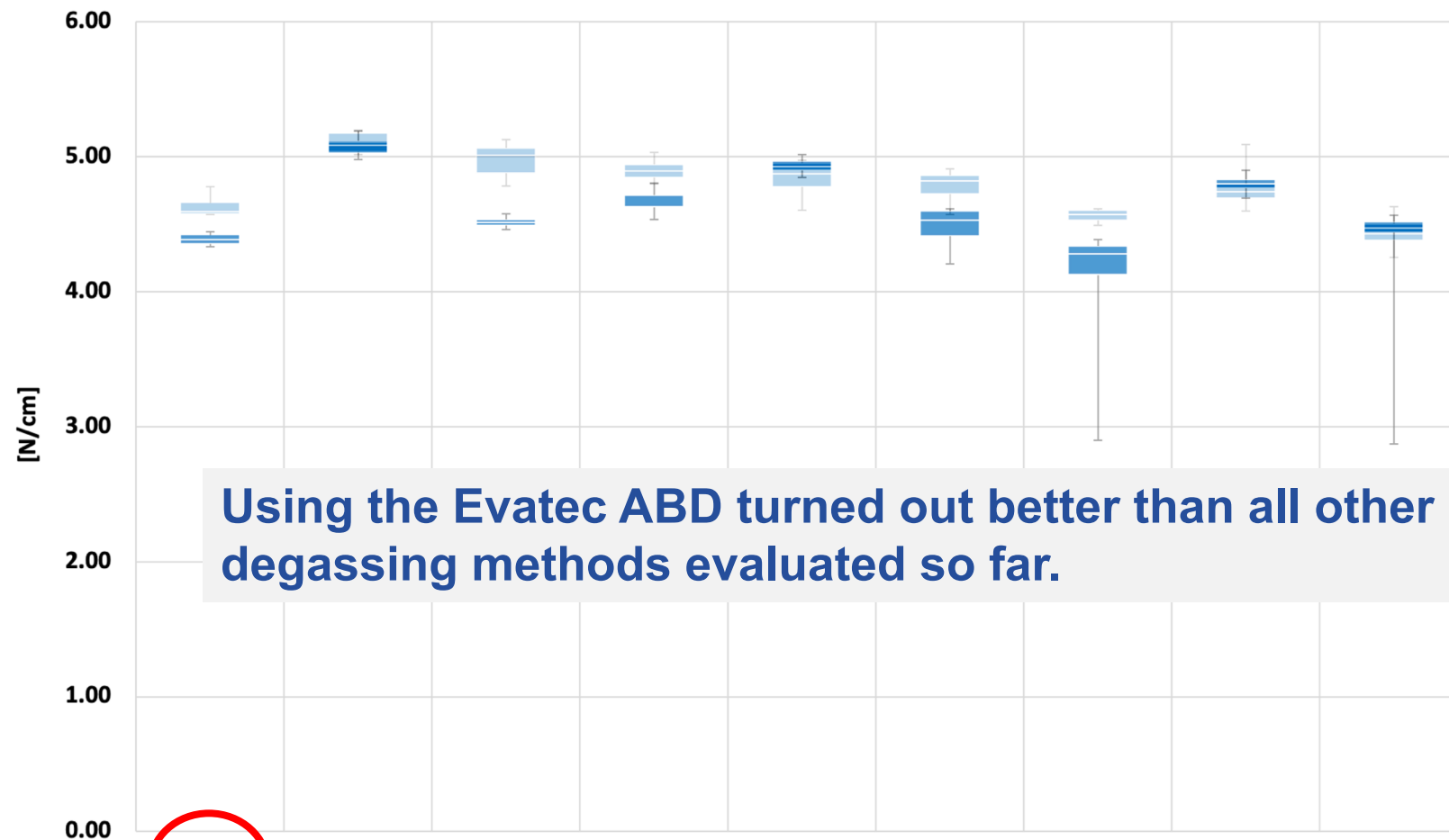




Mass 18 = H₂O



boxplot - peel force mean values



VBD

ABD experiments with different settings, different pre-treatments and adhesion layer.



