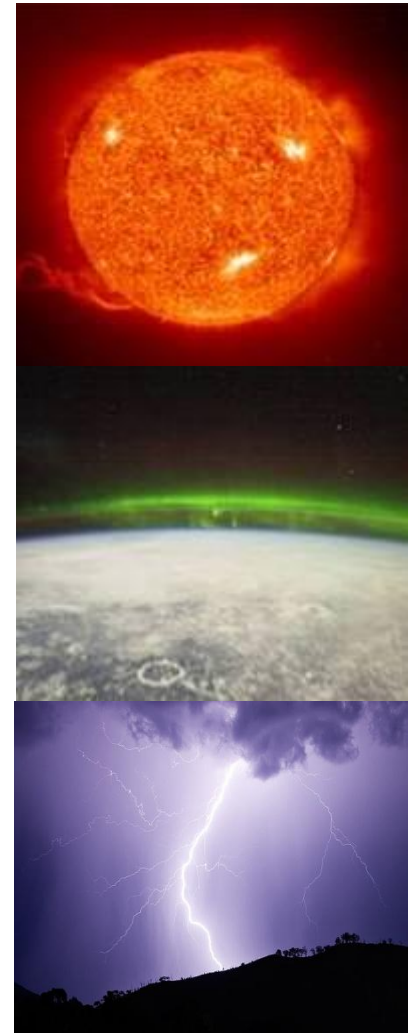


Robby Rego
VITO's Atmospheric Plasma Team

What is plasma ?

- Next to solid, liquid and gas phase, plasma is often referred to as the fourth state of matter.
- A plasma is a (partially) ionised gas in which ions and electrons are present as well as radicals and molecules in an excited state.
- A plasma contains both physical and chemical very reactive species.
- In “thermal” or “hot” plasmas all species have approximately the same (high) temperature.
- “Cold” or “non-equilibrium” plasmas have a high electron temperature but a low ion or gas temperature.



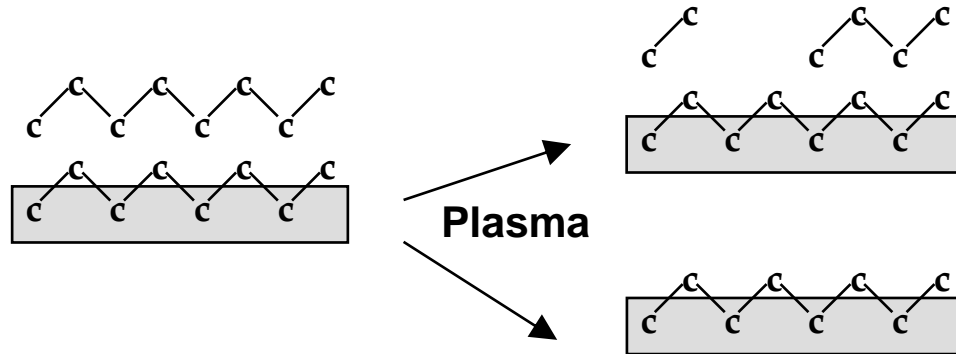
How to generate a cold plasma ?

- Cold plasma discharges can be generated by stationary and pulsed (DC) or alternating (AC) electrical fields.
- Various electrical power supplies can be used to generate the plasma discharges: (pulsed) DC, DBD (corona), RF, microwave, ICP, ...
- Although most applications are at low pressure, intermediate and atmospheric pressure applications are emerging.

