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Piezoresistive sensing performance of ex-situ transferred nanocrystalline graphite on a flexible substrate

O.-G. Simionescu[1,2], C. Pachiu[1], G. Crăciun[1], N. Dumbrăvescu[1], S. Vulpe[1], A. Avram[1], R. C. Popa[1], O. Buiu[1]
[1]National Institute for Research & Development in Microtechnologies, 126A Erou Iancu Nicolae street, Voluntari city, Ilfov county, 077190, Romania;
[2]Faculty of Physics, University of Bucharest, 405 Atomistilor street, Măgurele city, Ilfov county, 077125, Romania;

ABSTRACT

Our contribution presents the performance of NCG as a piezoresistive element in strain sensors. The NCG film is grown by plasma enhanced chemical vapour deposition (PECVD) (Nanofab 1000 - Oxford Instruments, UK) on a metallic substrate; the structure and the morphology of the film is investigated by Raman spectroscopy (high resolution Scanning Near-Field Optical Microscope fited with the Raman Module Witec Alpha 300S - Witec, Germany) and scanning electron microscopy (SEM) (Nova NanoSEM 630 Scanning Electron Microscope - FEI Company, USA). After the ex-situ transfer onto a flexible substrate, the piezoresistive performance is investigated by measuring the electrical resistance (precision multimeter 8846A - Fluke, USA) of the sensitive layer during controlled mechanical stretching (MultiTest 2.5-i - Mecmesin, UK) of the device. Experimental results confirm NCG is a fitting material for low-strain (< 1%) piezoresitive sensing, GFs of up to 236 being recorded.

EXPERIMENTAL DETAILS

The NCG growth is carried out by RF-PECVD in a CH_4:H_2 (1:1.25) atmosphere, using a parallel plate reactor. The precursor is injected through the top electrode, while the substrate is placed on the lower grounded electrode. The full process parameters are presented in Table 1.

Table 1: NCG growth parameters

Step	Time t (min)	Heating speed (°C/min)	Temperature T (°C)	Pressure p (Pa)	RF power P_{RF} (W)	Gas flow (sccm)		
						Ar	H_2	CH_4
Heat-up	-	15	200↗890	40	-	1500	200	-
Cleaning	0.5	-	890	200	-	1500	200	-
Growth	0.5 – 120	-	890	200	100	-	75	60
Post plasma processing	0.5	-	890	200	-	-	75	60
Cool-down	-	9	890↘200	200	-	1500	200	-

MORPHOLOGICAL AND STRUCTURAL INVESTIGATION

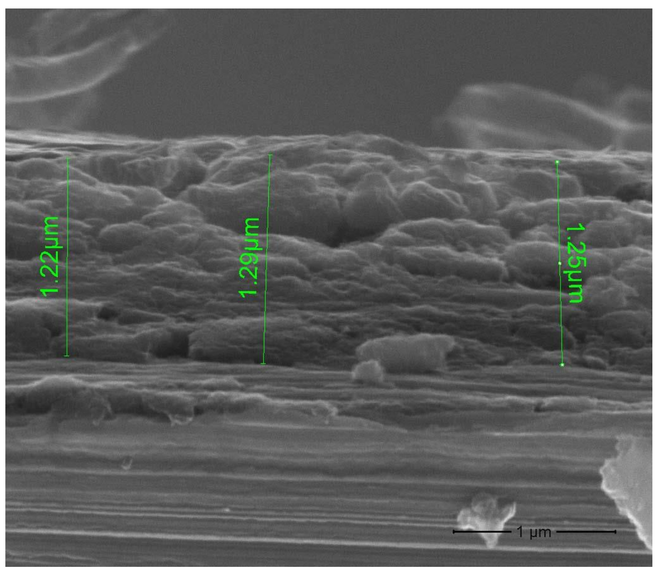

Figure 1: Cross-section SEM micrograph of a 1.25 µm thick NCG film grown on a metallic substrate.

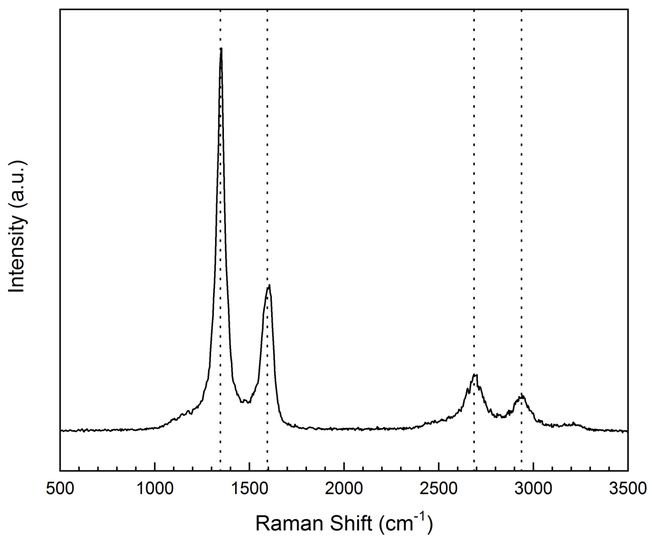

Figure 2: Raman spectrum of a 1.25 µm thick NCG film grown on a metallic substrate. The dotted lines at 1347 cm^{-1}, 1595 cm^{-1}, 2687 cm^{-1}, 2937 cm^{-1} represent the specific D, G, 2D and D+D' peaks, respectively.

