BioCombs4Nanofibers

Project BioCombs4Nanofibers

D3.6 Replication of nanostructured surfaces

Reporting period	from	**01.10.2020**	to	**30.09.2022**
Report completed and released		**29.03.2022** **Werner Baumgartner**		

1. Goals and Detailed Description

Overall goal: **D3.6 Replication of nanostructured surfaces** is a public report on replication for download at the project web-site.

As an alternative approach to structuring metal- or polymer-surfaces by means of mechanical-, laser- or plasma-treatment, replication of nano-structured surfaces by casting was investigated. We could establish replication procedures by molding (biological) surfaces with dental silicon and either casting this mold with epoxy-resin or by obtaining a full metal replica by galvanic plating (Hischen et al. 2018). The principle for metal replicas is depicted in Fig. 1.

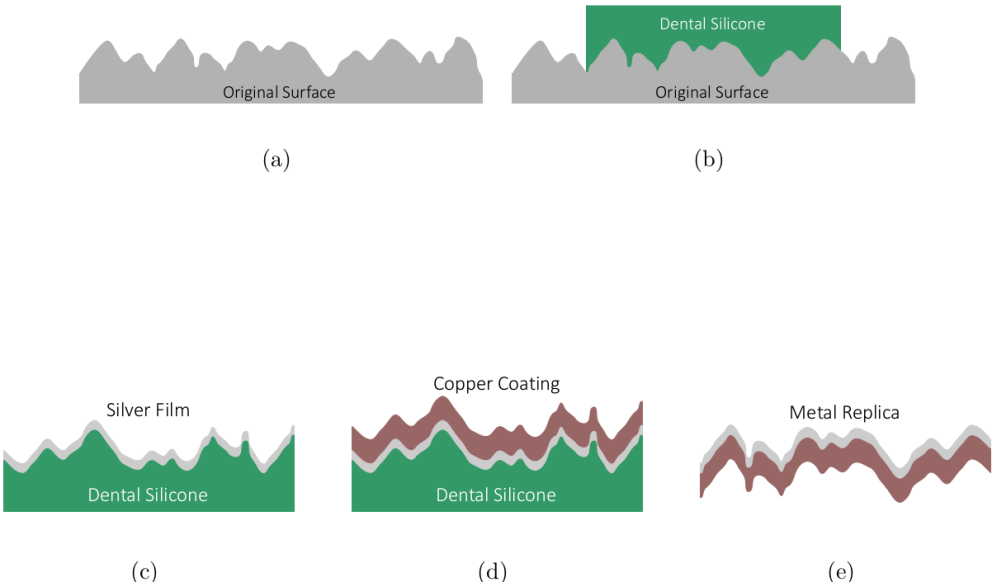

Fig. 1: Schematic of replication process: (a) original surface to be replicated; (b) dental silicone imprinting; (c) silver deposition on silicone mold; (d) copper electroplating; (e) finished copper replica.

Instead of the metal deposition simple casting of the dental silicon mold in vacuum with an epoxy resin can be applied.