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Emissivity independent

Precise temperature control

N2 laminar flow

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RIE pre-Treatment I+II

Cleaning the surface

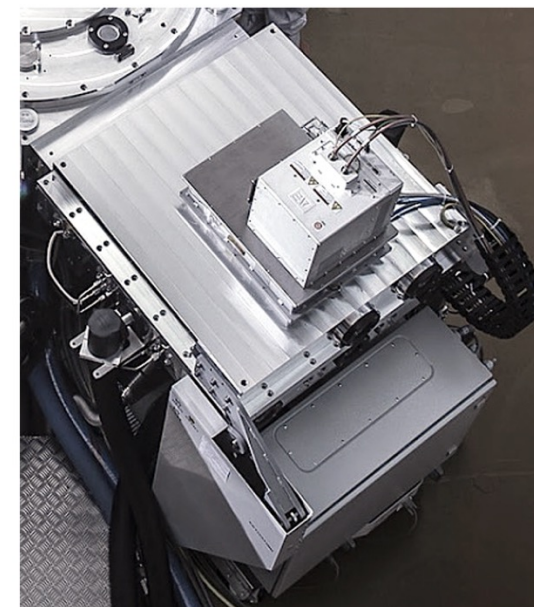
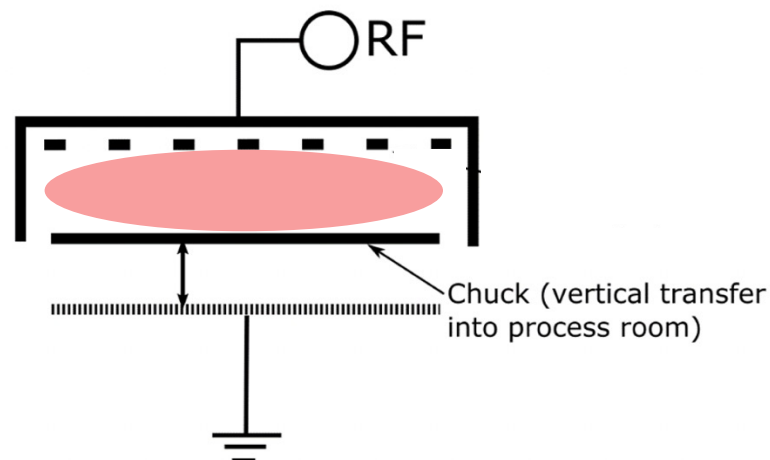
Removing native oxides

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Choose the right chemistry

RIE PRE-TREATMENT using innovative CCP Hardware

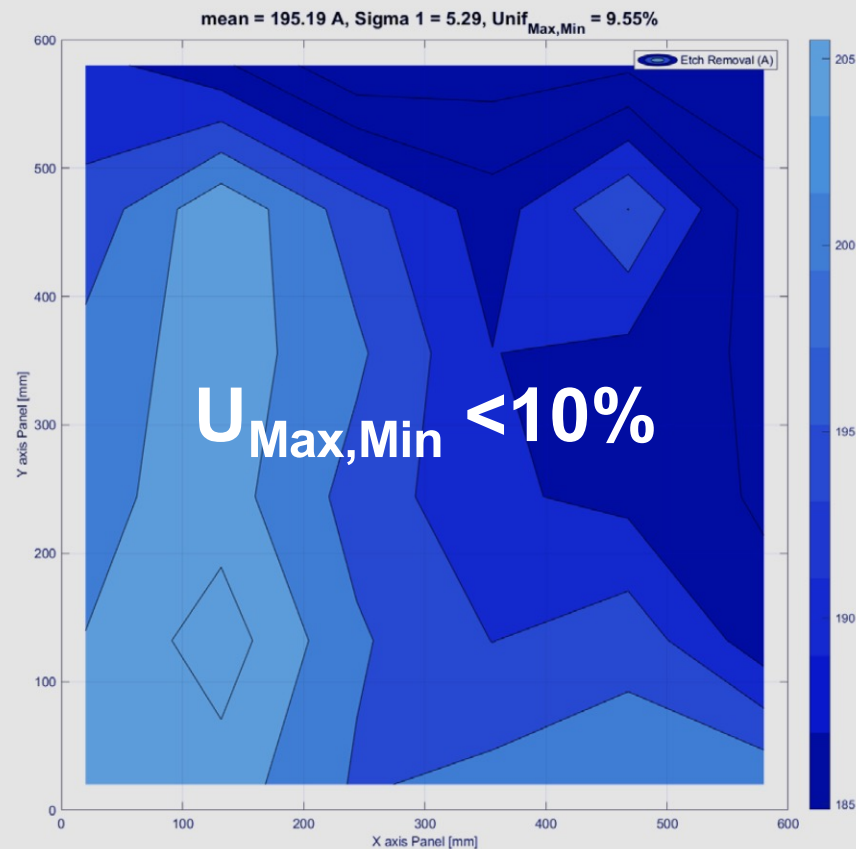
- + Dual frequency for adjusting ion-bombardment and plasma density
- + large area etch → low recontamination
- + steady substrate and no moving parts
- + excellent particle performance
- + Reactive Ion Etch (RIE)



