Carbon clusters as an example for self-organization

Prikhodko A.[1]*, Konkov O.[2]

[1]*St.Petersburg State Polytechnical University, 195251 St.Petersburg, Russia*
[2]*Ioffe Physical-Technical Institute RAS, 194021 St.Petersburg, Russia*
**e-mail: aleks@tuexph.stu.neva.ru*

According to the main principles of self-organized criticality (SOC) concept [1], there is a number of giant dissipative dynamical systems which are able to accumulate small external perturbations. Mathematical criterion of self-organization is a power-law behavior of avalanche size probability density. Several systems have been shown to exhibit SOC in terms of finite-size scaling as well as power law avalanches, such as pile of rice, magnetic vortices in superconductors [2] etc. The aim of this work is to show that carbon clusters such as nanotubes and graphite powder can serve as convenient objects for experimental investigations of SOC. Self-organized criticality can be experimentally observed as a power-law resistivity behavior. The samples investigated were in the form of carbon nanotubes (CNTs) with 20–70 nm diameter and up to 150 nm length and in the form of graphite powder of grains with 3-5 μm diameter. We need to measure the slope of the heap (φ_c) for «avalanches» of CNTs and single grains of the powder. We present here the experimental study results of the evolving sandpile resistivity dynamics. The samples were formed on an inclined plane with fixed angle (φ_c) with electrodes as described in [3]. Each sample was formed by periodically adding material portions (n) of the same volume (~10^{-5} cm^3). The φ_c value is 55° for CNT, and 35° for graphite. We present a detailed study of the static voltage-current characteristics which vary from ohmic (U_{min}) to breakdown (U_{max}) on above mentioned samples (U=0-20V). The typical I–V curves with an S-type instability region are obtained. At voltages close to the critical one, the detailed shape of the I–V curve is typical of multi-walled CNTs [4]. Typical dependencies of CNTresistance R by the number of material portions n are shown at the Fig. The power-law behavior of R(n) typical for SOC is observed. Dependency of line slope (B) by voltage (see Fig.) can be an evidence of inter-nanotube circuits influence to the critical state formation. Line slopes of graphite powder are: B=-1.27 (U_{min}), B=-0.45 (U_{max}). The experimentally observed curves are attributed to CNTs and graphite powders for angles $0 \le \varphi \le \varphi_c$ and voltages $0 \le U \le U_{max}$.

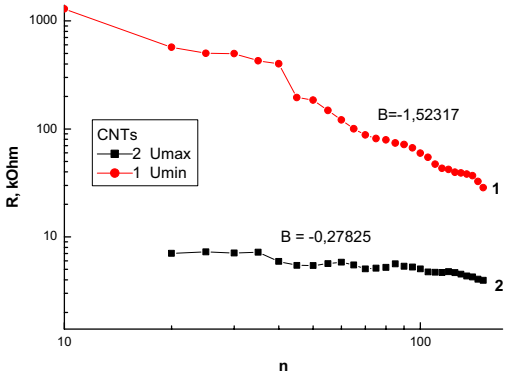

Figure. The resistance R of CNTs at U_{min} (1) and U_{max} (2) as a function of n. Best fit line slope-B.

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