PO3080

# Hybrid Inorganic-Organic Functional Coatings for Injection Molding Applications

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## Background, Objective

Tools for injection molding processes are usually coated to increase their corrosion and abrasion resistance. The application of such protective coatings is nowadays a standard procedure for smooth or slighty contoured tool surfaces but becomes increasingly difficult for micro- and nanotextured surfaces. Tools with such surfaces are needed for optical and micromechanical parts with functional surfaces. However, the texturing amplifies the tool's geometric surface in comparision to a smooth surface and leads to an increased demolding force. These problems become even more severe while processing reactively-hardening optical polymers and laquers with high processing temperatures and high sticking tendencies.

### Objective

Development of a a hybrid, PVD-based inorganic-organic coating process which combines the deposition of a nanostructured hard coating by reactive sputter deposition with the subsequent deposition of an ultrathin teflon-like polymeric layer by plasma polymerisation without breaking the vacuum.
The nanostructured hard coating should reduce the reflectivity of the components' surface upon replication in analogy to the well known moth-eye effect. The teflon-like top layer should facilitate the demolding process.

## Hybrid Coating

PVD-CVD-coating equipment at Fraunhofer IWM

Deposition equipment :

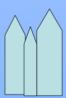
- separate PVD and CVD- deposition chambers with load-lock-system
- additional RF-biasing
- inline-process

Coating Parameters:

- RF-sputter-process for deposition of TiAlN- and $TiO_2$-nanostructured coating
  *Surface and Coatings Technology 200 (1-4), 1088 – 1092 (2005)*
  thickness 1µm – 3µm; mean structure size 150 nm -250 nm
- plasmapolymeric overcoat with microwave plasma, 100 W, $C_3F_6$-Gas as precursor; thickness ~30nm

## Results

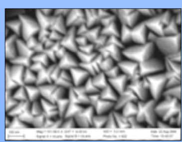
### Polymeric overcoat preserves structures from anorganic coating, no flattening of topography



coating

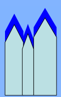


AFM: nanostructured TiAlN-coating 4,5µm x 4,5 µm

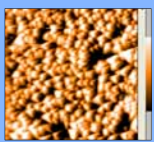




SEM: nanostructured TiAlN-coating

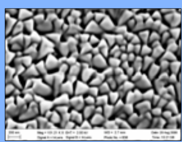


hybrid coating





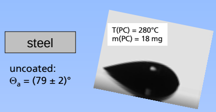
nanostructured TiAlN-coating with organic overcoat





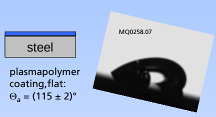
nanostructured TiAlN-coating with organic overcoat

### Surface energies and wetting behaviour of PC:



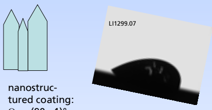


uncoated: $\Theta_a = (79 \pm 2)°$





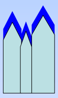
plasmapolymer coating, flat: $\Theta_a = (115 \pm 2)°$



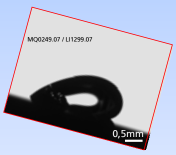


nanostructured coating: $\Theta_a = (90 \pm 1)°$

| material | Surface energy in mN / m | | |
|---|---|---|---|
| | disperse | polar | total |
| PC DP1-1265 | 31,38 | 4,64 | 36,03 |
| PTFE (Lit.) | 18,4 | 1,6 | 20,0 |
| ‚PTFE-IWM' MQ327.08 | 14 | 2 | 16 |
| Hybrid-coating (MQ0244.07 / LI1298.07) | 7,53 | 0,25 | 7,78 |



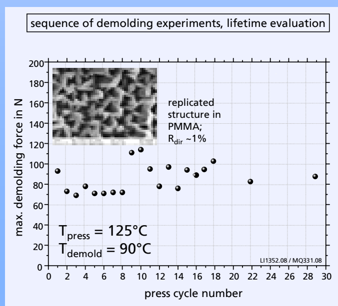
hybrid coating: $\Theta_a = (136 \pm 2)°$



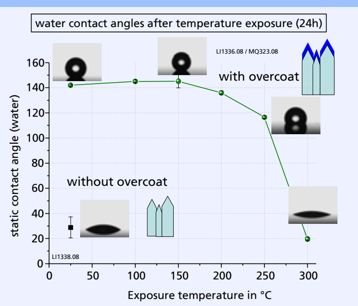


Polycarbonate -droplets (280°C) on different substrates, tilted setup

### Thermomechanical stability of plasmapolymer – overcoat





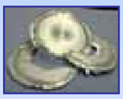




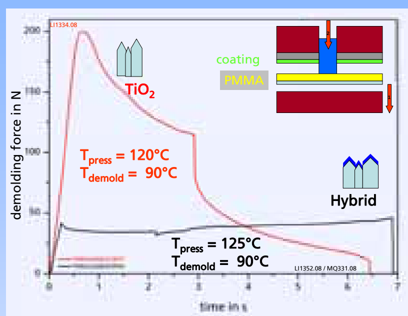
- no increase in delamination force after 30 press cycles
- stable contact angles up to ~ 200°C, total loss of hydrophobic effect at 300°C

### Replication process, Demolding force vs distance/time

experimental setup for replication process and measuring of demolding forces



Result of press-experiment at $T_{press}$= 125°C without organic overcoat





Without organic overcoat, damage-free demolding possible up to $T_{press}$= 120°C.
At temperatures $T_{press}$> 120°C, damage occurs during demolding.
With organic overcoat, demolding at $T_{press}$= 125°C possible, significant lowering of demolding forces observed.

## Conclusion

Inorganic/organic hybrid coating deposited, organic overcoat conserves structure of anorganic coating, very low surface energies, good durability > 30 press cycles, temperature stability > 200°C, significant lowering of demolding forces

## Acknowledgements

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INNONET

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