EVALUATION OF DIAMOND-LIKE CARBON COATINGS ON PDMS SUBSTRATES

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[ENGINEERING OF BIOMATERIALS 138 (2016) 118]

Introduction

In recent years, an increase in the use of carbon coatings in variety of areas including medicine can be observed. Such interest in these coatings is primarily due to their chemical inertness, good corrosion resistance and biocompatibility [1-2]. They are used successfully in the modification of metal and polymer surfaces [3-4]. This work is devoted to research of carbon coatings produced on PDMS polydimethylsiloxane polymer substrates using radio frequency methane plasma (RF PACVD). The investigation was aimed to determine the influence of the thickness of the substrate and RF power on the properties of synthesized coatings.

Materials and Methods

In this work, PDMS from Dow Cornning Inc. company, under the name of Sylgard 184 was used. Before the modification, the substrates were cleaned in ultrasonic cleaner in isopropyl alcohol bath for 10 min and then dried using compressed air, and placed onto the water cooled RF electrode in plasma-chemical reactor. The modifications of PDMS substrates were conducted using radio frequency plasma assisted chemical vapour deposition (RF PACVD) method. The chemical structure was determined using the inVia confocal micro-Raman (Renishaw) and Nicolet IS50 FTIR spectrometers. Dry sliding friction and wear tests were conducted on T-11M tribometer working in ball-on-disc configuration. As the counter sample, commercially available ZrO_2 balls 6.35 mm in diameter were used.

Results and Discussion

Optical microscopy results of PDMS substrates before and after the modification made it possible to determine that the plasma treated PDMS surface is more developed, and takes the form of “wrinkles”. The smallest surface irregularities were observed for carbon coatings synthesized with the RF power of 900 W. In addition, a tendency to increase the surface irregularities with decreasing the PDMS substrate thickness was observed.
The results of Raman spectroscopy primarily were used to determine the chemical structure of carbon coatings in the preliminary investigation. Based on the calculated ID/IG ratios, for each carbon coating, it was determined that it changes depending on the RF power – initially it decreases between 100 and 500 W, and subsequently increases between 500 and 900 W.
The highest concentration of C-C sp^3 hybridized carbon bonds contains the coating synthesized under RF power of 500 W, whereas the lowest was observed for coating synthesized under the RF power of 900 W. Further Raman spectra analysis conducted on samples with different thickness have shown, that in the case of RF power of 300 and 500 W the thickness of the substrate has no significant influence on the shape of registered Raman spectra. The FTIR spectroscopy made it possible to characterize the chemical bonds present on the surface of PDMS substrates and carbon coatings as well. Based on the FTIR spectra in the range between 1500 – 500 cm^{-1} it was determined, that carbon coating manufactured under RF power of 500 W contained higher concentration of Si-O-Si bonds, compared to these synthesized under RF power of 300 and 900 W. Based on the analysis of spectra in the range between 3000 – 2850 cm^{-1} changes in the concentration of C-C sp^3 bonds were determined. Based on the observations of changes of the coefficient of friction in time under load of 1N, it was concluded, that the result of formation of carbon coatings on the PDMS substrate is decrease of this parameter. The value of coefficient of friction for the carbon coatings was between 1 – 1.5, whereas for the unmodified substrate it was 4.2. The lowest value of the coefficient of friction was obtained for RF power of 500 and 900 W.

Conclusions

The results of conducted research proved the influence of the conditions of synthesis of carbon coatings on their surface morphology, chemical structure and tribological properties. It was determined that the highest concentration of C-C sp^3 bonds was characteristic for coatings synthesized under RF power 500 W, and the lowest for RF power of 900 W. Carbon coatings made it possible to decrease four times the value of the coefficient of friction. The presented results prove the possibility of steering the properties of carbon coatings synthesized on PDMS substrates using varying RF power supplied during the modification. The thickness of the modified polymer substrates does not significantly influence the changes in structure and chemical bonds of DLC coatings.

Acknowledgments

The works have been financially supported by the Ministry of Science and Higher Education of Poland as the research project Micro- and Nano-Systems for Chemistry and Biomedical Diagnosis MNS DIAG POIG.01.03.01-00-014/08-00

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