CCP Etch Single Process Module

TAKE A LOOK AT THE RESULTS

Panel size: 600 x 600, 36 SiO₂ chips, measurement EE = 20mm



“DUAL
FREQUENCY
CCP ETCH AND
NO MOVING
PARTS DURING
PROCESSING
GUARANTEE
BEST IN CLASS
ETCH RESULTS”



Typical gases and applications:

Ar+O ₂	Ar+O ₂ +Fluorine	Ar+N ₂ +H ₂
- Remove organic residues - Leakage descum	- Homogeneous removal of composite materials - Surface activation	- Improve dielectric adhesion (before lamination) - Improve adhesion of seed layer on dielectric - Surface passivation

Etch Rates:

Material	Etch rate (nm/sec.)
PI	2.6
PBO	2.24
ABF GY50	3.13
ABF GX T-61	2.84

Main lever for fine tuning are:

- Gas ratio
- Power
- Ratio of dual frequency
- Pressure



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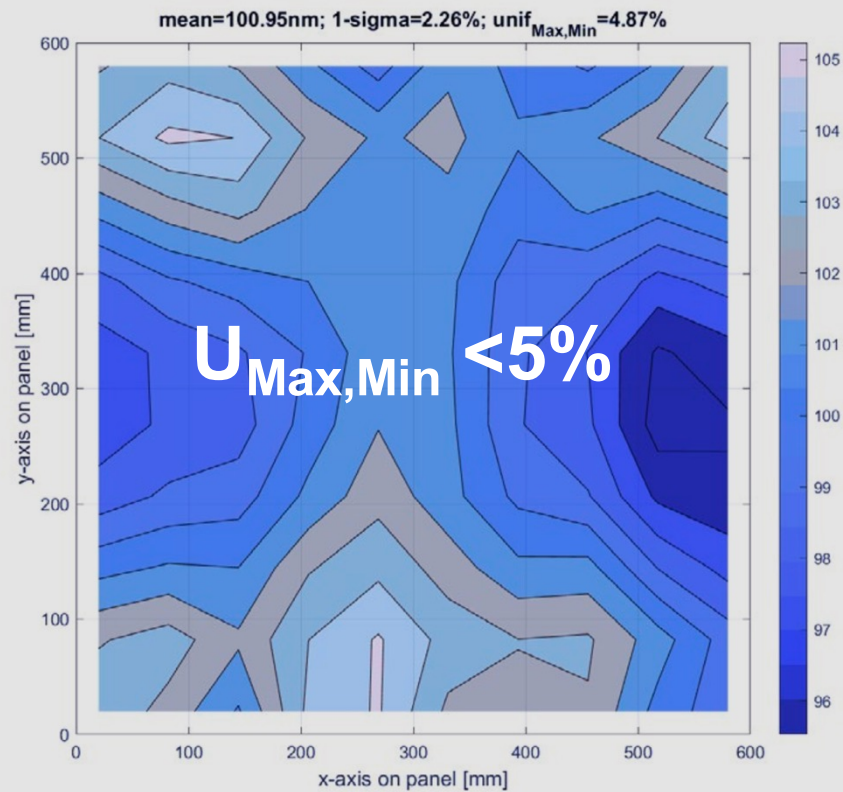