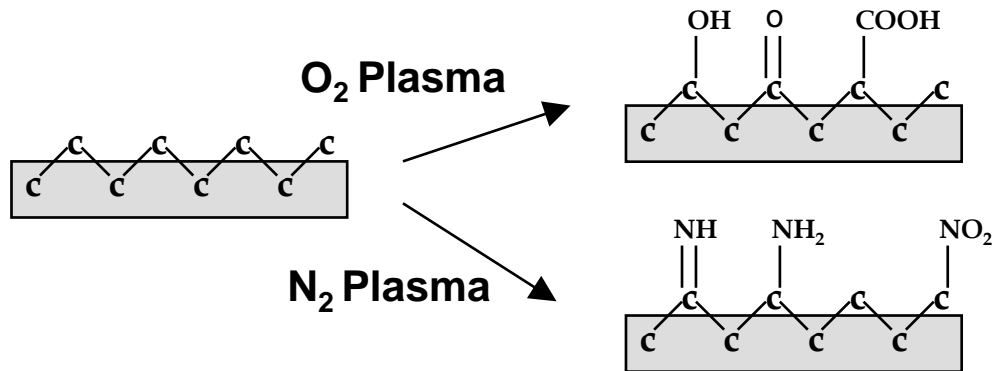


Plasma assisted surface engineering

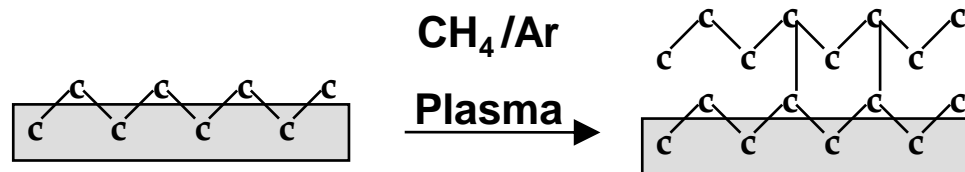
Cleaning, etching
and sterilisation



Activation



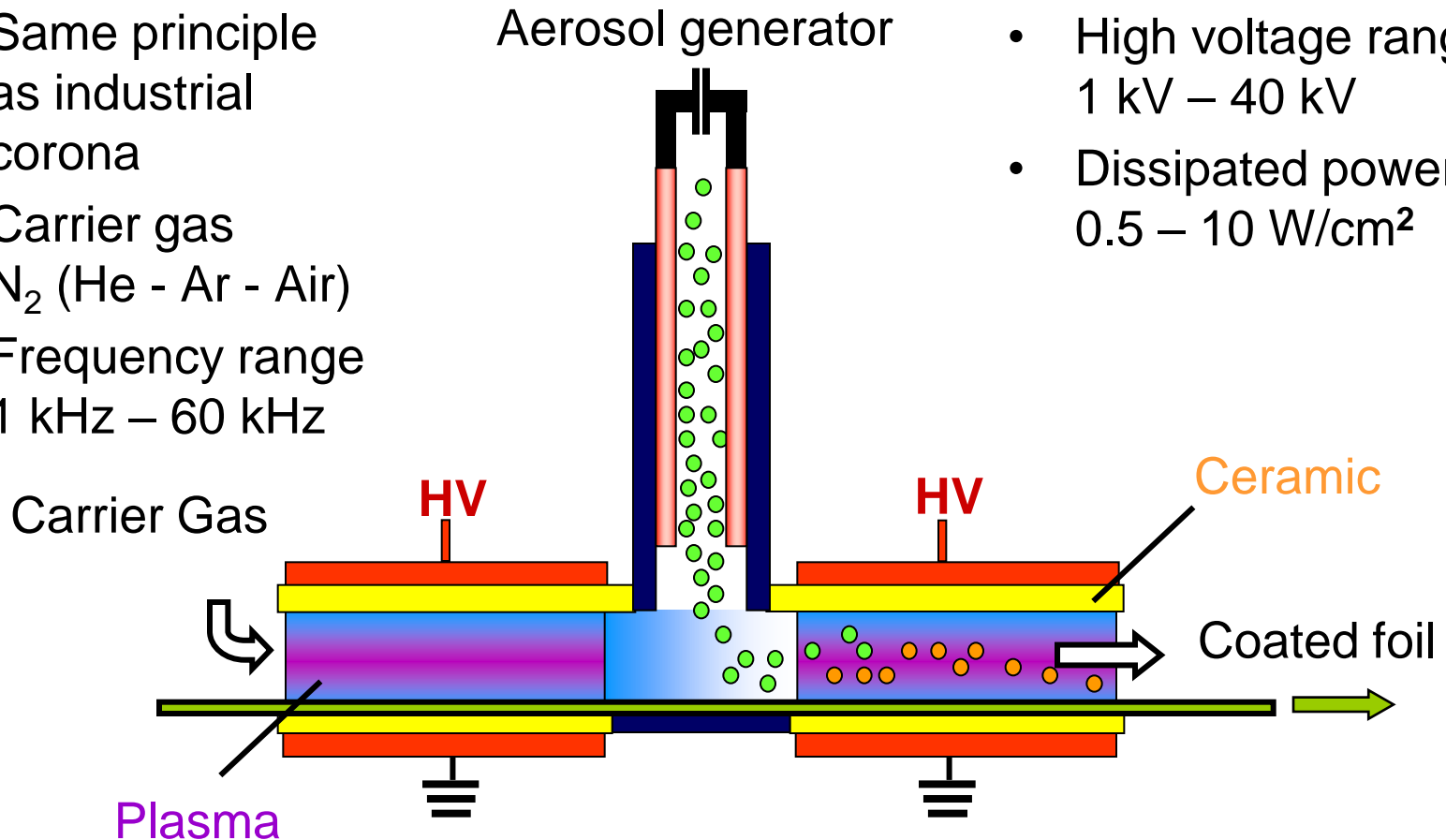
Coating



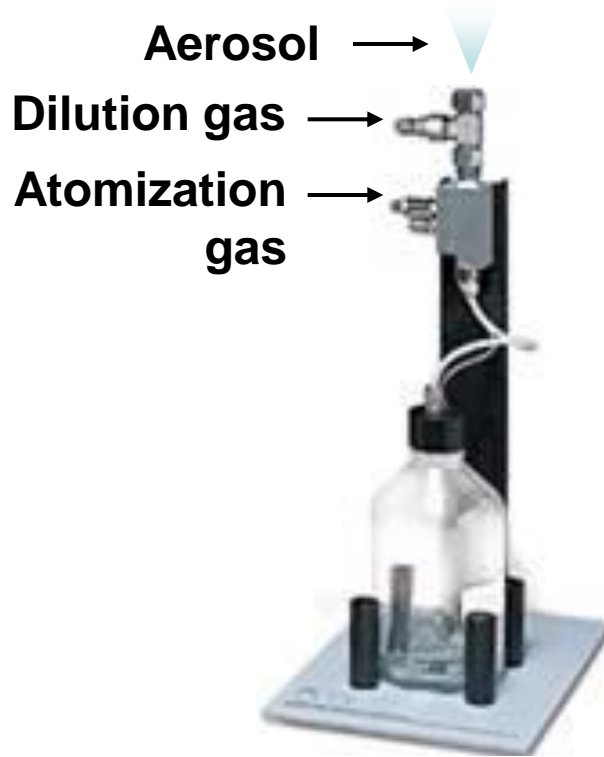
Recent developments at VITO Aerosol Assisted Plasma Deposition

- Same principle as industrial corona
- Carrier gas N_2 (He - Ar - Air)
- Frequency range 1 kHz – 60 kHz

