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SINEQUANET WP8: Support to HOS-Technik

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Introduction of Company

- HOS-Technik GmbH was established in 1988 in Austria.
- Development from chemical engineering planning office to chemical production facility (from pilot plant to batches of up to several tons).
- Small privately owned enterprise, ~ 20 employees.
- Specialisation: Production of speciality polymers for high temperature composites and additives for the plastic and rubber industry. The monomer Homide® and its precursors are produced in-house. Applications *e.g.* in Airbus A 380, BMW.
- Current efforts to expand product range:

  - New materials, development of polybenzimidazole resins.

  - Vertical diversification, from raw material to end product.
- Business partners mainly Europe (UK, Germany, Italy, Denmark), small activities in Japan, attempts to start activities in USA.

Product Range - Examples

HOMIDE

- Mono and Bismaleimides as raw materials for temperature resistant resins, cross-linking agents and adhesives.
- Homide 250: Bismaleide resin for high temperature resins. Applications for prepregs and laminates for PCBs, insulators, high temperature applications, composites (glass, carbon, aramide fibre), *etc.*

HOZOLE

- Polybenzimidazole (PBI) is an excellent polymer for high temperature applications (short term 500°C, long term 310°C). Applications: Composites, thermal protective clothing, plain bearings, brake disks, adhesives, films and foams, *etc.*

Custom tailored product development possible.

Expectations of HOS-Technik

- Space sector is very attractive for speciality products.
- Due to size of company limited resources

  - Limited fundamental research activities, R&D activities are focusing mainly on product improvement driven by market requirements.

  - Difficult to perform testing campaigns of products for specific applications (*e.g.* durability for space applications).

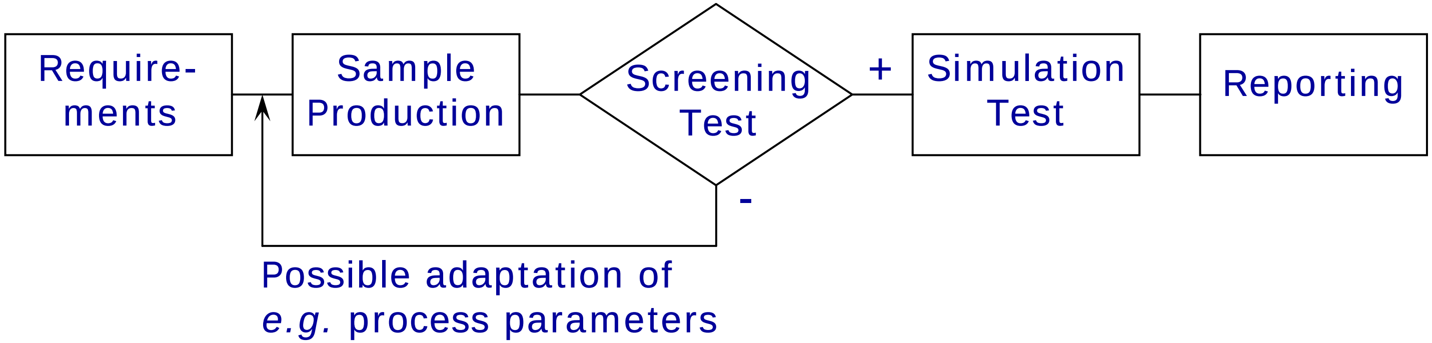
- Based on performance of materials according to space requirements, product properties can be improved, respective markets can be exploited.
- The entrance barrier to the space market is very high due to ‘exotic’ materials requirements, and it is hoped that after performance testing of polymers the demand of these products can be increased in the space sector.

Benefits to ESA

- The Materials & Process division is constantly looking for new materials on the market that appear promising for space applications, in particular in view of new requirements (*e.g.* demanding thermal environment).
- Strong interest to support European companies. The polyimide sector is dominated by the US-manufacturers Du Pont (Kapton®) and the alternative Japanese supplier Ube Industries (Upilex®).
- Alternative materials such as PBI could lead to very interesting alternatives.
- ESA as an 'end-user' of these materials can give guidance towards its market requirements and act as promoter for these new European products.