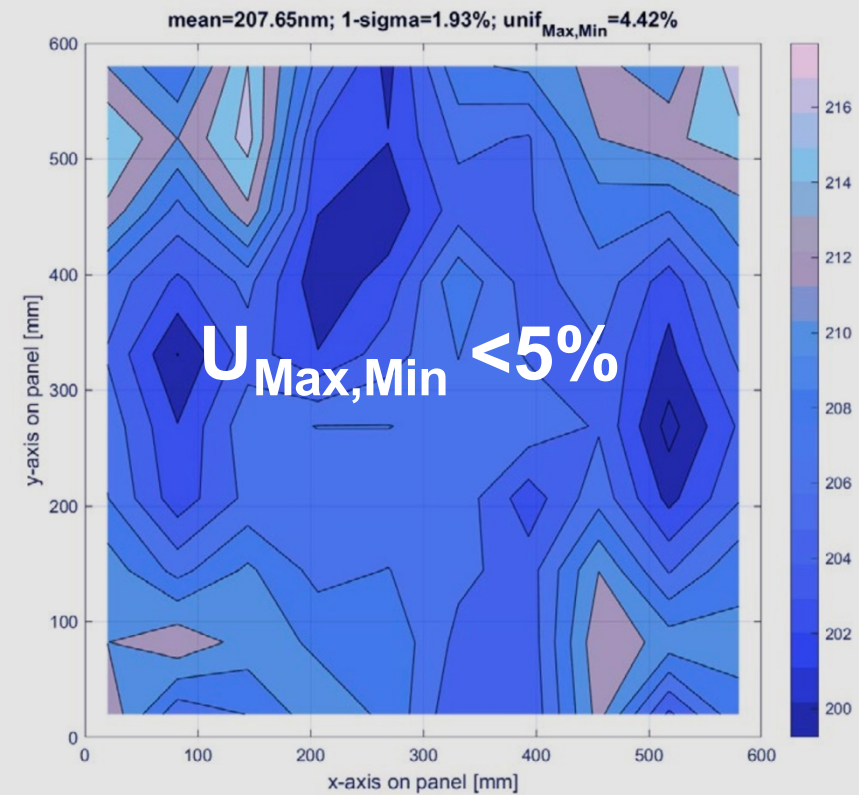
“ROTATING TARGET TECHNOLOGY OFFERS LONGEST TARGET LIFE FOR LOWEST COST OF OWNERSHIP”