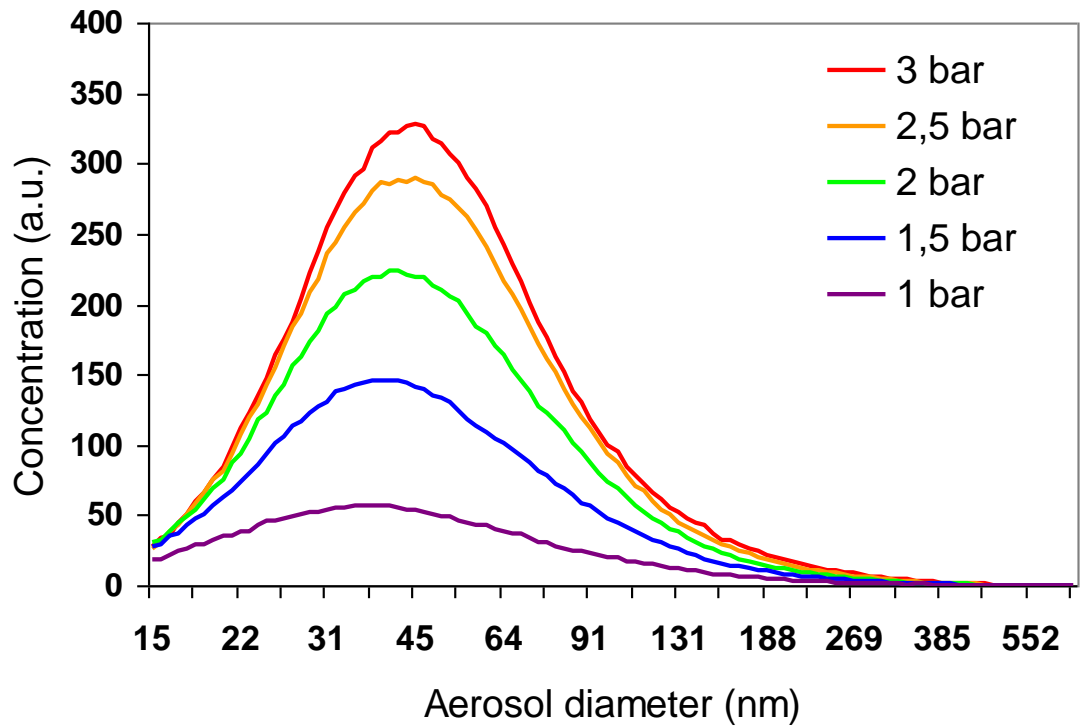
- High voltage range 1 kV – 40 kV
- Dissipated power 0.5 – 10 W/cm²



