NANOANTENNAS INTERFACES FORMATION BY LASER MICROMACHINING OF THIN-FILM COATINGS

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Nanoantennas are the optical equivalent of classical antennas used to receive and transmit information at radio and microwave frequencies. Like RF antennas, nanoantennas are capable of efficiently converting optical radiation into highly localized fields (receiving antennas) and reverse transformation (transmitting antennas). At the moment, a number of scientific papers have been published describing the successful use of elements. At present, nanoantennas are already successfully used in near-field microscopy and Raman spectroscopy. The use of such nanoscale structures as biomedical sensors and high-resolution environmental control sensors is extremely effective [1-6].

There are many methods of micro- and nanoscale technologies for obtaining and processing thin-film elements. The indisputable advantage of thin-film technologies is their flexibility, which is expressed in the possibility of selecting materials with optimal characteristics and obtaining almost any required element configuration. In this case, the tolerances with which individual parameters are maintained can reach a few percent. The following types of metals are used as the material of the conductive layer of the substrate: gold, silver, copper.

In view of the foregoing, the most relevant solution to the problem of obtaining nanocircuit elements, in particular nanoantennas, is the use of femtosecond laser writing technology to form the topological structure of elements on the substrate surface. Selective laser ablation technology with ultrashort pulses offers an excellent solution for precision-controlled processing of thin film coatings and the formation of micro- and nano-sized features. Studies of the characteristics of the formed nanosized structures are carried out by the methods of scanning electron and atomic force microscopy.

The use of ultrashort laser pulses as a tool to selectively remove areas of thin film coatings offers a unique approach for rapid prototyping and validation of various optical antenna interface geometries. A correctly selected mode of exposure allows avoiding physical and thermal damage to the adjacent surface, as well as preventing changes in the morphology of the dielectric substrate.

Bibliography

1. Huang W. et al. Versatile visual logic operations based on plasmonic switching in label-free molybdenum oxide nanomaterials //Analytical chemistry. – 2018. – T. 90. – №. 3. – C. 2384-2388.

2. Yarahmadi M., Moravvej-Farshi M. K., Yousefi L. Subwavelength graphene-based plasmonic THz switches and logic gates //IEEE Transactions on Terahertz Science and Technology. – 2015. – T. 5. – №. 5. – C. 725-731.

3. Yesilkoy F. et al. Phase-sensitive plasmonic biosensor using a portable and large field-of-view interferometric microarray imager //Light: Science & Applications. – 2018. – T. 7. – №. 2. – C. 17152-17152.

4. Chkalov R. V. et al. Femtosecond laser-induced formation of low-dimensional thin-films elements //Journal of Physics: Conference Series. – IOP Publishing, 2019. – T. 1164. – №. 1. – C. 012009.

5. Kuchmizhak A. A. et al. Multi-beam pulsed-laser patterning of plasmonic films using broadband diffractive optical elements //Optics letters. – 2017. – T. 42. – №. 14. – C. 2838-2841.

6. Wang A. et al. Mask-free patterning of high-conductivity metal nanowires in open air by spatially modulated femtosecond laser pulses //Advanced Materials. – 2015. – T. 27. – №. 40. – C. 6238-6243.