TAKE A LOOK AT THE RESULTS

10 x 10 points were measured by 4-point probe

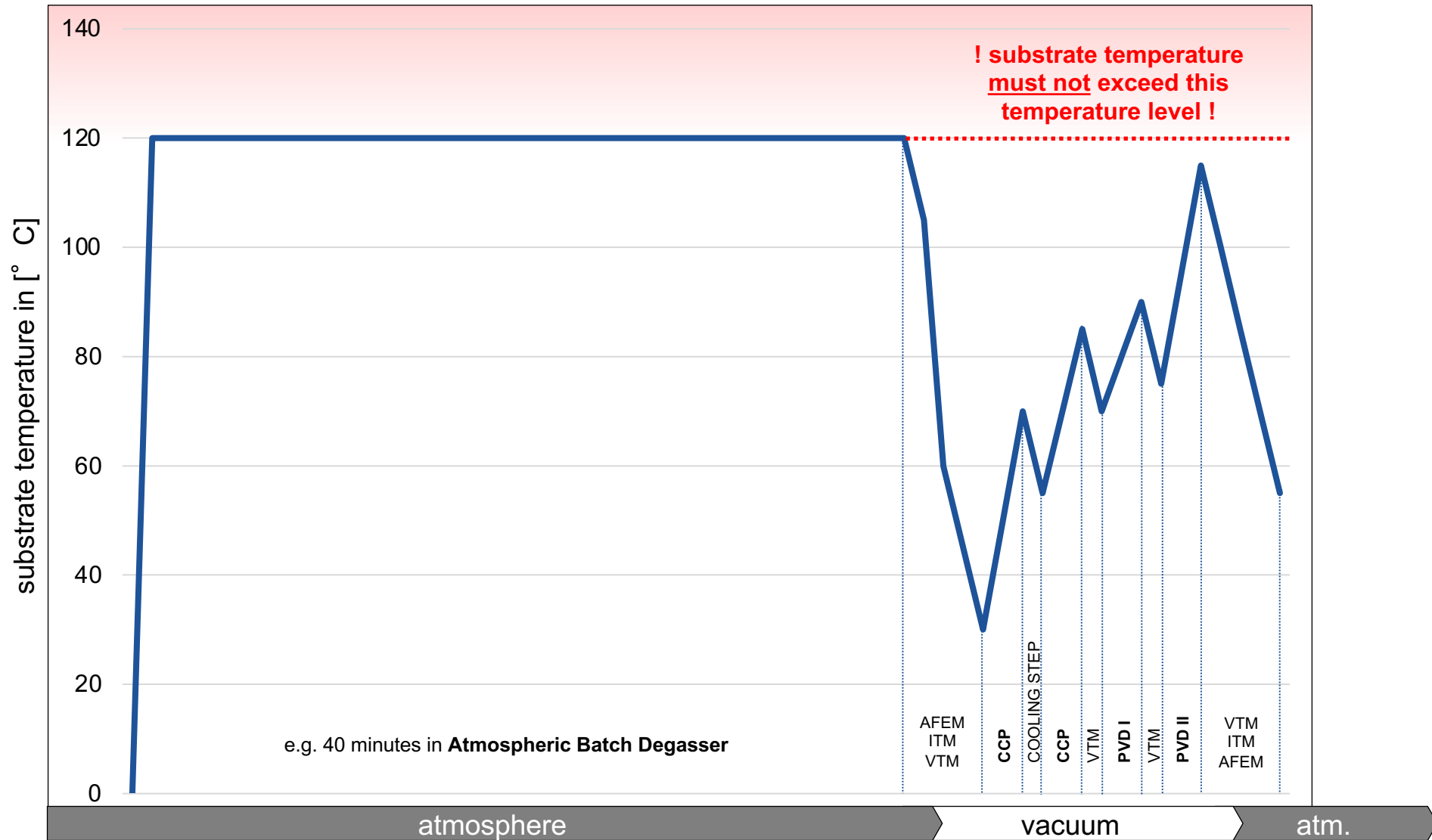


Ti deposition



Cu deposition





Foil Peel strength testing conditions:

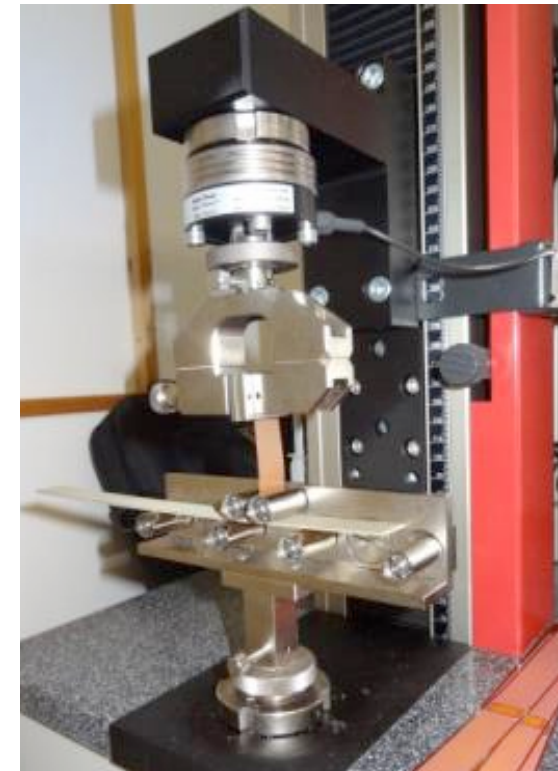
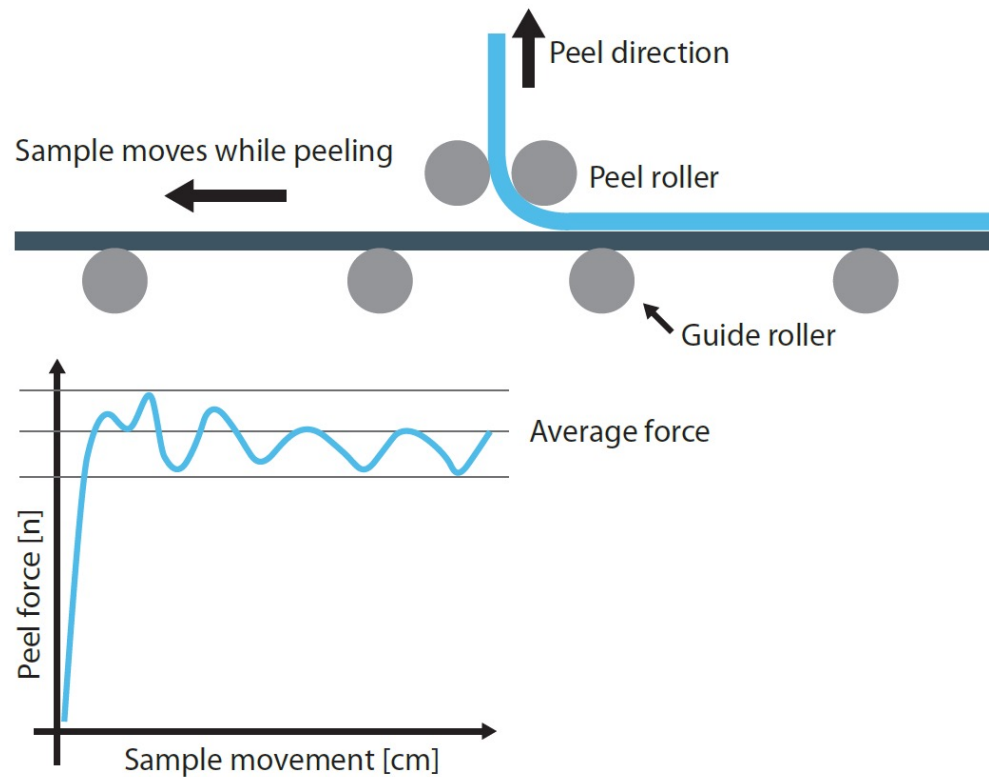
- “as deposited”
- after thermal stress, comprising 5x Reflow at 260° C
- After HAST(Highly Accelerated Temperature and Humidity Stress test) comprising exposure for 96h at 130C and 85% relative humidity.

