Supplemental Document

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Metal-coated concave cone in a fused-silica rod as a multi-function plasmonic element: supplement

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FABRICATION

The solution devised and implemented at the University of Applied Sciences of Jena consists in diamond machining followed by polishing. Special tools are required for this machining sequence in order to be able to produce the 90° apex angle as accurately as possible. Figure S1 shows these 90° taper tools, which were manufactured and used by the company Günter Effgen GmbH.

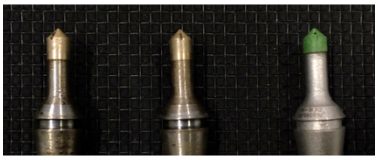

Fig. S1. 90° taper tools for shaping by ultrasonic-assisted grinding: a) metal-bonded tool with D91, b) metal-bonded tool with D30, c) resin-bonded tool with DX16.

Metal-bonded grinding tools with an average diamond grit of 91µm and 30 µm are used for pre-grinding, then fine grinding of the concave cone structures. This is followed by an ultrafine grinding process with the resin-bonded tool sketched in Fig. S1c. The finer diamond grit, average grit diameter of 16 µm, in combination with a resin bond already delivers very high surface quality. To ensure sufficient cooling of the grinding layer, the tools were provided with internal cooling. The slotted structure ensures the cooling of the diamond grain in the contact zone and also an efficient removal of the abraded quartz particles. By using a superimposed ultrasonic vibration (amplitude approx. 4 µm and frequency > 20 kHz) along the rotation axis of the grinding tool, gentler processing can be achieved. This grinding technology can ensure a very sharp upper edge of the cone oblique wall without chipping. After ultra-fine grinding, however, the Mid-Spatial Frequency Error is still too large. This manifests itself in periodic grinding grooves caused by the inherent basic kinematic principle of circumferential grinding. These errors could be eliminated by a subsequent lapping process. For this purpose, a special lapping tool was made of aluminum with a conical head of 90°. A WCA600 precision lapping powder medium was used. After the above machining sequence, the concave cone wall is ready to be submitted to the last process of polishing which also requires a dedicated polishing tool made here in a much softer polymer material by means of the additive manufacturing process Polyjet 3D Printing of Stratasys [1] with different printed and tested shore hardness. The final surface roughness of 4 nm meets the requirements for the subsequent coating process. The required processing times for each step are given in table S1.

Table S1: Summary of required processing times

Machining step	Machining time
Pre-grinding	20 minutes
Fine grinding	6 minutes
Ultrafine grinding	13 minutes
Lapping	1 minute
Polishing	6 minutes

The gold layer was deposited at the Hubert Curien Laboratory of Saint-Etienne University using a thermal evaporation technique in high vacuum at a rate of 10 Å/s controlled by a quartz crystal. A mask prevented the deposition of the metal at the cylinder wall. The thicknesses (and those in Fig. 2 in the main text) are defined normally to the interface. The deposition is oblique under 45 degrees; hence a corrective factor is used. Each of the gold thicknesses was checked a posteriori by profilometer measurement on a flat sample placed perpendicularly to the evaporation source.

Reference

1. Y. Lu Tee, C. Peng, P. Pille, and M. Leary, JOM: the journal of the Minerals, Metals & Materials Society **72** (3), 13 (2020).