Aerosol generation by pressure atomization

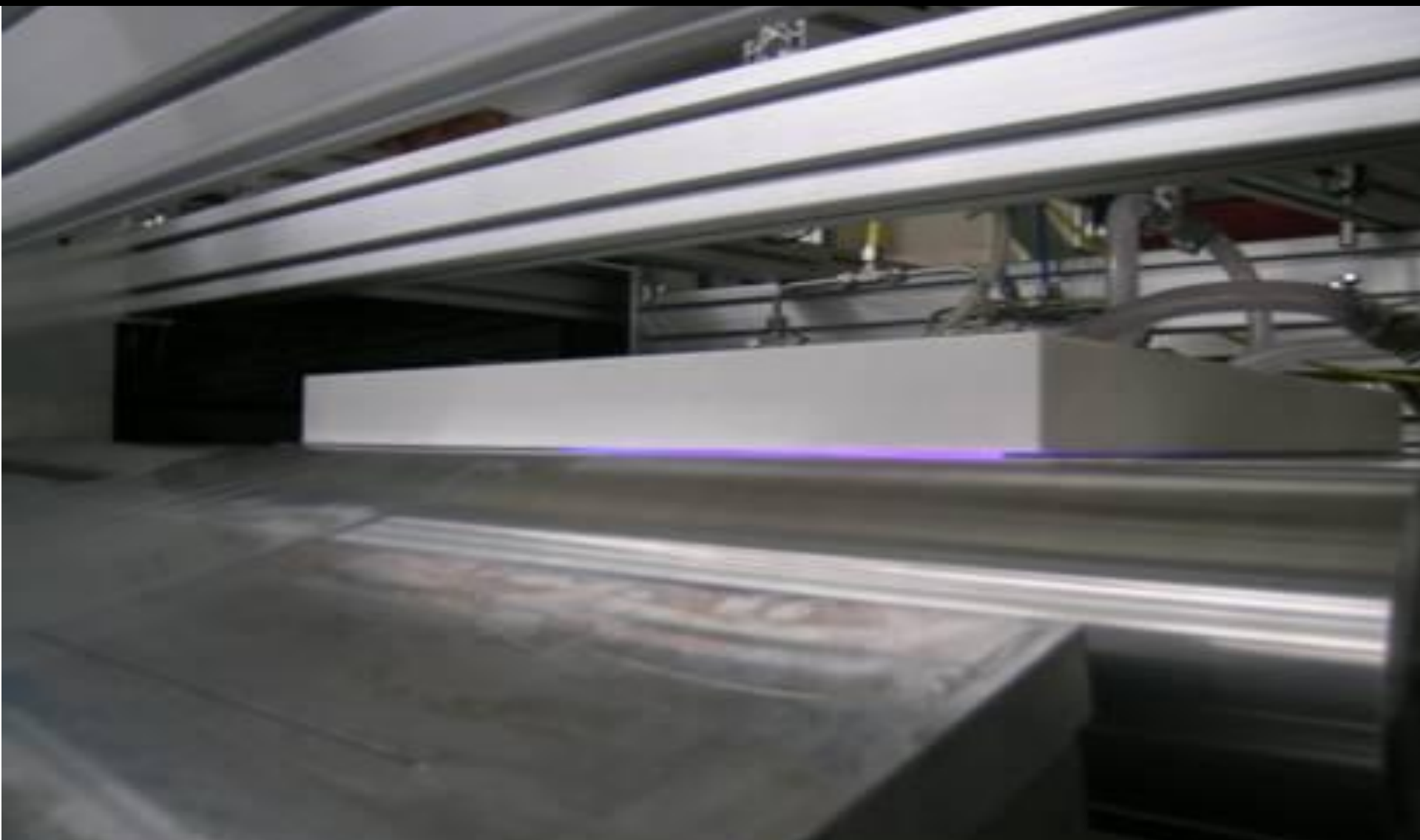


TSI Atomizer Model 3076



Aerosol is nano-sized, typical in range of 20-200 nm

ATMOSPHERIC PLASMA VERSUS CORONA

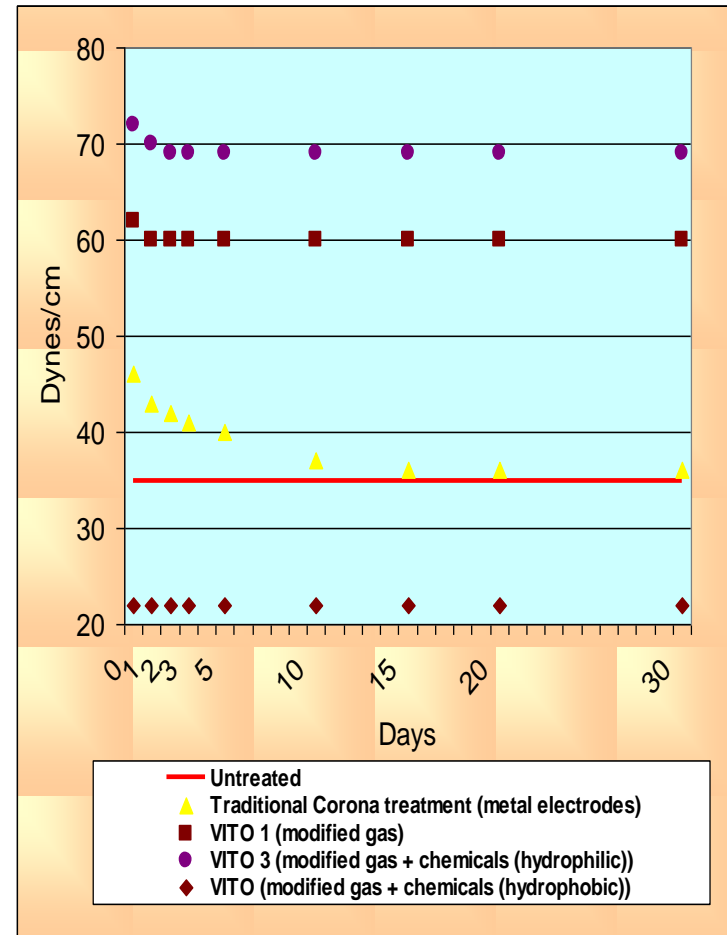


PLASMA versus CORONA

	VITO Plasma	Traditional Corona
Treatment gas	Nitrogen, air, oxygen, carbon dioxide, hydrogen, helium, argon,... and any mixtures thereof	Air
Chemical precursors (liquid or gaseous)	No limitations: even dispersions of liquids with solid particles can be introduced	Not applicable
Frequency	Adjustable from 1 – 100 kHz	Around 25 kHz
Pulsed power	YES	YES

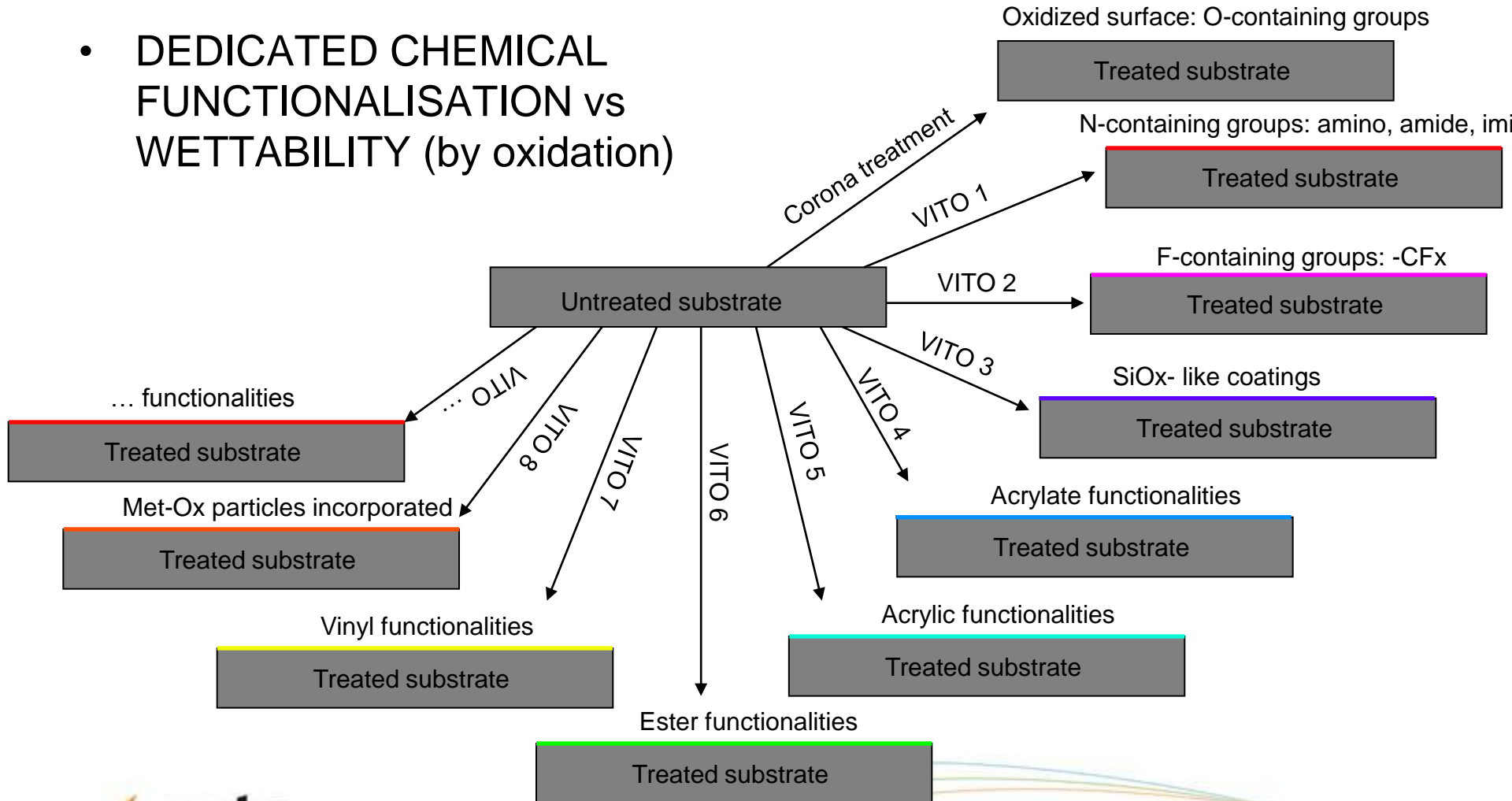
PLASMA vs CORONA

- Permanent vs Temporary
- High vs Medium dyne levels
 - Corona PE:
 - 46 dynes
 - Plasma PE:
 - 60 dynes permanent (modified gas)
 - > 70 dynes with chemical plasma
- Hydrophobic treatment possible



