1

2

Extract from the annual report 2018
To the website: www.ist.fraunhofer.de/en.html

STRUCTURES FOR AIRFLOW INVESTIGATIONS

In space travel, re-entry bodies are built with thermal shields to protect them against the enormous heat when entering the atmosphere. These shields must fulfill high safety standards. In order to be able to dimension them correctly, the influence of their surface properties on transition from laminar to turbulent flow is being measured in wind-tunnel investigations at the Institute of Fluid Mechanics of the Technische Universität Braunschweig. Within the framework of the project "HYPTRANS PAK742", the Fraunhofer Institute for Surface Engineering and Thin Films IST has therefore produced microstructures of differing roughness on a generic Apollo capsule.

Microstructures with defined roughness

A UV-sensitive photoresist, as used in semiconductor technology, is applied to the surface of the wind tunnel capsule model. Subsequently, a tempering step is performed. An exposure mask is then applied and exposed to UV radiation. Following development, resist microstructures remain on the surface in the center of the capsule base body (see Figure 2). The quadratic structures have a height of 20 µm and an edge length of 100 µm. The microscope image in Figure 3 shows that the distance between two microstructures is 100 µm as well. The entire so-called roughness patch covers an area of 20 x 20 mm^2.

Wind-tunnel trials

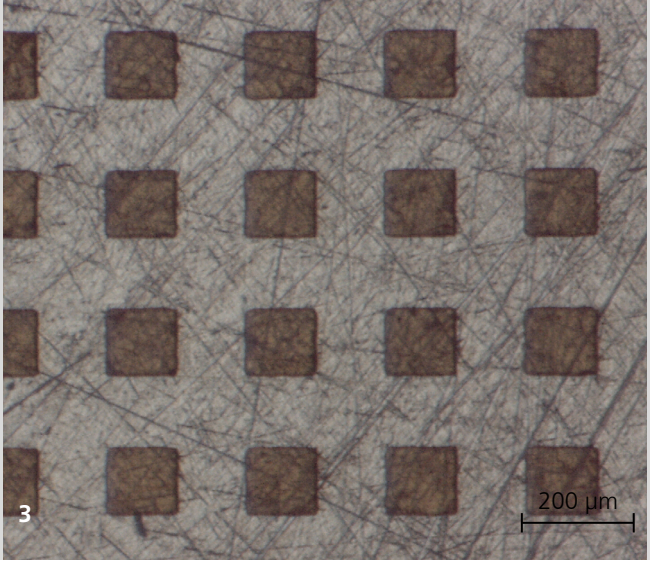
For the investigation of the transition processes, heatflux sensors are flush-mounted on the surface of the produced roughness patch. In order to be able to unequivocally determine whether the measured heat flows are in the laminar or turbulent range, simulation data are available for comparison with regard to the laminar heatflux distribution. A deviation of more than 5 percent from the laminar calculation is considered to be the starting point of the transition.

The simulated heat flow is derived from a purely laminar flow simulation with an ideally smooth wall. This dataset allows, through comparison, the categorization of the experimental data with respect to the shift from laminar flow to transition. It can be seen that, compared with the ideally smooth measurement configuration, the subcritical roughness patch has no influence and that a transition in the vicinity of the capsule shoulder only occurs once the freestream tunnel noise becomes sufficiently high, which corresponds to an alteration of the capsule position in the test area.

Outlook

For the next phase of experiments, the height of the elements will be set to 80 µm in order to obtain access to the area of pure roughness-based transition. The spaces between the structures are dimensioned with an optimal wavelength which, according to the flow simulation, predicts an optimal increase of disturbance energy causing transition.

Fraunhofer Institute for Surface Engineering and Thin Films IST | Bienroder Weg 54 E | 38108 Braunschweig | Germany



1 *Illustration of an Apollo capsule re-entering the atmosphere.*

2 *Test capsule with microstructures.*

3 *Microscope image of the microstructures on the surface of the test capsule.*

The project

The described results were obtained within the project "HYPTRANS PAK742". The project was funded by the Deutsche Forschungsgemeinschaft (German organization for science and research, DFG) within the second funding period from 2015 to 2018.

CONTACT

Dr. Saskia Biehl
Phone +49 531 2155-604
saskia.biehl@ist.fraunhofer.de

Nancy Paetsch
Phone +49 531 2155-765
nancy.paetsch@ist.fraunhofer.de

Fraunhofer Institute for Surface Engineering and Thin Films IST | Bienroder Weg 54 E | 38108 Braunschweig | Germany