MECHANO-ELECTRICAL INVESTIGATIONS

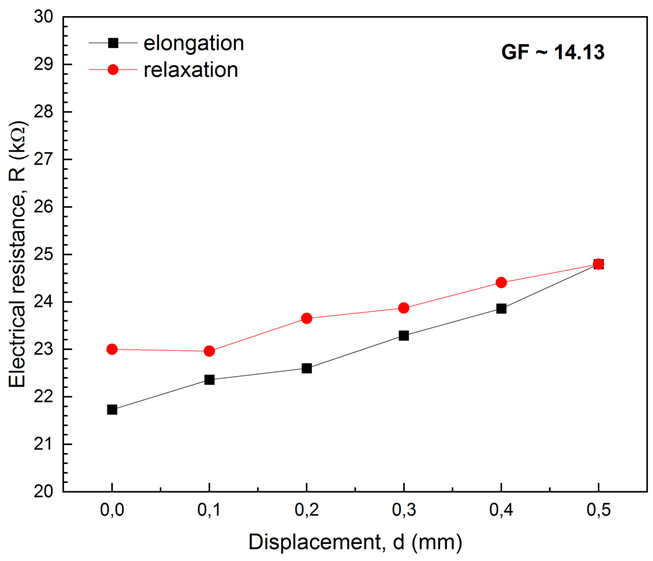

Figure 3: Electrical resistance variation with respect to the mechanical displacement for a 10 nm thick NCG film before the conditioning cycles.

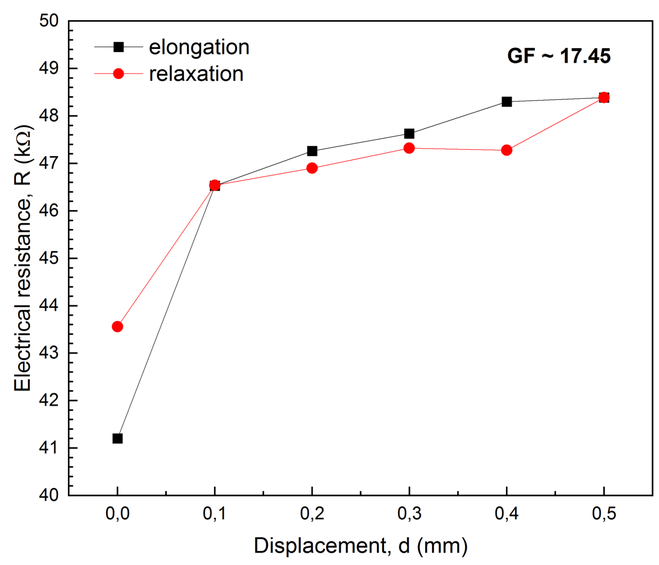

Figure 4: Electrical resistance variation with respect to the mechanical displacement for a 10 nm thick NCG film after 200 conditioning cycles.

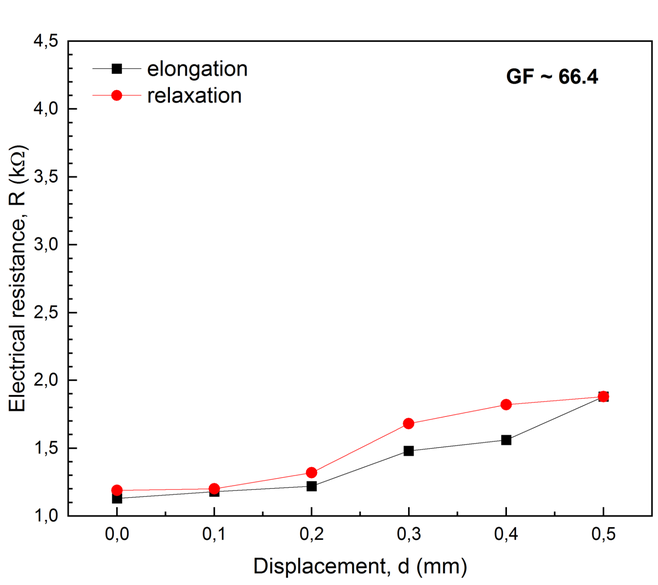

Figure 5: Electrical resistance variation with respect to the mechanical displacement for a 1.25 µm thick NCG film before the conditioning cycles.

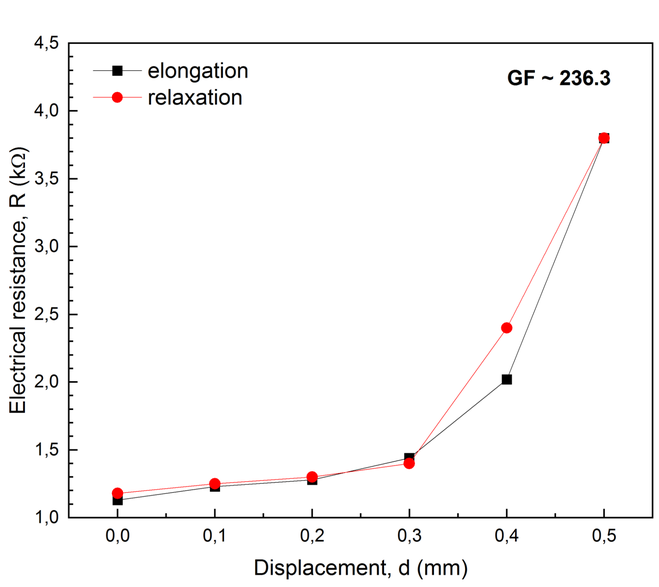

Figure 6: Electrical resistance variation with respect to the mechanical displacement for a 1.25 µm thick NCG film after 200 conditioning cycles.

CONTACT PERSON

Octavian-Gabriel Simionescu
octavian.simionescu@imt.ro

Dr. Octavian Buiu
octavian.buiu@imt.ro

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