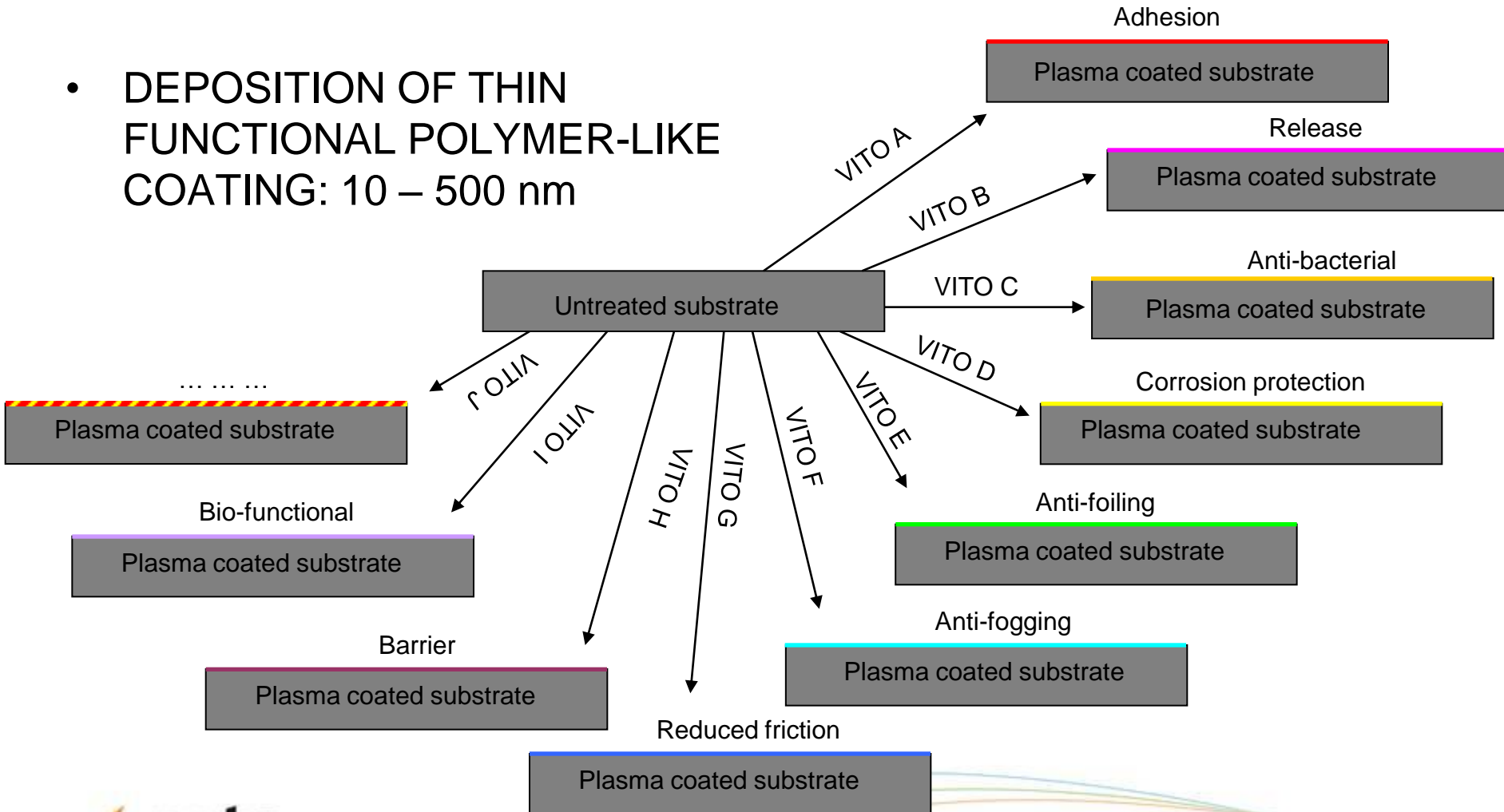
Plasma can do more !

- DEDICATED CHEMICAL FUNCTIONALISATION vs WETTABILITY (by oxidation)



Plasma can do more !

- DEPOSITION OF THIN FUNCTIONAL POLYMER-LIKE COATING: 10 – 500 nm



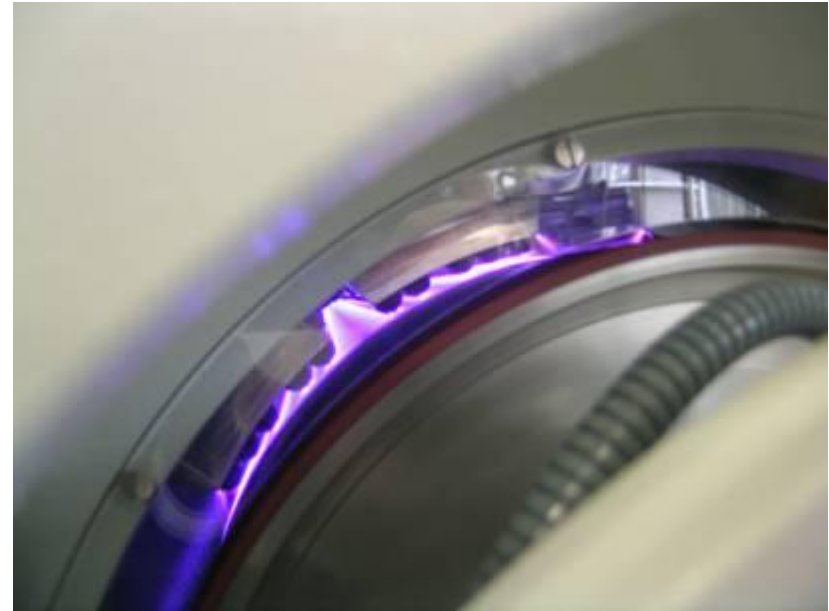
Equipment developed by VITO for DBD plasma deposition