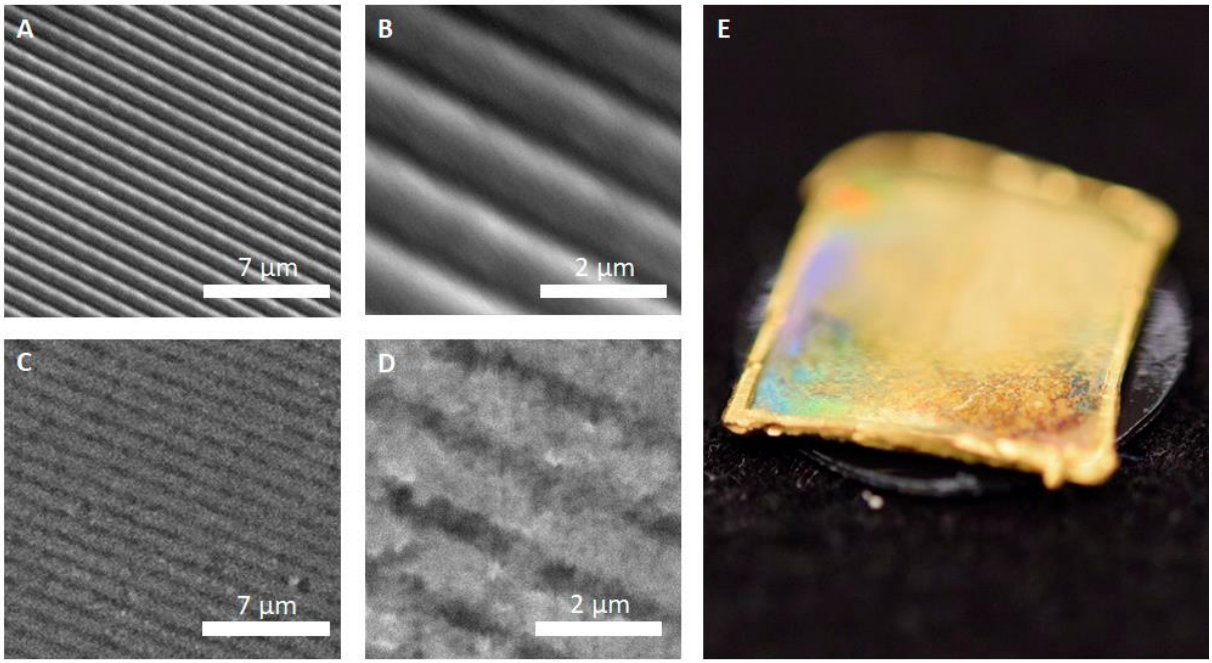

Fig. 2: A diffraction grid (overview in A and higher magnification in B) was replicated (overview in C and higher magnification in D) in Metal. A macroscopic view (E) shows that the diffraction properties are maintained (modified from Hischen et al.).

As shown in Fig. 2 ripples similar to the structures found on the calamistrum of cribellate spiders can, in principle, be replicated. The diffractive behavior of the surface can be reproduced as can be seen in the overview (Fig. 2E). Nevertheless, the resolution of the replication is rather limited.

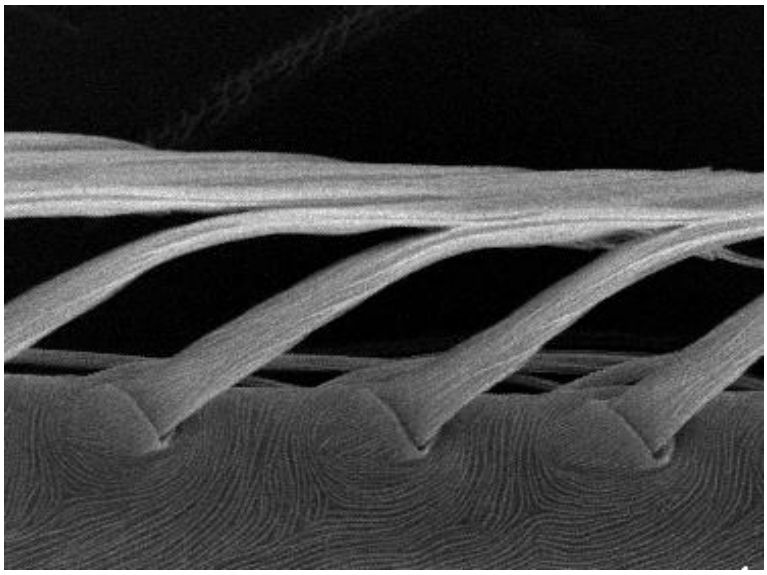

Fig. 3: SEM-image of the calamistrum on the leg of a feather legged spider (*Uloborus plumipes*).

We tried to directly mold the complete calamistrum of *Uloborus plumipes* (Fig. 3) and remove the leg from the silicone. Unfortunately, the setae were too fragile and the calamistrum was

ripped off when molded in vacuum. When trying to mold only the upper surface with reduced pressure, no impressions in the dental silicon were obtained, presumably due to the flexibility of the setae.

However, a rather similar finger print like structure as on the calamistrum can be found on other locations of the spiders legs, where the dimensions of the structures are slightly different with respect to spacing and heights of the ripples. This can be seen in Fig. 3 below the calamistrum. We could replicate these structures with mediocre resolution as can be seen in Fig. 4.