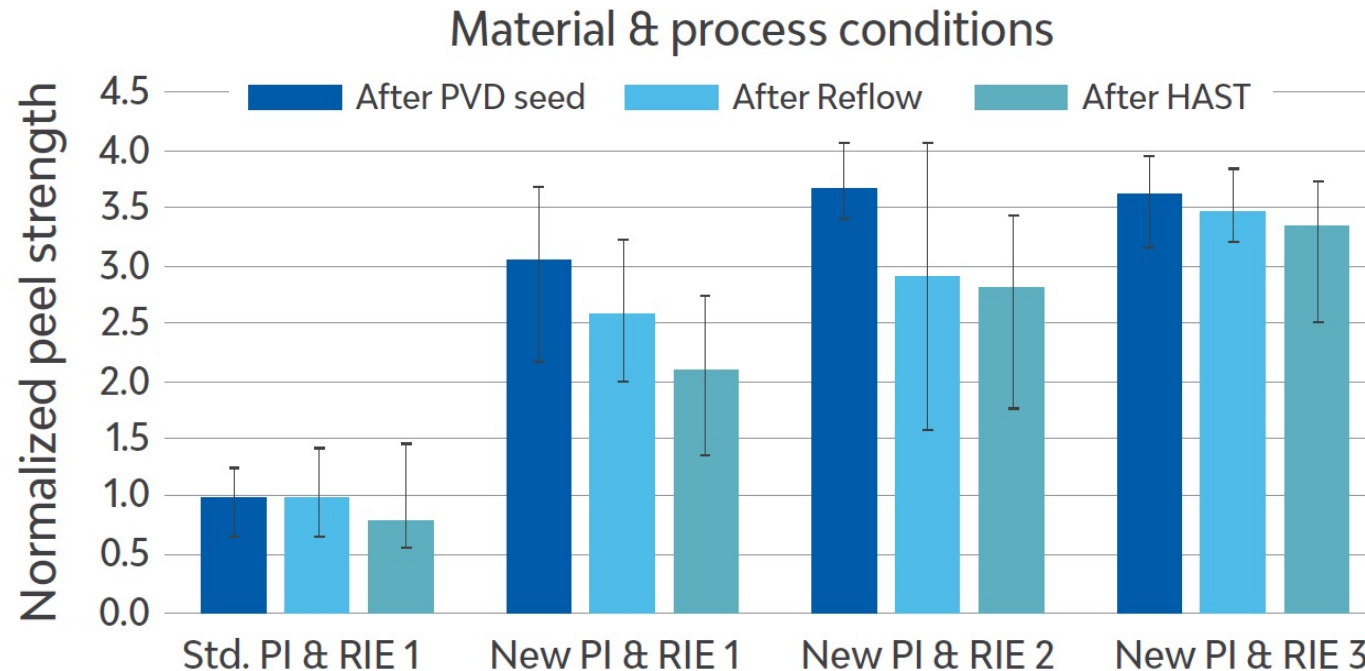
Testing methods according with IPC-TM-650 test and standards

- Six (6) test strip measurements to evaluate the material adhesion for each set of process conditions.
- The average value and variance were compared in the analysis.



- Separation takes place along perpendicular axes
- The peel force required is plotted as a function of sample movement





