

# NANOCLEAN



Optimisation and upscaling of self-cleaning surfaces for the automotive sector by combining tailored nanostructured machined injection tools and functional thermoplastic nanocompounds



A European Project supported through the Seventh Framework Programme for Research and Technological Development

**CP-FP 229100**

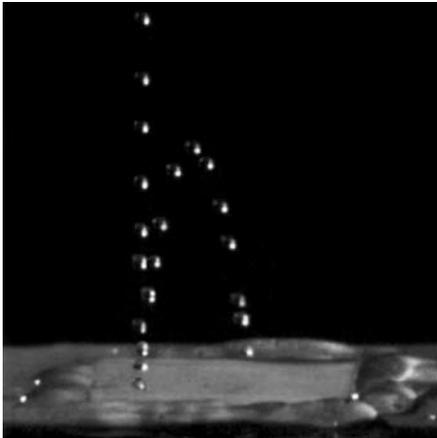
*NMP-2008—2.1-2 Processing and upscaling of nanostructured materials*



# BACKGROUND



*A water droplet in 'fakir' state on a Lotus leaf*



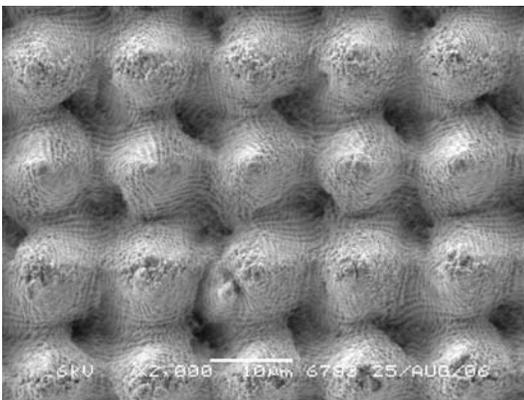
*A water droplet bouncing on a super hydrophobic plastic surface*

The goal of the NANOCLEAN project is to develop an industrial production method for injection moulded products to mimic the highly water repelling (super hydrophobic) surfaces of for example Lotus leaves. This property results in self-cleaning surfaces for outdoor applications, where rainwater washes off the dirt without leaving any traces.

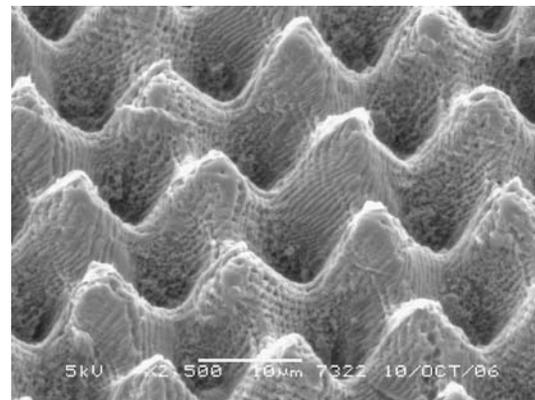
For such super hydrophobic surfaces a combination of low surface tension materials and a specific surface structure is required. The structure of the Lotus leaf for example is characterized by micropillars covered with waxy nanostructures.

The project based on the lab-scale technology that was developed at the University of Twente and further developed by the spin-off company Lightmotif. Ultrashort pulsed lasers are used to machine a negative combined micro-nano structure into a metal mould. By injection moulding the structure is directly replicated onto the plastic products. This way mass production with functional surfaces is enabled.

**The NANOCLEAN project aimed at up-scaling this technology by an integrated approach with the goal to mass-produce self-cleaning 3D complex plastic components for the automotive industry. This is achieved by applying functional structures to mould surfaces and copying them to plastic products by injection moulding.**



*A micro-nano structured surface in a steel mould*

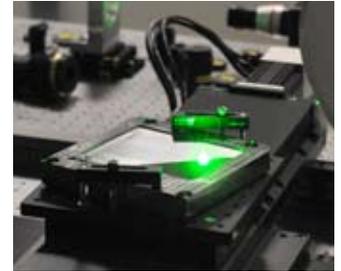


*The injection moulded plastic surface with the replica of the structure*

# PARTNERS

*Lightmotif*

Lightmotif developed the laser structuring processes, the machine and methods for structuring of flat and 3D curved surfaces.

