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Nanoantennas interfaces formation by laser micromachining of thin-film coatings

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Optical antennas are the microsized equivalent of classic microwave antennas used to transmit and receive information. A characteristic feature of such antennas is the ability to enhance photophysical effects. The basis of the antenna is its interface¬ – a thin-film structure of a given geometry from a conductive material, formed on a dielectric substrate. The actual solution to the problem of manufacturing optical antennas interfaces is the use of selective laser ablation technology by femtosecond pulses as a flexible technology for the formation of complex geometry thin-film elements.

Laser ablation technology implies the formation of micro-sized elements according to a top-down mechanism by controlled removal of coating areas from a dielectric substrate. A laser system with a wavelength of 1029 nm was used as a radiation source for the experiments. The radiation was focused by means of a 50x objective, the diameter of the laser spot in the waist region was 1 µm, and the focus position was fixed. To move the processed sample relative to the laser beam, a nano-positional platform was used (Fig. 1).

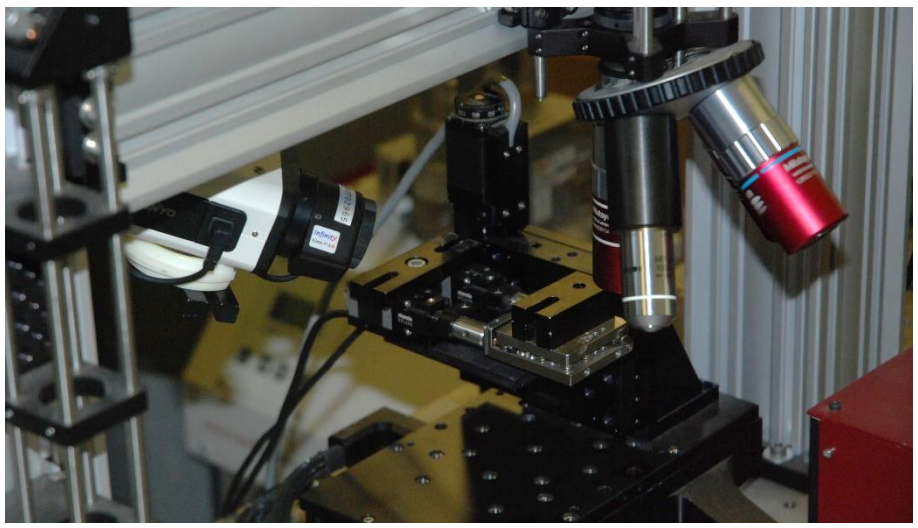

Fig. 1. System of laser radiation automated focusing and samples spatial positioning.

The main problem of microsized processing of thin-film coatings is the selection of operating parameters to ensure uniform material removal. Insufficient radiation power, instead of the material ablation effect, leads to volumetric heating of the surface, which causes the film to peel off. Exceeding the threshold power can cause melting of the substrate, mixing of the material in the molten bath region.

Fig. 2 shows an example of bow-tie shaped optical antenna interfaces. In applied problems of topological structures synthesis, the presented thin-film elements are formed in the form of extended arrays, which implies a significant duration of the processing operation.

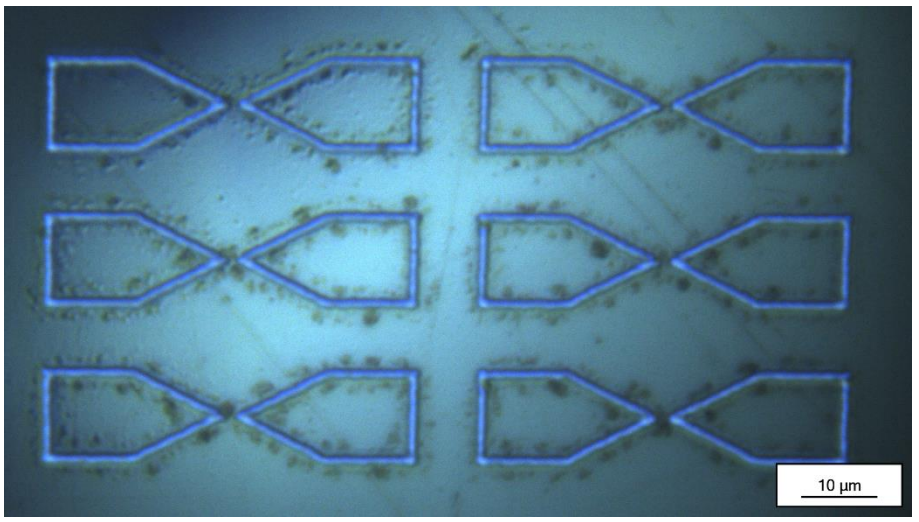

Fig. 2. Optical antennas interfaces array formed by femtosecond laser ablation.

The prepared samples were examined by scanning electron microscopy methods. The obtained results show the presence of minimal deviations of the geometric contours of the formed microsized structures from the standard, which is achieved through the use of original synchronization algorithms for the laser system and the sample positioning system.