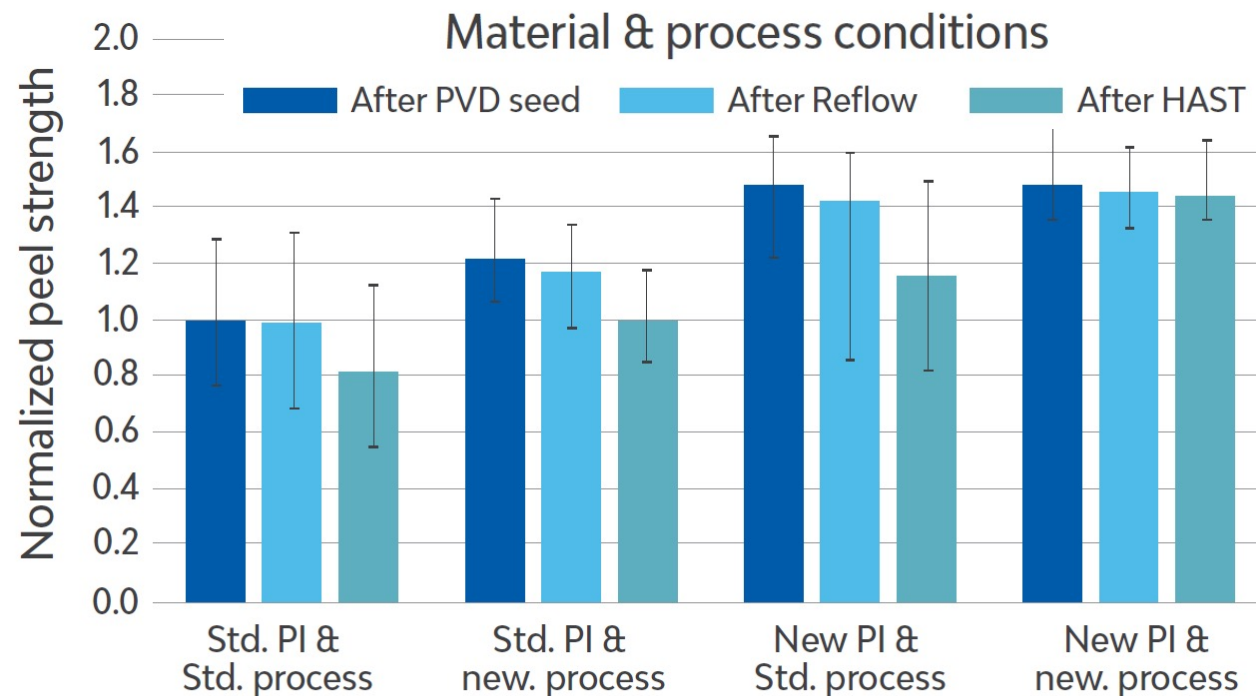
Varying Reactive Ion Etching (RIE) gas mixtures and ratios showed different results.

Process conditions “RIE3” resulted in excellent adhesion values after all reliability tests were performed.

Two additional phenomena for this set up was observed:

1. Less degradation during Reflow and HAST tests
2. Less statistical fluctuation of the measured values around the average value





- Choice of PI material
- the selection of material for adhesion promotion (including outgassing, surface treatment and adhesion layer deposition) at controlled temperatures
- Adhesion performance with good peel strength values achieved for the optimum set show only minor change and degradation.



Optimizing conditions for pre-treatment, metal film deposition and handling for flexible foils using CLUSTERLINE® 600 in cooperation with GS Swiss PCB has achieved important milestones:

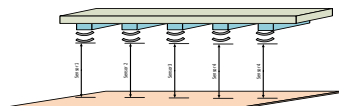
- The qualified process is compatible with the existing manufacture flow for foil processing without major changes to CLUSTERLINE® hardware and at low cost of ownership
- The polymer foil could be processed on both sides with excellent adhesion promotion and copper seed layers showing improved adhesion exceeding expectations and withstanding the reflow and HAST environments
- Cost effective fabrication of HDI-PCBs is a reality



in atmosphere

ATMOSPHERIC HANDLING

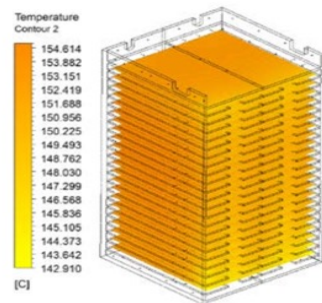
Tailormade handling integration for manipulating the substrates from the FOUP or customer cassette through the system and back. Incl. in-situ warpage measurement and full SECS/GEM integration.



ATMOSPHERIC BATCH DEGASSER

The atmospheric batch degasser is ideal for **repetitively accurate** outgassing of organic substrates.

Very high benefit from it's advantages when processing **substrates with material mix** (e.g. different emissivity's of Cu and ABF).

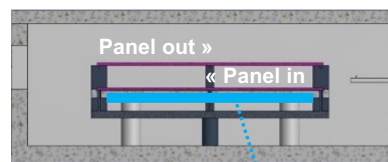


in vacuum

COOLING

After sufficient degassing, the substrates are transferred to vacuum and **cooled**.

This ensures enough thermal budget for the subsequent process steps.



