Conductivity of Carbon Nanomaterials Modified with Metals

Ovsiienko I.V., Tsaregradskaya T.L., Vovchenko L.L., Matzui L.Yu., Saenko G.V., Marinin O.D.

Taras Shevchenko National University of Kyiv, Departments of Physics, Volodymyrska Str., 64/13, 01601, Kyiv, Ukraine, tsar_grd@ukr.net

The aim: to determine the effect of modified carbon nanomaterials structure, method of modifier deposition and modifier concentration on the conductivity mechanisms of resistivity

Methods of obtaining of modified carbon nanomaterials (CNM)

1. Liquid-phase chemical method based on the impregnation of source CNM (Thermoexfoliated graphite (TEG)) by water-salt solution of metal acetate with the subsequent reduction of metal in a hydrogen flow. Modifiers are nickel, cobalt, iron, copper, modifiers' concentration is from 10% up to 50% mass.

2. Method of simultaneous thermoexfoliation and modification of source natural dispersive graphite. Modifiers are nickel, cobalt, iron The concentration of modifier is ~1 % mass.

3. Method of modification of CNM with organic substances. Organic modifiers are polyvinyl acetate (PVA), phenol-formaldehyde resin (PFR), silicon -organic binder (SO).

4. Method of reinforcing of bulk TEG specimens by carbon fibers with simultaneous modification by PVA.

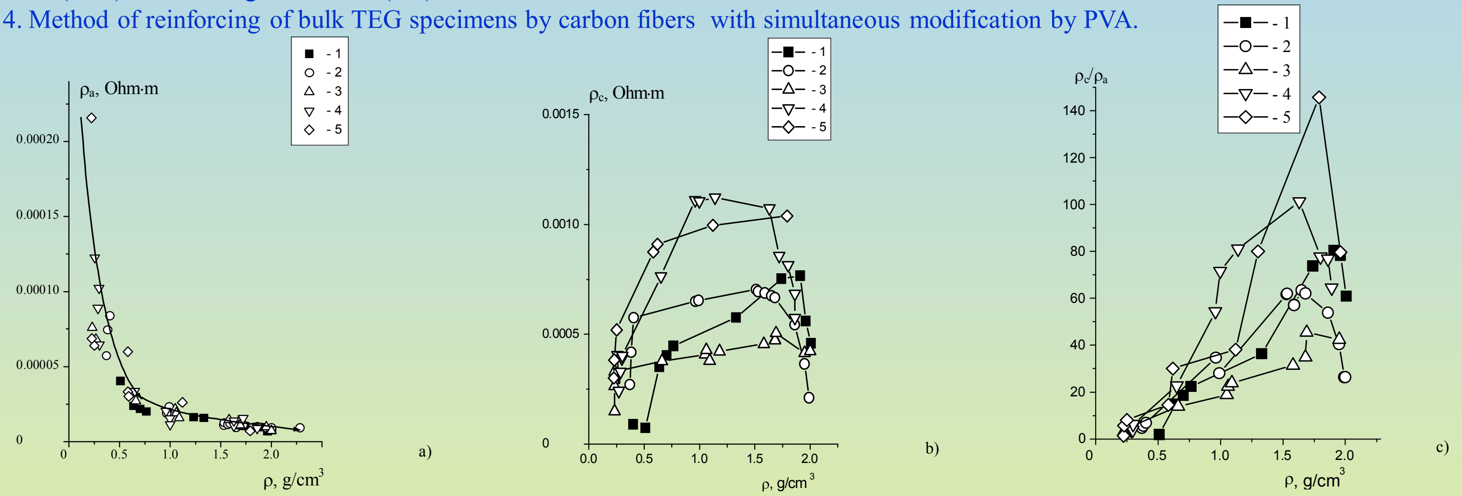

Fig. 1. The dependences of resistivity perpendicular (ρ_a) (a) and along (ρ_c) (b) compression axis and ratio ρ_c/ρ_a on material density for TEG with different modifiers: 1- TEG; 2 - TEG-Ni; 3 - TEG- Co; 4 - TEG-NiFe; 5- TEG-Fe.