WP 8: Support to HOS-Technik

- Definition of requirements relevant for space applications:
  Vacuum compatibility, thermal environment, radiation environment, *etc.*
- HOS-Technik will produce film and bulk material based on polyimide and polybenzimidazole that best suit these requirements.
- TEC-QMC will test the polymer films according to established standards
  - Vacuum compatibility (outgassing)
  - Thermal stability (thermal vacuum)
  - Radiation stability (UV)



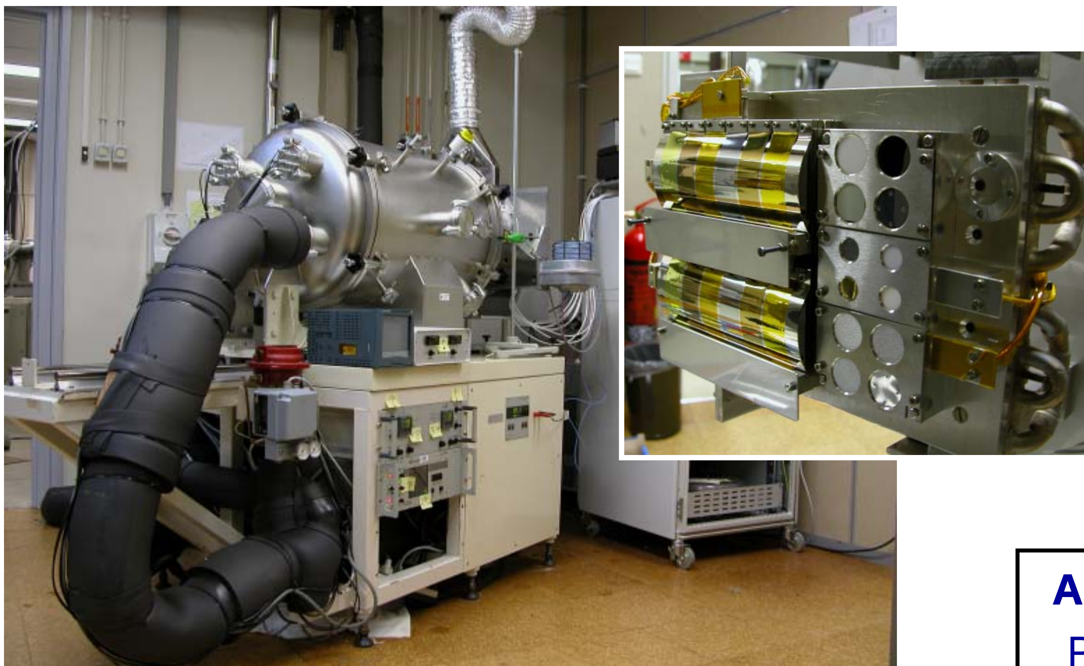
Vacuum Compatibility (ECSS-Q-70-02)

Sample	CVCM, %	RML, %	TML, %	VWR, %
PBI-1	0.01	0.66	**9.23**	**8.57**
PBI-2	0.02	**1.45**	2.52	1.06
PBI-3	0.00	0.47	1.31	0.84
PBI-4	0.00	0.79	2.08	1.29
PI-1	0.00	0.81	1.33	0.52

Requirements:
RML < 1.0%
CVCM < 0.1%
VWR case dependent

PBI-1: Polymer film, processed from solution
PBI-2: Bulk polymer, M ~ 30000, extruded
PBI-3: Bulk polymer, M ~ 45000, compression moulded
PBI-4: Bulk polymer, M ~ 70000, compression moulded
PI-1: Bulk polymer, compression moulded

Vacuum UV Irradiation (PBI film)



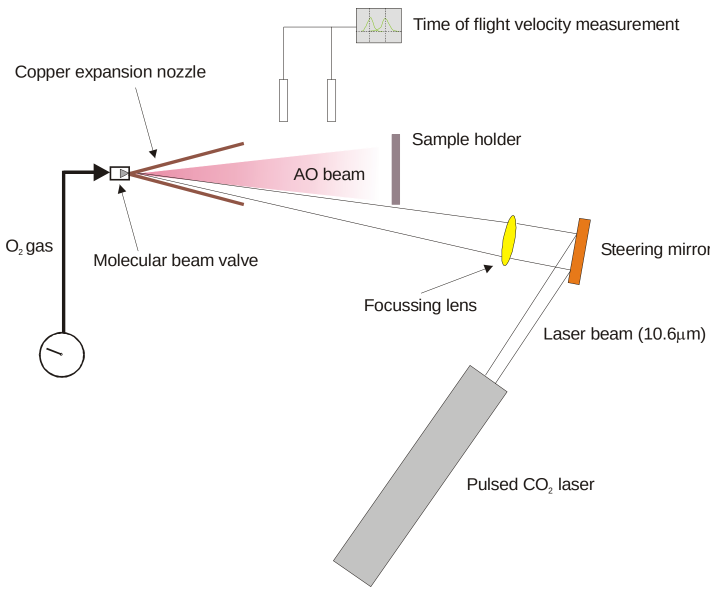
Vacuum UV test (200 – 400 nm)