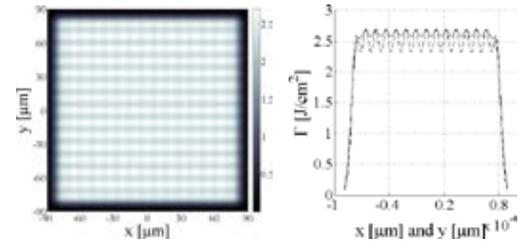


Maier designed and fabricated the moulds used in the project and injection moulded the plastic parts.



## UNIVERSITY OF TWENTE.

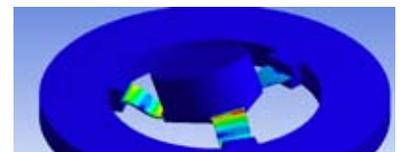
The University of Twente assisted in the analysis of surface structures and developed a model for nanostructuring of surfaces.



Gaiker-IK4 assisted in injection moulding and performed analysis on the functional surfaces.



Demcon assisted in mechatronic design of machine components for the 3D surface texturing machine.

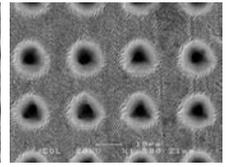
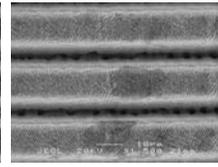
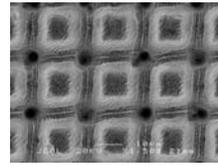
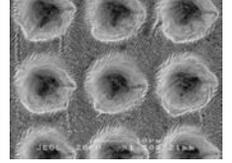
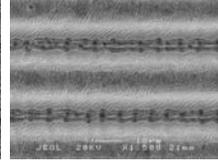
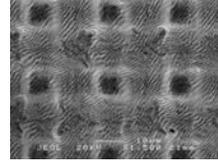
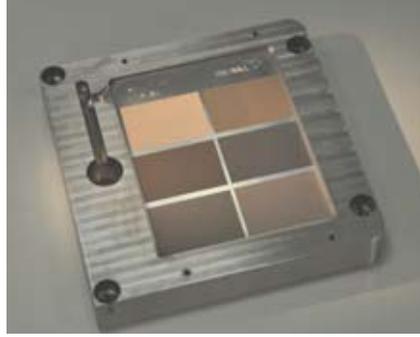
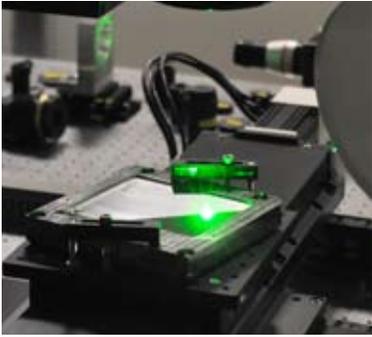


**CENTRO  
RICERCHE  
FIAT**

Centro Ricerche Fiat is the end user of the project, defines requirements and performs the final assessment.



# FLAT MOULDS

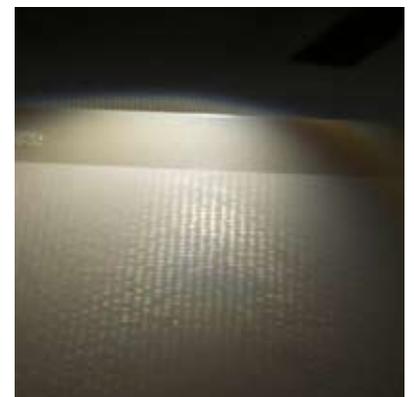


A mould for flat cavity inserts was designed and fabricated by Maier. Several inserts have been laser structured by Lightmotif and used for injection moulding of test plaques. In the first experiments various structures have been applied to the insert. The injection moulding of the micro-nano structures was optimized by Maier and Gaiker-IK4. Analysis by SEM and confocal microscopy was performed by the University of Twente to understand the replication behaviour.

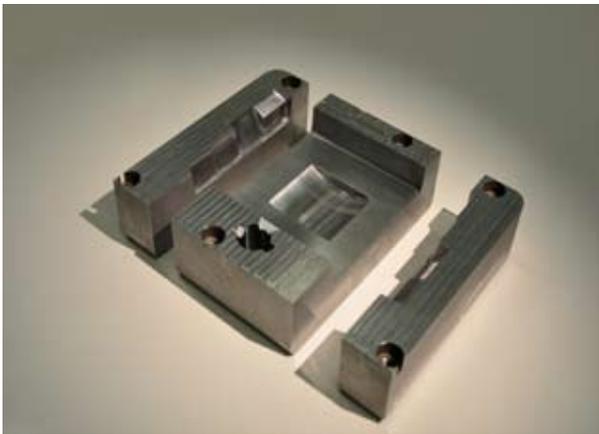
The plastic test plaques have been tested for various properties by Gaiker-IK4 and CRF. Most importantly the super water repelling behaviour was studied by contact angle measurements and falling droplets experiments.

