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Faculty of Material Science and Applied Chemistry

ABSTRACTS

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Bolometric Photoresponse of Polymer/Nanostructured Carbon Composite

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Keywords – **carbon, nanocomposite, bolometric sensor**

I. Introduction

Attempts to utilize polymer/carbon nanoparticle composites for use in optoelectronics are being made (e.g., single-walled carbon nanotubes are being used as polymer fillers)[1,2,3]. Polyisoprene/nanostructured carbon (PNC) composites show large resistance change effect as mechanical strain is applied[4]. Therefore, it was expected that PNC composites also could show bolometric photoresponse.

In this study, bolometric photoresponse measurements of PNC composites containing carbon black (CB) filler irradiated by a laser beam of different wavelengths were conducted.

II. Samples and Experiment

A. Samples

PNC samples were manufactured from PaleCrepe natural rubber (with curing ingredients) and high structure CB Degussa™ Printex™ EX-2 using Rondol™ hot press. Electrical contacts were created using Electrolube™ Silver Paint. The area of sample to be irradiated was matched with the diameter of laser beam (2.2 mm). The thickness of samples was 0.2 mm. Several series of samples containing different amount of CB were created.

B. Experiment

The measurement setup was as follows. The sample was connected through the wiring to the data acquisiton unit Agilent 34970A which measured the electrical resistance. The sensitive area of measured sample was cyclically irradiated by a laser beam. Semiconductor 532, 650 and 980 nm continuous wave lasers were used as light sources. Exposure time to the beam was 30 s. After the irradiation the beam was "switched off" with a shutter for 30 s. Then the cycle was started again. To monitor the laser beam power Ophir Nova II laser power meter was used.

III. Results and Discussion

PNC samples containing 6 phr of CB, which is in the percolation transition region for CB concentration, showed a maximum relative resistance change $\Delta R/R_0$ under the same light intensity. At the same time, these samples showed more resistance noise. Since PNC samples containing 8 phr of CB showed high relative resistance change and small electrical resistance noise in the same time, they were chosen for series of different experiments.

Measurements with samples containing 8 phr of CB showed that relative resistance change effect is considerably larger when the sample is irradiated with 532 nm laser beam compared to 980 nm laser beam. One illustration of PNC composites' relative resistance change graph for different laser radiation wavelengths is given in Fig.1. It can be seen that the sensitivity of the sample is approximately 1.8 times larger to green light than to infrared light. The reason for such a difference in sensitivity could be in the different ability of PNC composite to absorb light of different wavelengths.

From additional measurements conducted it is known, that at the same laser beam intensity (12.4 mW/mm^2) when samples with increased thickness (1 mm vs regular 0.2 mm) are irradiated the exposure time to achieve maximum $\Delta R/R_0$ is approximately twice as long than for thin samples. This indicates that the resistance change effect has a thermal or mainly a thermal origin. The mechanism of laser beam induced resistance increase in PNC composite is as follows: thermo-optically induced matrix expansion causes exponential reduction of tunnelling currents between carbon nanostructures in the composite, thus, the resistance of composite increases[4].

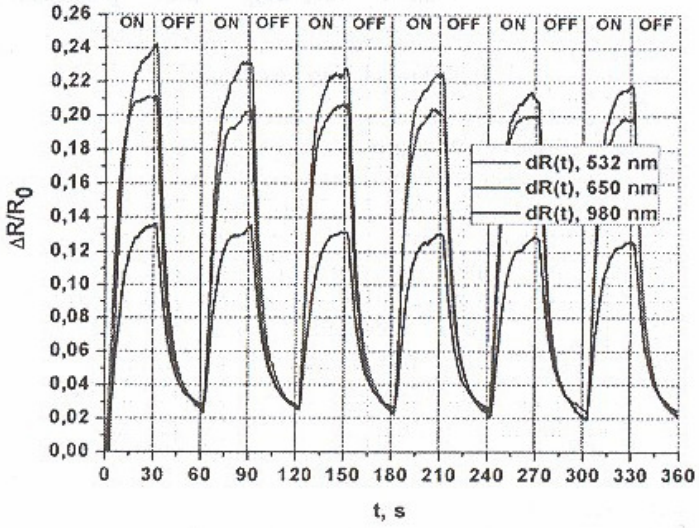

Fig.1. Relative resistance change of PNC composite containing 8 phr of CB irradiated by 532, 650 and 980 nm laser beam with same intensity (12.4 mW/mm^2).

IV. Conclusions

PNC samples containing 8 phr of CB have shown that the largest sensitivity from three laser wavelengths used is achieved in case of 532 nm light. Experiments with samples with increased thickness indicate that the resistance change effect mostly is caused by thermal expansion of the polymer matrix. To estimate possible photoconductivity effect, precise surface temperature measurements should be conducted.

V. References

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