in collaboration with



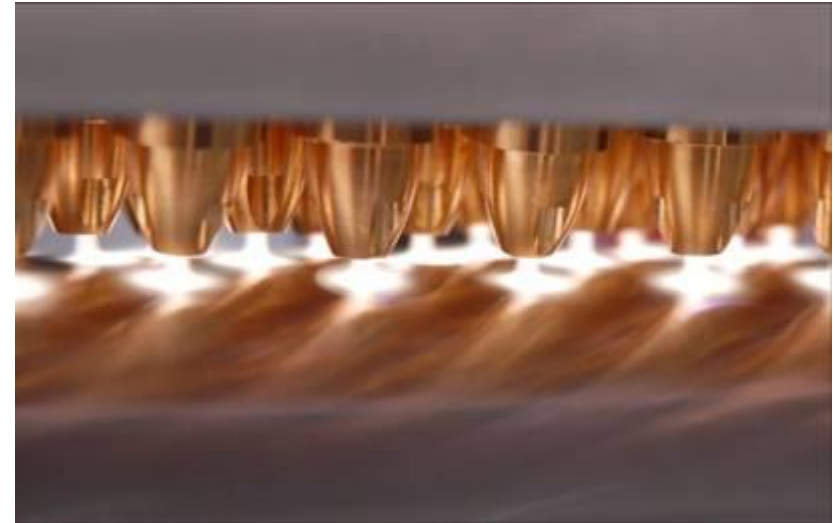
Nitroplas system/ modified Aldyne system

- Modified corona station with controlled gas atmosphere (N₂)
 - Realized in cooperation with VITO
 - Water cooled HV electrodes
 - Low gas consumption
 - Robust design
- For permanent activation of foils
 - e.g. CPP, OPP or BOPP
 - > 54 dynes stable for > 6 months
 - currently up to 200 m/min (VITO)



Plasmatrix

- Plasma multijet
 - Standard operation in air
 - Modified gas atmosphere possible
 - Robust design
 - Process development with VITO
- For activation and fine cleaning
 - e.g. air activation PP up to 42 dynes
 - e.g. hydrocarbon removal from aluminium

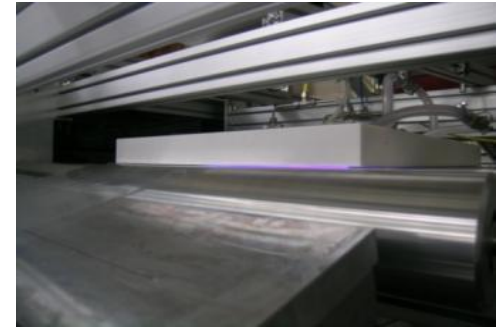
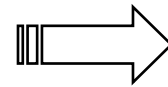


Atmospheric plasma systems developed @ VITO

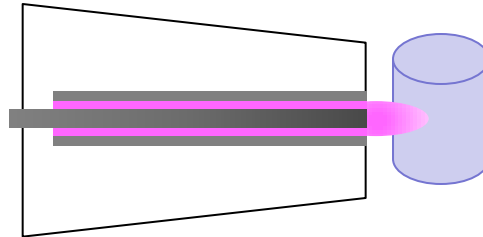
PlasmaZone®
Permanent
functionalisation
and coating



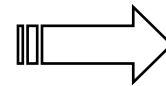
Direct



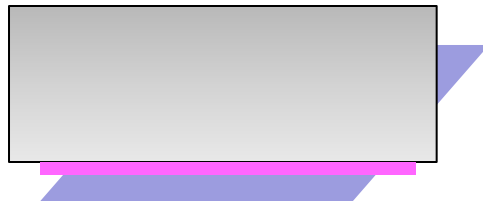
PlasmaSpot®
local treatment
of 3D parts



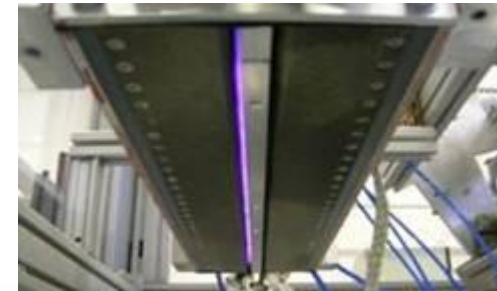
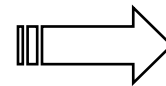
Indirect