Besides applications as self-cleaning surfaces, the structures can also be adapted towards improved haptics: silky soft surfaces are generated by specific microstructures.

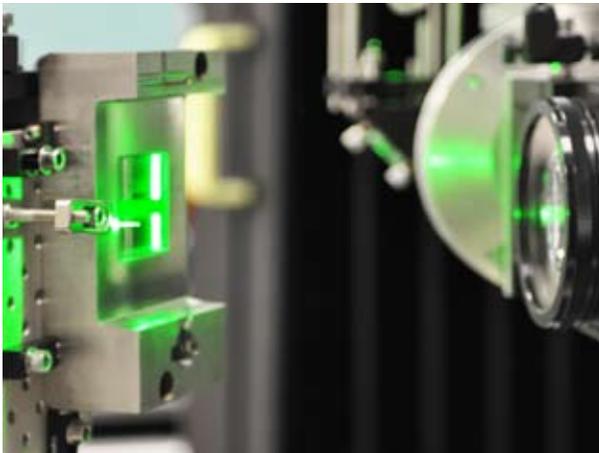
The structured surfaces are also highly anti-reflective. This is illustrated in the two pictures at the bottom right. A bright light reflects from the non-structured area, whereas the blinding reflection disappears on the micro-nano structured surface.



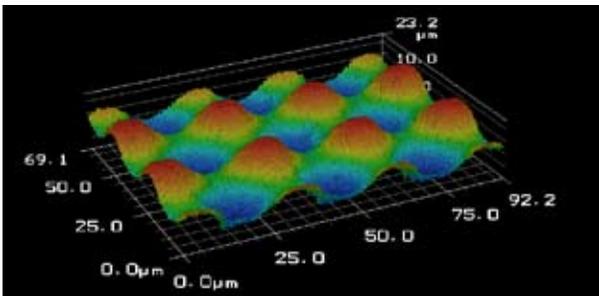
# 3D MOULDS



In order to apply these advanced functionalities onto real products the technology had to be developed towards 3D curved surfaces. Several aspects are affected by the transition from 2D to 3D surfaces, like what structures are capable of releasing from inclined surfaces in the mould and how to accurately laser machine the structures into a complex mould in the first place.



A specific mould was designed by Maier consisting of several inserts that could be individually structured. The inserts were equipped with surfaces showing various draft angles and a cylindrical surface. Lightmotif applied laser structures using different strategies and together with the University of Twente the results were analyzed and improved structures were chosen. Again Gaiker-IK4 performed analysis of the functional properties of the surfaces.

