VISUALISATION OF FEMTOSECOND LASER ABLATED MICROSTRUCTURES IN DLC:AG NANOCOMPOSITE THIN FILMS VIA MAPPING WITH SPECTROSCOPIC ELLIPSOMETRY

Justas Deveikis[1], Aušrinė Jurkevičiūtė[2], Tomas Tamulevičius[1,2], Sigitas Tamulevičius[1,2]

[1] Department of Physics, Faculty of Mathematics and Natural Sciences, Kaunas University of Technology, Studentų st. 50, LT-51368 Kaunas, Lithuania
[2] Institute of Materials Science of Kaunas University of Technology, K. Baršausko st. 59, LT-51423 Kaunas, Lithuania
justas.deveikis@ktu.edu

Diamond-like carbon (DLC) thin films are well known of their distinctive mechanical, optical, electrical and chemical properties [1]. Introducing free electron metal nanoparticles into DLC can be used to tailor the properties of films even further and opens up new possibilities in plasmonics. In this work, we investigated nanocomposite DLC films with embedded silver nanoparticles (DLC:Ag), irradiated by femtosecond laser. The analyzed films on the quartz substrate were deposited employing reactive magnetron sputtering of silver target in direct current mode under hydrocarbon atmosphere [2]. It was determined that the silver content in 60 nm thickness film was 12.6 at %.

Spectroscopic ellipsometry (SE) is a powerful optical measurement technique which is used to determine the change in polarized light upon reflection or transmission on a sample. This technique basically measures two parameters: amplitude ratio Ψ and phase difference Δ between *s* and *p* polarized waves [3]. Using these parameters, it is possible to calculate refractive index and the thickness of the film, deeper analysis provides information about surface roughness, etc.

Direct laser interference patterning (DLIP) was employed to impose periodic patterns in DLC:Ag films. A matrix of points varying applied number of pulses (1000-125000 pulses) and laser fluence (1-17 mJ/cm^2) was imposed. Total irradiated area was 300 × 300 μm^2. Data for preparing the SE map was acquired using spectroscopic ellipsometer GES5-E (Semilab). The angle of incidence was 75° and the step along *x* and *y* axis was 30 μm. Ψ parameter map was plotted at the wavelength of 690 nm and Δ was plotted at the wavelength of 640 nm (Fig. 1 a and b respectively). The wavelengths for different parameters Ψ and Δ map were chosen with highest differences in parameter values at different areas of the sample (Fig. 1c).

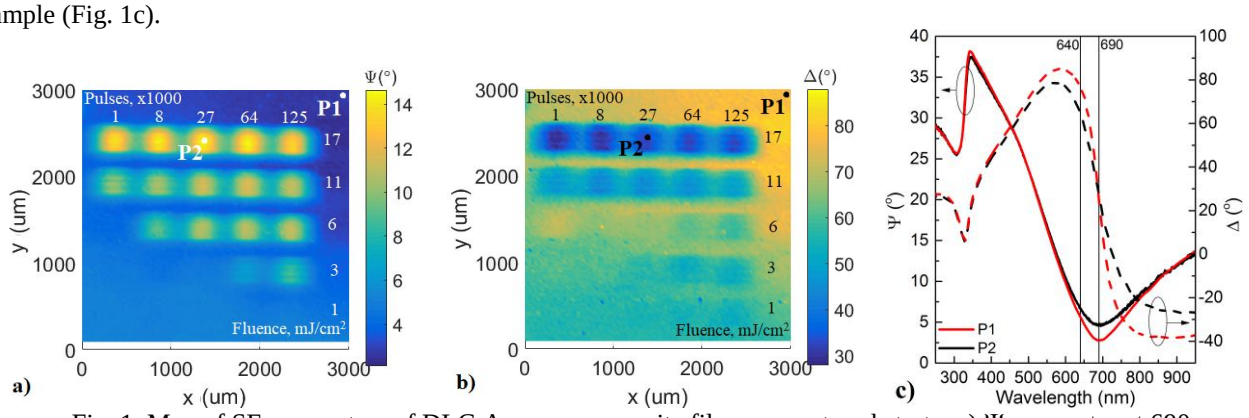

Fig. 1. Map of SE parameters of DLC:Ag nanocomposite film on quartz substrate: a) Ψ parameter at 690 nm wavelength; b) Δ parameter at 640 nm wavelength; DLIP fluence increases from bottom to top and number of pulses from left to right. c) Ψ and Δ dependencies on wavelength at two different sample locations identified (P1, P2) on the SE maps.

From the obtained SE maps, it is clear that increasing laser fluence provides highest differences in ellipsometric parameters. At fluences 6 mJ/cm^2 and lower, number of pulses becomes an important parameter. The further data analysis would lead to thickness decrease and refractive index modifications depending on applied number of pulses and laser fluence.

[1] J. Robertson, Diamond-like amorphous carbon, Master. Sci. Eng. R. Reports. **37**, 129-281 (2002).
[2] Sigitas Tamulevičius, Šarūnas Meškinis,Tomas Tamulevičius. Diamond like carbon nanocomposites with embedded metallic nanoparticles, Rep. Prog. Phys. **81**, 024501 (2018).
[3] H. Fujiwara. Spectroscopic Ellipsometry: Principles and Applications. 2007 John Wiley & Sons, Ltd. ISBN: 978-0-470-01608-4.