PlasmaLine®
web activation
without back
treatment



Indirect

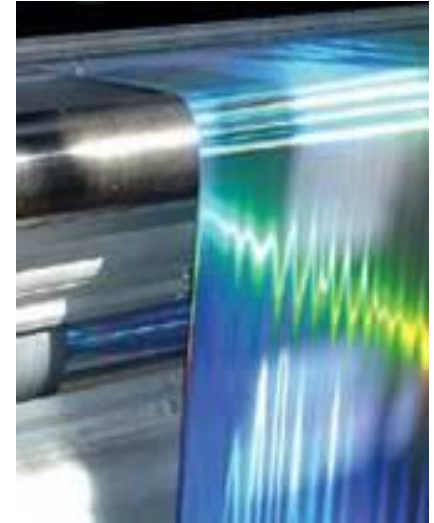


Long term adhesion improvement of polymeric films

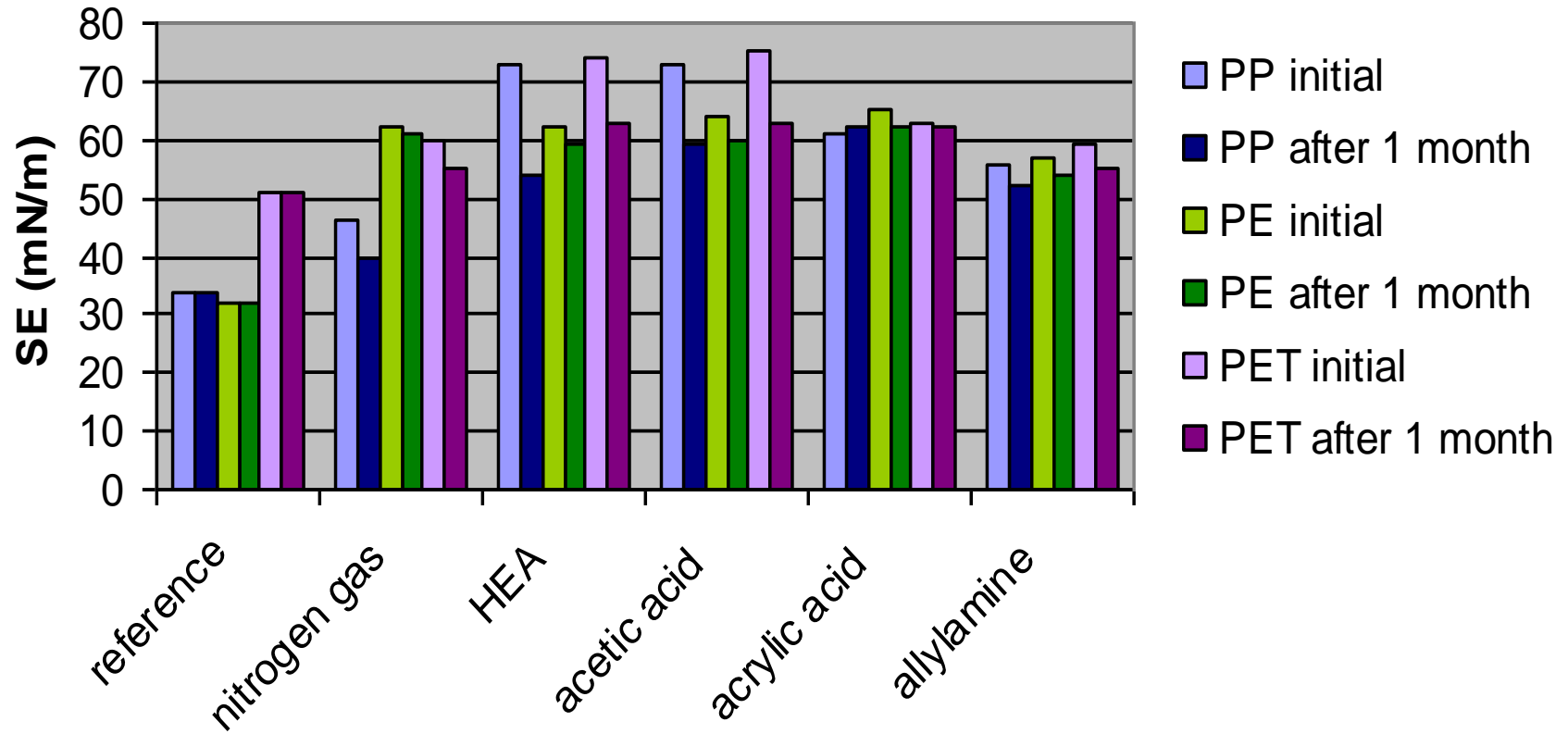


Long term adhesion improvement: solvent free

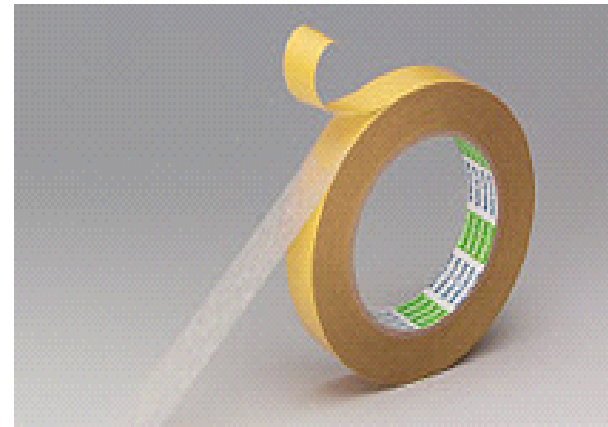
- Problem
 - Adhesion problems of plastics remain to be an important cause of production losses and consumer/end-user complaints
 - New REACH legislation will restrict the currently wide spread use of (toxic) primers
- Aim of research
 - Permanent activation of plastic foils for gluing, printing or lamination as an alternative for temporary effects obtained by currently widespread used flame or corona treatments or the use of (toxic) primers