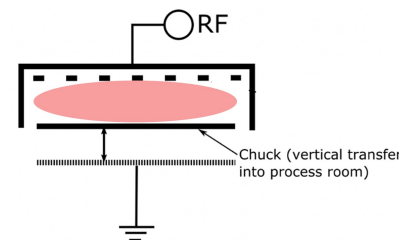
Cooling plate

PRE-TREATMENT I, II

Dual frequency CCP (13,56MHz and 60MHz) for controlling **plasma density** and **ion bombardment**.

This ensures ideal interface preparation for subsequent PVD processes

- **Cleaning the interface**
- **Removing native oxides**
- **Surface activation by RIE**
- **maximize adhesion**
- **minimize Rc**



PVD I, II

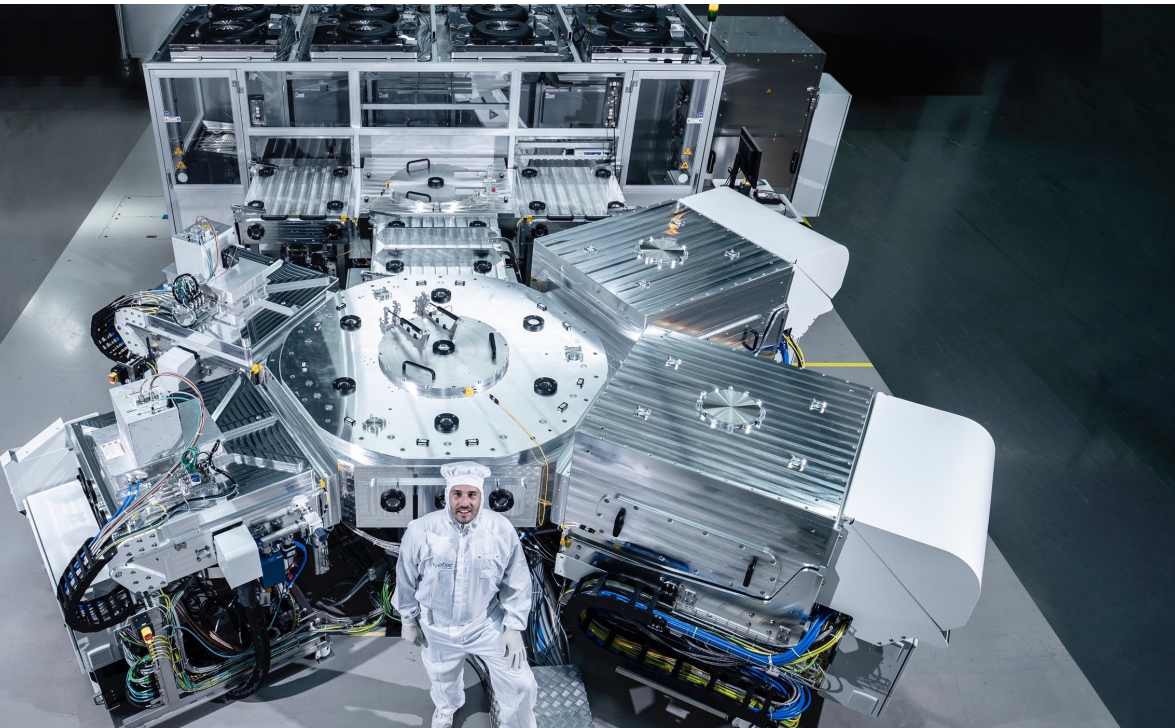
The required layers are deposited with **Rotatable Tube Cathodes**.

These cathodes have an excellent target utilization (bone erosion).

Well aligned process steps guarantee that temperature limits are maintained.



No moving substrate in process modules → **best in class particle performance**



Clusterline ® 600
Panel Level Processing System



Mohamed Elghazzali
Senior Scientist at Evatec AG

About GS Swiss PCB



GS Swiss PCB AG is a Swiss manufacturer of flex, rigid-flex and HDI-substrates employing over 170 people. The company specializes in miniaturization and the production of IC-substrates and printed circuit boards for chip on board (COB), chip on flex (COF), flip chip and multi-chip modules (MCM). A second focus is the fabrication of rigid-flex circuits for the medical and aerospace markets. Company capabilities range from laser and mechanically drilled micro vias, contours and depth milling with narrow tolerances to ultra fine line structures and copper filled vias in combination with sequential build up (PVA-Technology). The company has invested more than 10 million Swiss Francs for implementing Semi Additive Process capability (equipment, cleanrooms etc.).

Their PCBs can be found worldwide in the medical field, aerospace applications and challenging industrial products thanks to excellent quality and high reliability.



The GS Swiss PCB team

www.swisspcb.ch/en/





LET'S SHAPE THE
FUTURE TOGETHER