Duration: 900 esh
Acceleration factor: 5

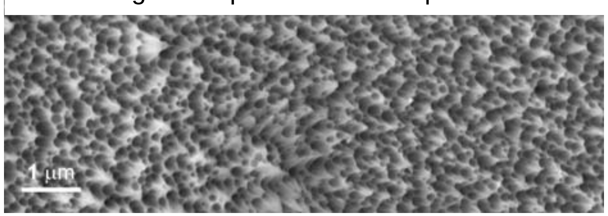
Absorptance	Emittance
BOL: 0.447	BOL: 0.81
EOL: 0.443	EOL: 0.77

Absorptance / Emittance	
PBI	0.55 → 0.57
Kapton HN	0.54 → 0.55
Upilex S	0.62 → 0.65

Atomic Oxygen Simulation (PBI film)



SEM image of Kapton-HN after exposure to AO



Typical AO energy = 5.5 eV, corresponding to impact velocity of 8 kms^{-1} in LEO

Average fluence = 1 x 10^{20} atoms cm^{-2} per day

Oxygen atoms neutral and in 3P ground state

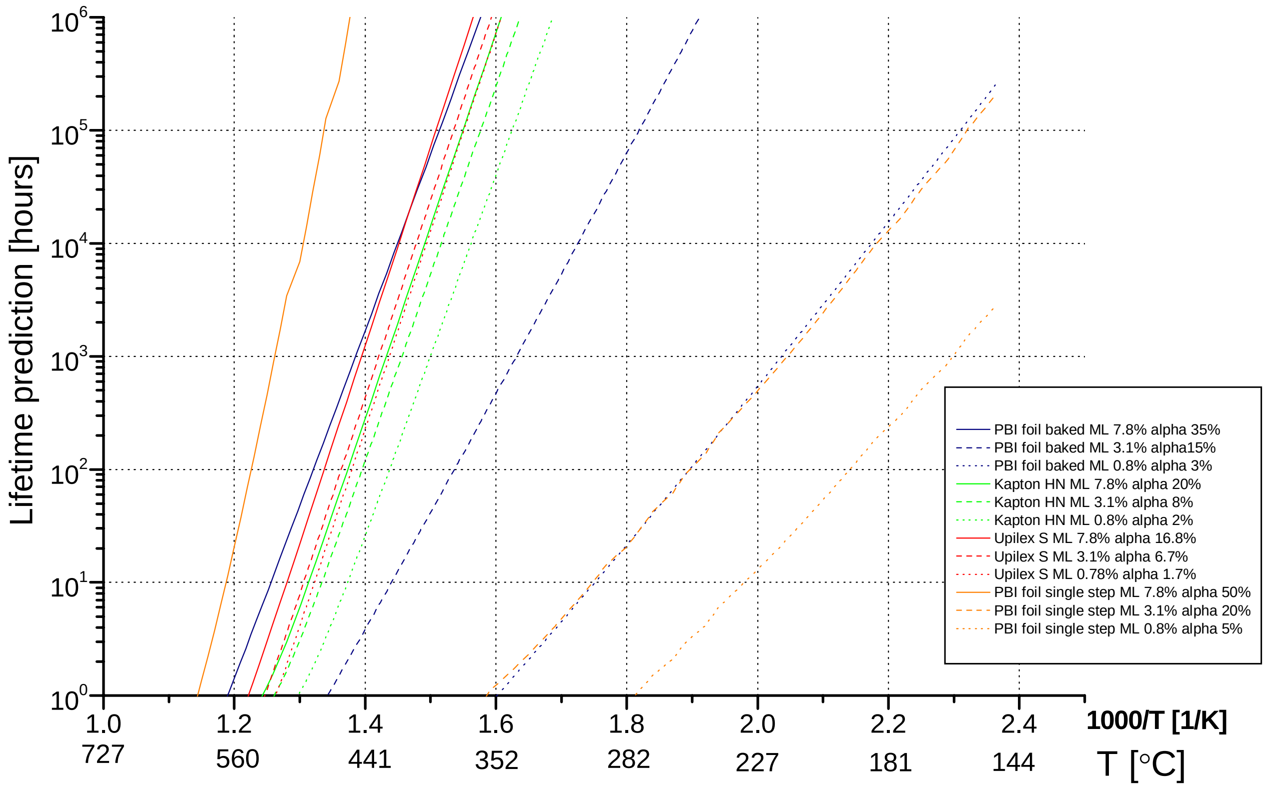
O^+ ion concentration < 10 ppm

Erosion rate

PBI:	2.2E-24 cm^3/particle
Kapton HN:	3.0E-24 cm^3/particle *

* Corresponds to surface recession of ~100 μm/year in a 400 km orbit during medium sun activity

Lifetime Prediction – PBI film



MFK (Model Free Kinetics)

Vyazovkin, S.; Wight, C.A. 'Kinetics in Solids' *Annual Rev. Phys. Chem.* **1997** *48* 125-149.