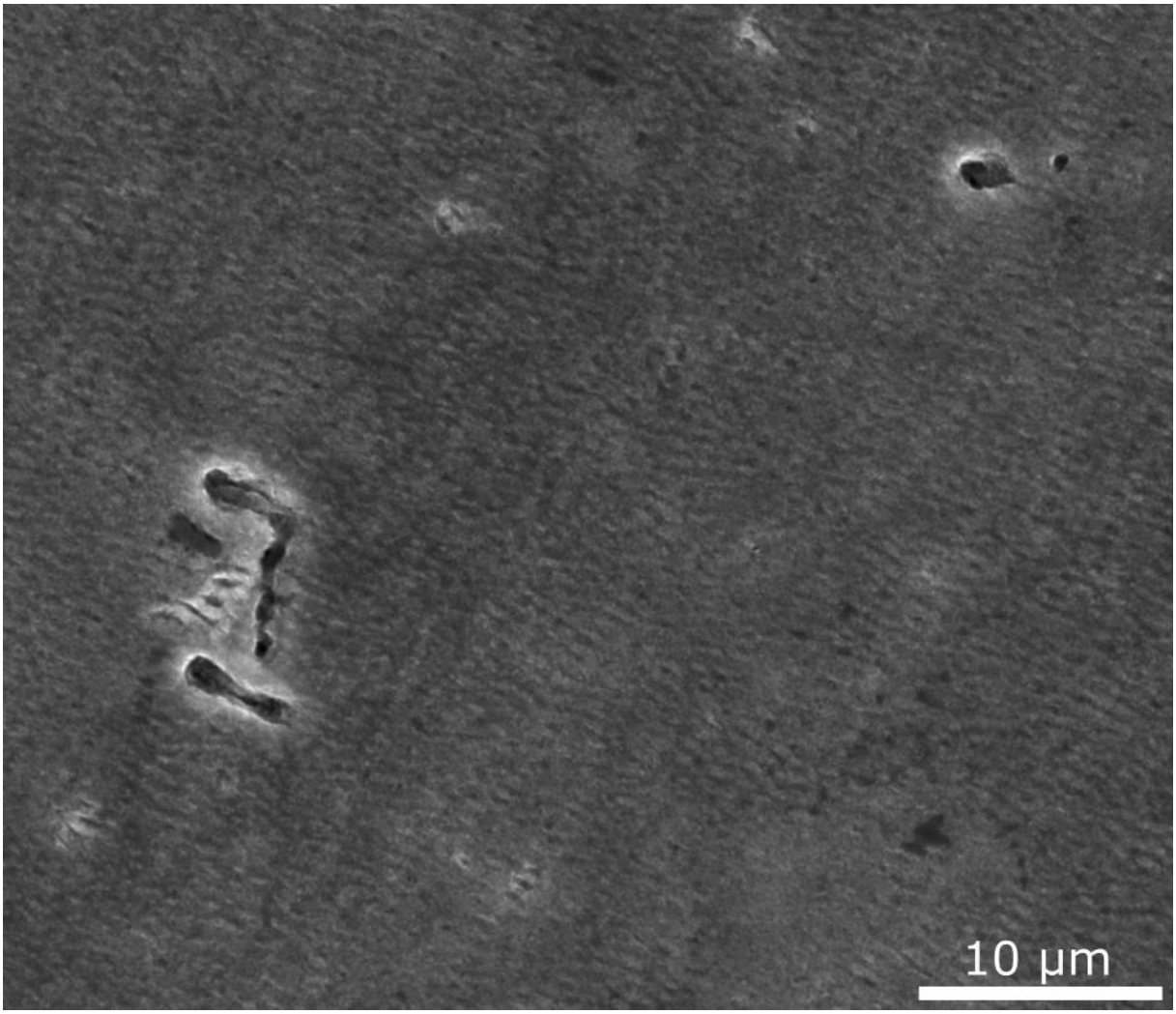

Fig. 4: Epoxy-replication of finger print like structures found on the leg of *Uloborus* in the vicinity of the calamistrum. In principle, the structure can be seen, however the resolution is rather limited and the surface is somewhat grainy and presumably due to air inclusions there are defects in the continuity.

Thus, the replication technique established is not very well suited for the replication of sub-µm-sized structures. However, the established methods were well suited for the flexible replication of µm-sized structures as the triangular shapes that were found to exhibit extremely low adhesion. Such a replicated surface is shown in Fig. 5.