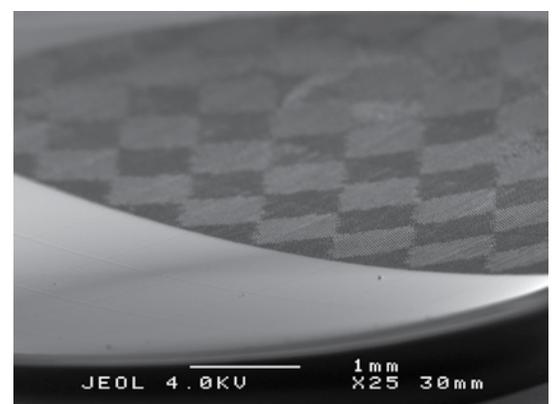
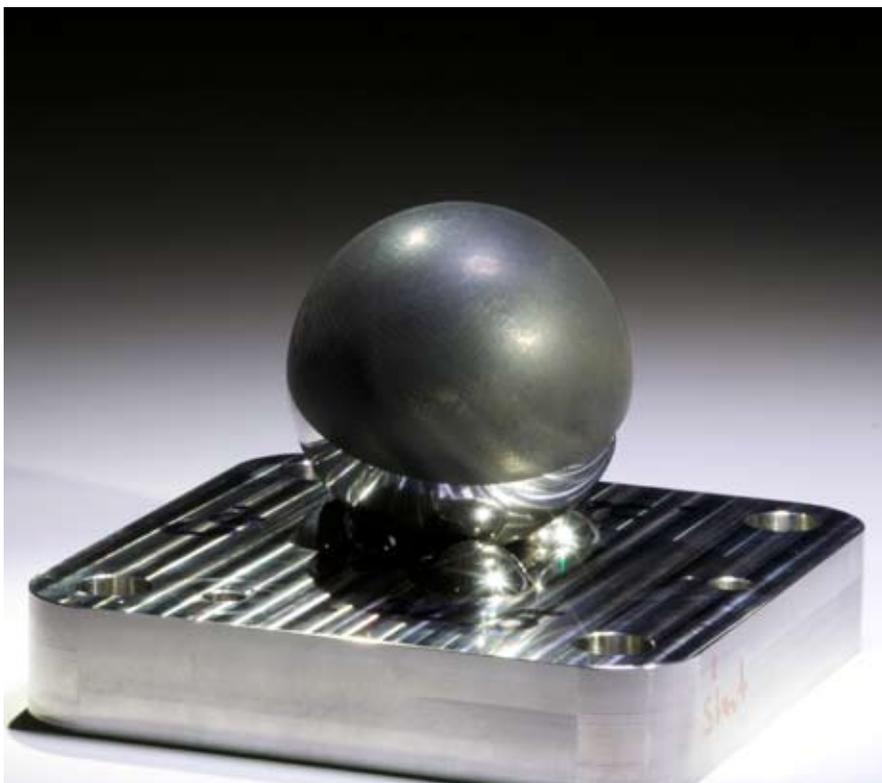
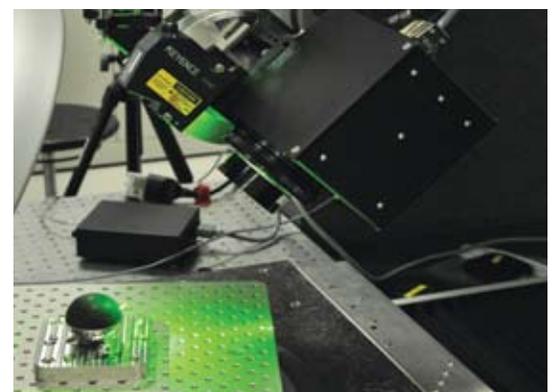
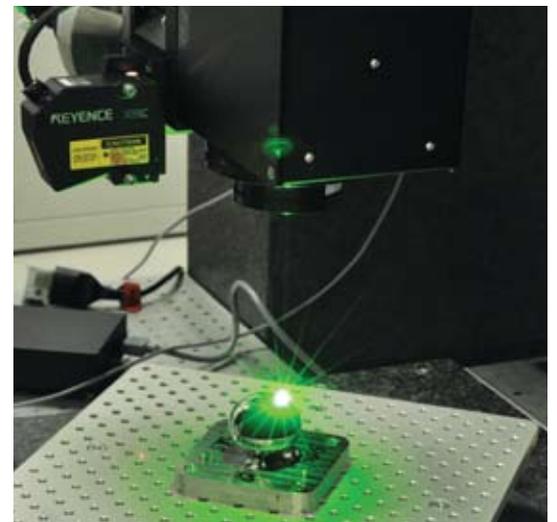
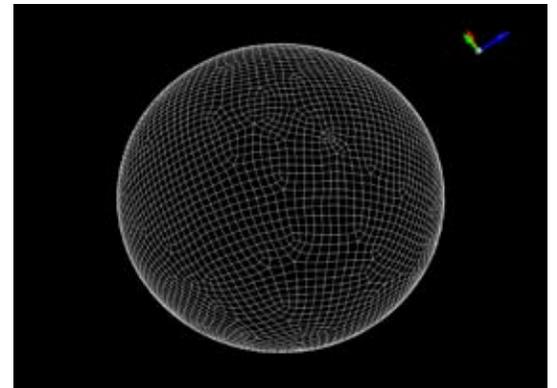


# CURVED SURFACES

Key in this technology is the ability to apply surface structures to freeform curved surfaces. For this a dedicated 5-axis machine was developed by Lightmotif. A kinematic model of the 5 axis machine was developed and integrated into Lightmotif's laser structuring software.

The structuring approach is based on a step and scan procedure. The surface is meshed into tiles that are individually structured by using a laser galvo scanner. The 5 axis machine is used to accurately position the galvo scanner in respect to each tile. The meshes are created using CAD data and the needed surface structure is distributed into each individual tile.

A first test was performed on a  $\varnothing$  50 mm stainless steel ball. Half of the ball was structured, appearing black due to the increased light absorption of the structures. The other half was machined with the edges of the individual tiles, illustrating the tiling approach. This is well visible on the cover page picture.