Long term adhesion improvement

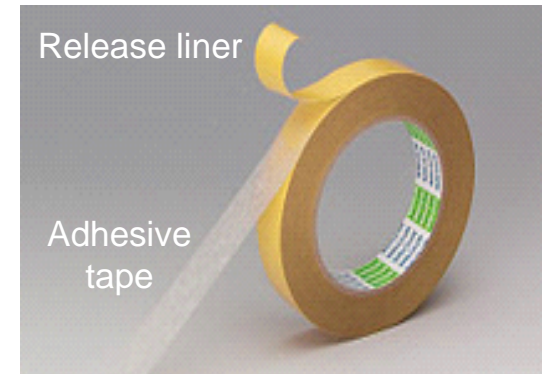


Alternative release liners for Pressure Sensitive Adhesive (PSA) tapes



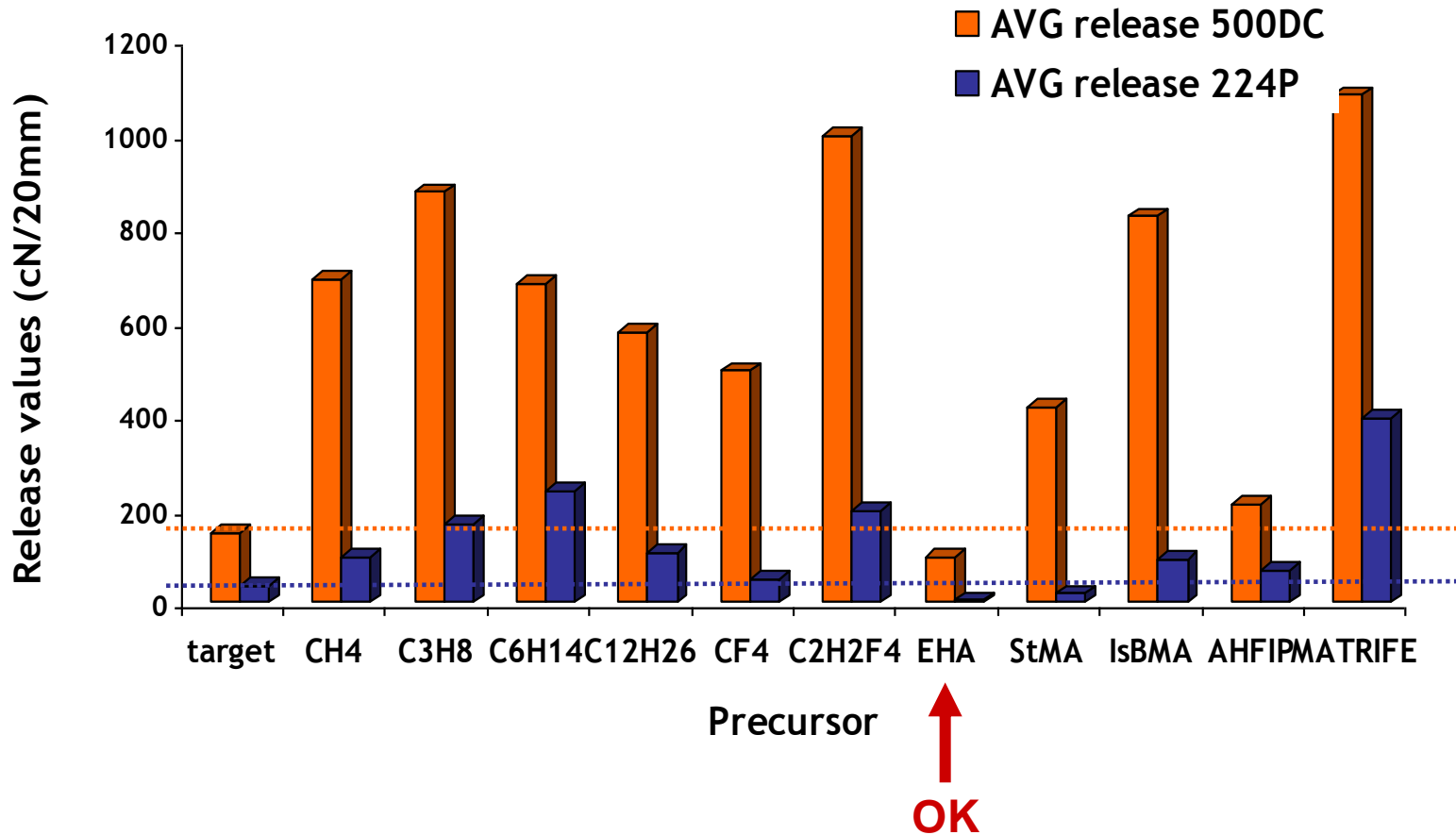
Alternative controlled release liners: solvent free

- Problem
 - Current wet-chemical release liner application is generally based on highly diluted silicones in organic solvents.
 - These processes have a significant cost and environmental impact (VOCs, CO₂-emission).
 - Unwanted silicone transfer may occur from the release liner to the counter part causing problems in subsequent processing steps.
- Aim of research
 - Development of an alternative solvent free process for the deposition of ultra thin silicone free release liners on plastic foils.



Initial release values for PVC tape

N2-plasma + precursor (best results)



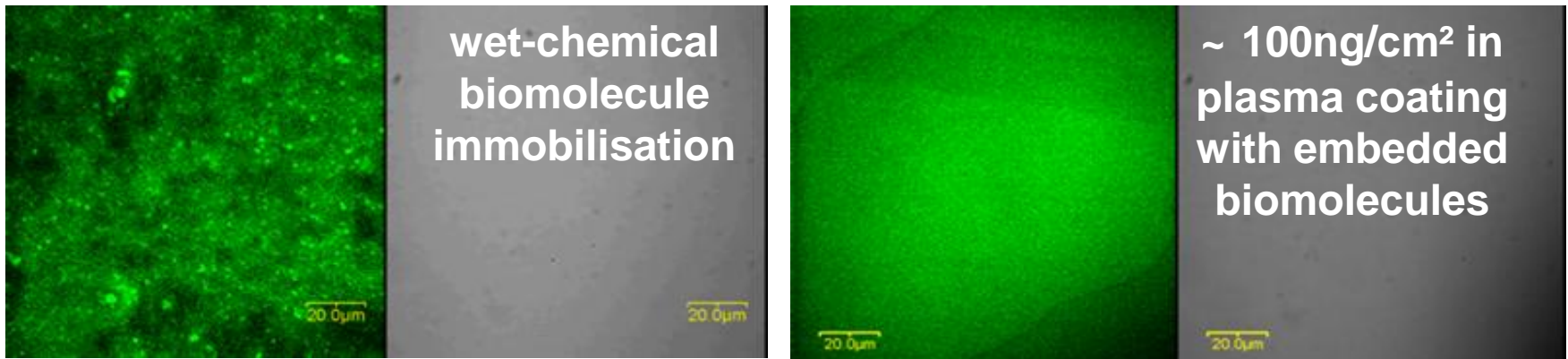
Single step biomolecule immobilization strategy

FP6 EC project BIOPLASMA



Bio-engineering by atmospheric plasma treatment

- Immobilization of biomolecules in plasma polymers
- Development of low cost, one-step immobilization technology
- Applications: bio-sensors, intelligent packaging, bio-mimicking ...



**Confocal laser scanning microscopy of
GOX enzyme in C₂H₂ plasma coatings**

Conclusions

Atmospheric DBD plasma processes, based upon the same technology as current state-of-the-art corona technology, offer new possibilities for sustainable dry surface engineering.

By controlling the gas atmosphere and the electrical conditions and by addition of reactive chemicals, one can increase the efficiency of the plasma surface treatment significantly and make the effects permanent.

The technology opens up new possibilities to deposit thin functional coatings in a continuous system at ambient pressure.

Thanks to VITO-AFS cooperation atmospheric plasma is an industrial reality

www.vitoplasma.com

Plasma Team @ VITO



19 persons + 6 persons in characterisation

Thank you for showing interest in our technology!

For more info visit:

www.vitoplasma.com