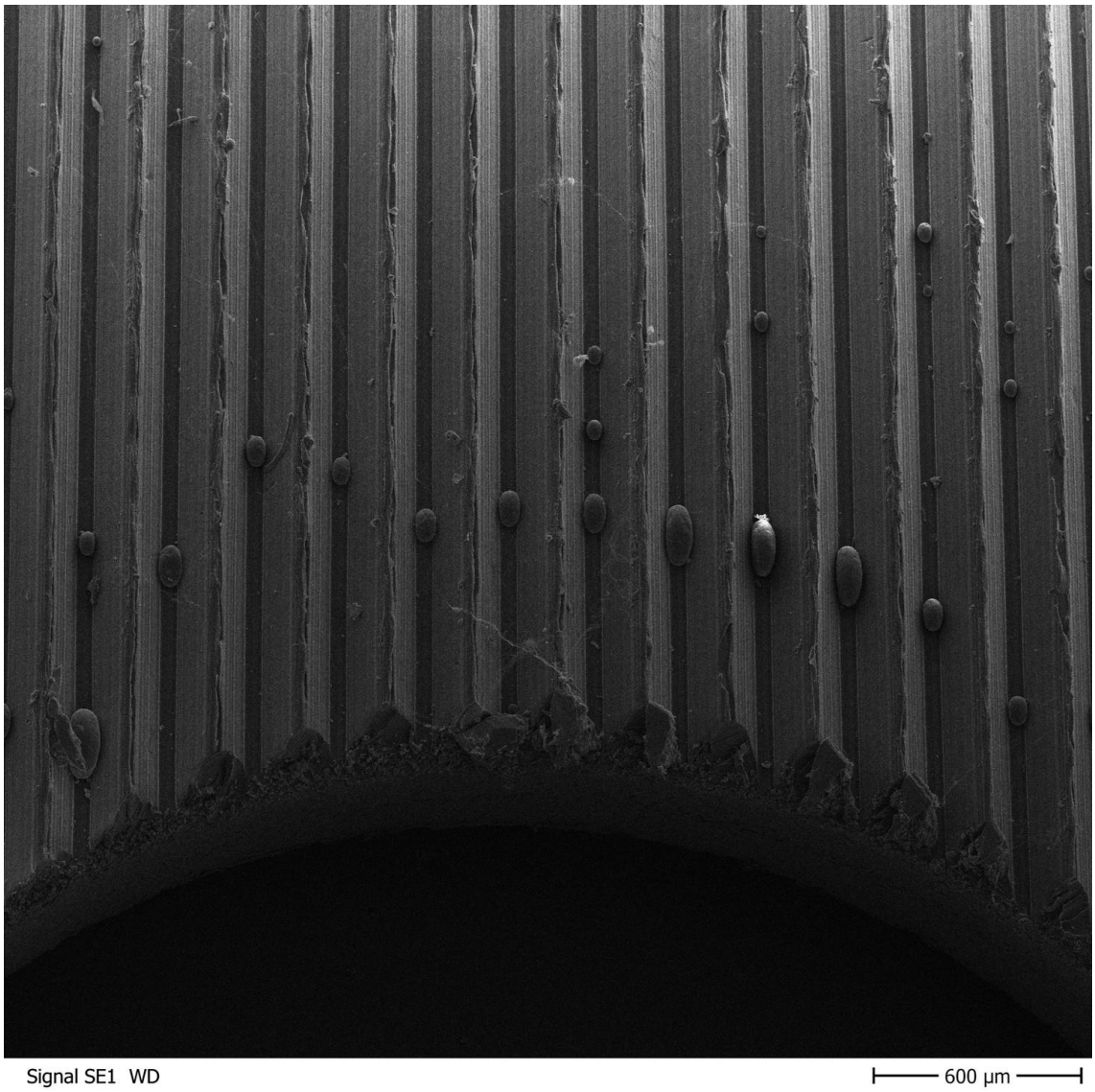

Fig. 5: Epoxy-replication of a low adhesive structure.

Details of this replication and the anti-adhesive properties of such surfaces are described in detail in D2.8 and in the milestone-report. Furthermore, a manuscript on this topic is currently in preparation and shall be sent to J. Bionic Engineering.

Literature:

Florian Hischen, Mirjana Keser and Werner Baumgartner, AMROBS: All-Metal Replicas of BiologicalSurfaces—A Novel Approach Combining Established Techniques, Biomimetics 2018, 3, 31; doi:10.3390/biomimetics3040031

2. Evaluation of Goals and Resulting Actions

This report has been finalized and submitted in time. It will be published on the website of the **BioCombs4Nanofibers** project (http://biocombs4nanofibers.eu).

Some results presented in this report are already published (Hischen et al.). Further results are planned to be published in scientific articles in the journals Beilstein Journal of Nanotechnology and Bionic Engineering.

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