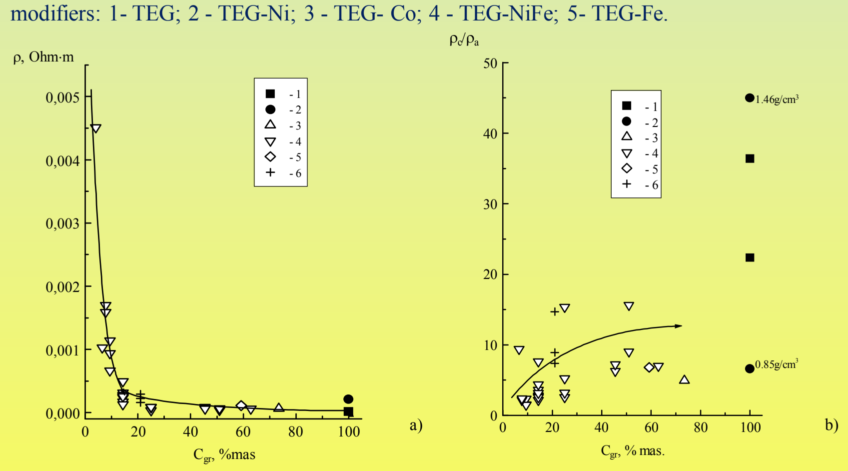

Fig. 2. The dependences of resistivity perpendicular (ρ_a) and ratio ρ_c/ρ_a on TEG concentration: 1 –TEG; 2- TEG+PVA+CF; 3 – TEG-SO; 4 – TEG-SO-Co; 5 – TEG-PFR; 6 – TEG-PVA.

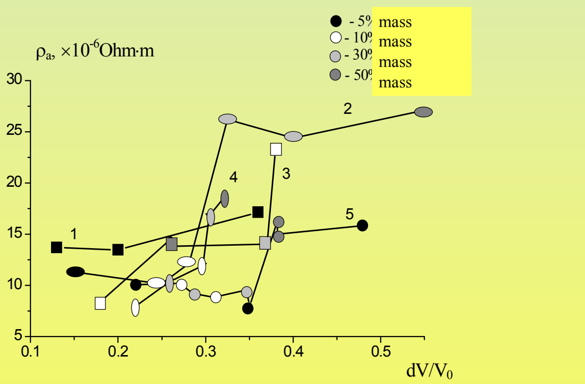

Fig.3. Dependence of ρ_a on porosity dV/V_0 at room temperature for specimens: 1- TEG; 2- TEG-iron; 3- TEG - cobalt; 4- copper; 5- nickel. Each metal concentration has its mark on the figure.

Conclusions

1. It is shown that impregnation of metal into TEG results in significant decrease of anisotropy parameter ρ_c/ρ_a in modified TEG, the more uniform and even the distribution of metal particles in TEG the greater the increase of anisotropy parameter.
2. It has been found that impregnation of metal from 10 mass % to 50 mass % into TEG results in insignificant (less than two times) decrease of electrical resistance perpendicular to compression axis of the samples. The magnitude of resistance does not depend essentially on modifier type or modifier concentration (at the concentration below 30 mass %) but depends on material porosity.
3. There is limit porosity for each TEG-modifier system at which electrical resistance perpendicular to compression axis increases sharply and below or above this limit the resistance practically does not depend on modifier concentration. The more uniform and even the distribution of metal particles in TEG the greater is the value of limit porosity.
4. The main factor that determines the magnitude of electrical resistivity in TEG- organic modifier systems is the amount of TEG in these systems. This situation is different from that observed in TEG-metal systems, where the main parameter determining electrical resistivity is the density or porosity of the material.