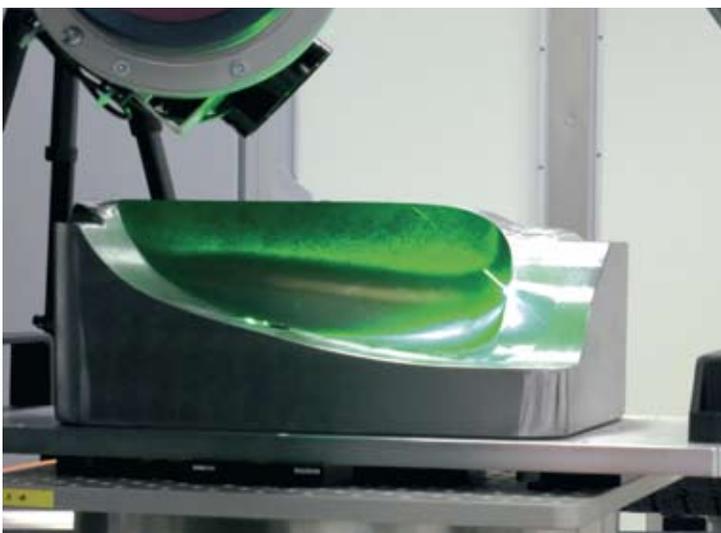
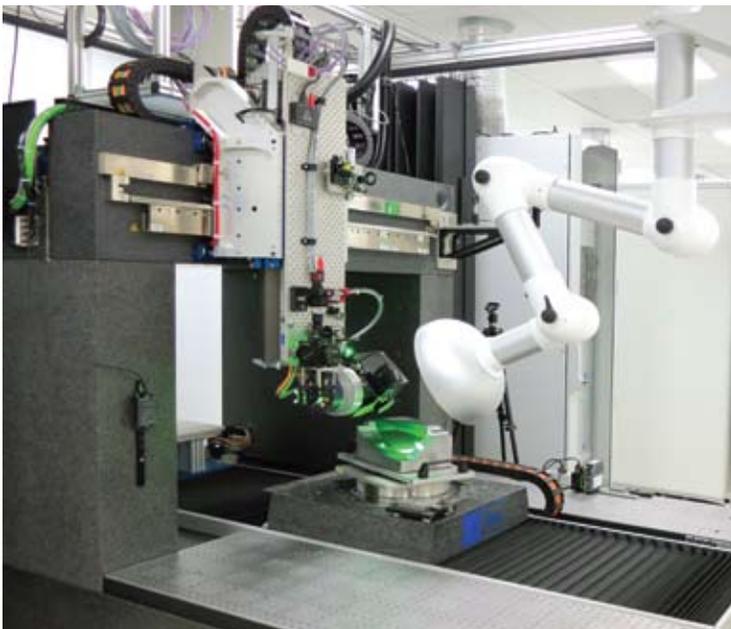
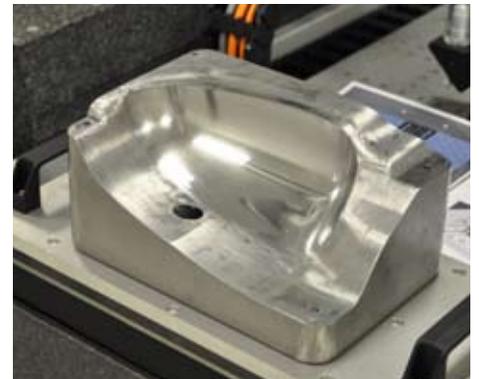


# DEMONSTRATOR

The project demonstrator is a plastic mirror cup. The mould was designed and fabricated by Maier. A 3D measurement of the cavity surface was performed to verify the surface accuracy needed for the laser micro-nano structuring.

The surface description from the CAD model was used by Lightmotif to generate the tile distribution and calculate the needed relative machine positions. The mould was calibrated and aligned to the laser structuring machine using the machine's integrated optical sensor systems. The laser structuring, shown on two pictures below, was performed successfully.

The injection moulding of structured plastic mirror cups using this mould is ongoing.



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## **CP-FP 229100**

### ***NMP-2008—2.1-2 Processing and upscaling of nanostructured materials***

#### **Project Facts:**

Duration: 2009 - 2012

Coordinator: Maier

Budget: 4.6 M€

EC Funding: 2.9 M€

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This brochure was created by Lightmotif.

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