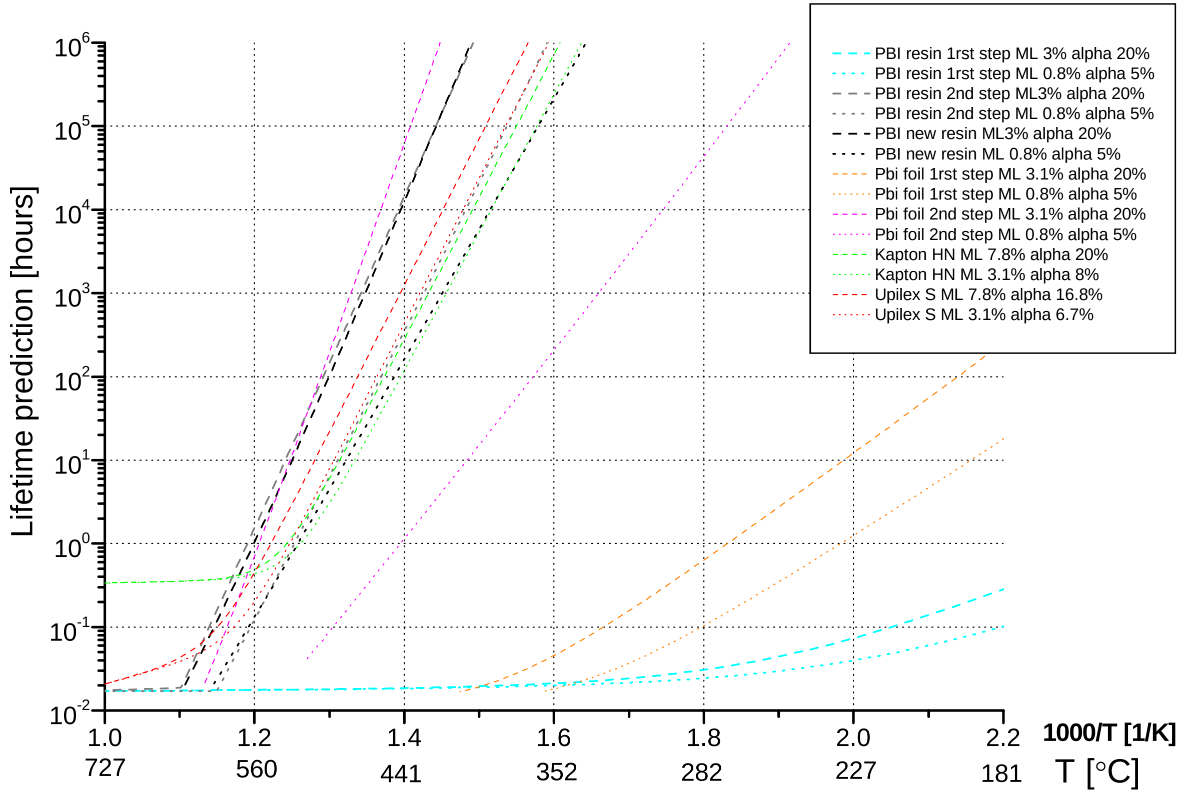
Kapton HN

Upilex S

PBI film

PBI film baked

Lifetime Prediction – PBI bulk



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Feedback and Experience

- **Newcomer** for the space market
- **IPR** / Disclosure of product details
- **Late contract signature**
- **Man power**: Priority to project support (ESA) and current business obligations (HOS-Technik)

  → Alteration of test logic

  → Assignment of tasks

  → Feedback/re-production loop delayed
- **Modification of primary scope** from PI to PBI from initial proposal to execution of work

  → Benefit on either side
- **Unexpected sample behaviour**

  → More intense method development

Conclusions and Way Forward

PBI film

- Radiation stability comparable to established polyimides
- Advantage: Superior thermal endurance
- Drawback: High water content

PBI and PI bulk material

Current focus on PBI: Similar properties compared to film, most important parameters are vacuum compatibility and thermal endurance. Ongoing:

- Process optimisation (chemistry of pre-cursor, process parameters)
- Post conditioning

Future activities

- Characterisation of optimised bulk materials (PBI and PI)