

LASER STIMULATED ELECTRON-ION PROCESSES IN NANOPOROUS CARBON MATHTERIALS

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Introduction

Nanoporous carbon (NC), used for creation of capacitors of very large capacity (supercapacitors), worked on charge/discharge principle of double electric layer, must possess definite parameters (optimum size pores distribution, specific conductivity, density and etc.), which far not always are provided proper technology of its receipt. Therefore the additional treatment of nanoporous carbon is used for the purposeful change of the indicated parameters in many cases [1-2].

Results and discussion

NC is the non-equilibrium system. Therefore it is possible easily to change its state by action of external factors. One of such factors is impulsive laser action by which it is possible effectively influence on the parameters of such systems and purposeful to control them.

We investigated the characteristics of supercapacitors formed on the NC basis, which consistently was modified by thermal pre-activation and laser treatment.

Dependences of specific capacity of such capacitors on time and temperatures of NC pre-activation, which are formed on its base, are presented on fig. 1. As we see from fig. 1, the thermal pre-activation allows multiply their specific capacity more than in two times. The given dependences indicate on that the effect of specific capacity increase takes place for NC, got both from natural, and from synthetic raw material (formaldehyde resins), that testifies to universality of the offered method.

However thermal NC pre-activation, multiplying the specific capacity of corresponding capacitors, does not lead to decreasing their internal resistance. Therefore we used method of introduction metals with the high-electronic density (Er, Cr) in NC matrix, which lead as to the specific capacity increase so to the internal resistance decline [3 - 4].

Meantime the coulomb efficiency of supercapacitors on the basis of NC injected by metals diminishes for enough cycle number due to frequent charge/digit (see fig. 2, curve 1). We irradiated given materials by the lasers impulses, which worked in the regimes of free generation

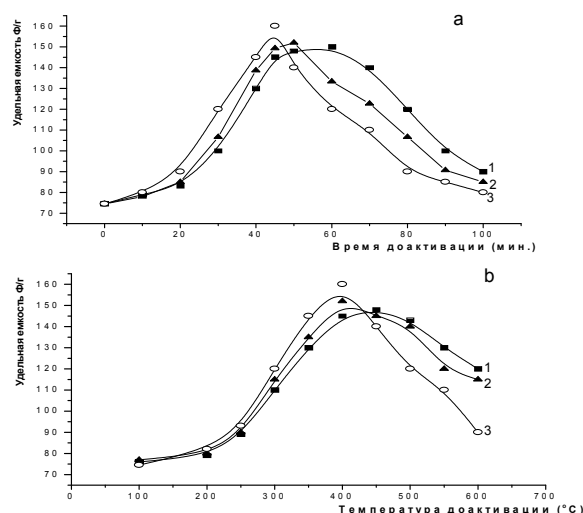


Fig. 1. Specific capacity of supercapacitors on a basis thermally pre-activated NC as functions of time (a) and temperature (b) of pre-activation:

- 1-NC got from apricot stone
- 2- NC got from cherry stones
- 3- NC got from phenol-formaldehyde resins

($\tau_i = 2$ ms) and modulated goodness ($\tau_i = 15$ ns). Irradiation of Er – injected NC by the laser impulses, which worked in the regime of free generation ($\lambda = 1,06 \mu\text{m}$, $\tau = 2$ ms, $E = 40\text{-}50 \text{ J/sm}^2$) practically does not change a specific capacity and internal resistance proper supercapacitors, but substantially influences on their coulomb efficiency (fig. 2, curve 2). As we see from fig. 2, the coulomb efficiency remains practically

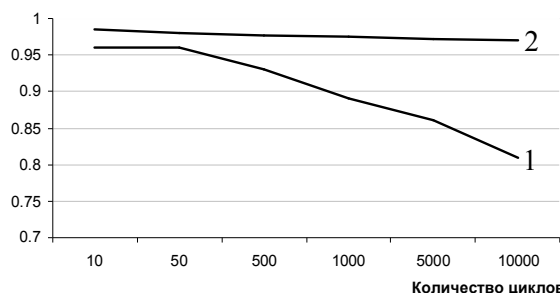


Fig. 2. Dependence of coulomb efficiency on the cycles number:

- 1- supercapacitor on a NC basis with 0,3% Er addition
- 2- supercapacitor on a NC basis with 0,3% Er addition and irradiated by laser impulses ($\tau_i = 2$ ms, $E = 44 \text{ J/sm}^2$)

invariable during 10^5 cycles for the irradiated standards, while it diminishes steadily for unirradiated ones. Most probably injected Er atoms diffuse deep of material as the as result of laser treatment and in that way the indicated atoms do not pass to the electrolyte at the nonexpendable recharging. Analogical results were got at use of laser, which worked in the regime of modulated goodness ($\tau = 15$ ns, $E = 0,02$ J, $\lambda = 1,06$ μ m, irradiation time of 3 min). But in this case it is possible oxidization of nanoporous carbon - injected metal structure due to considerable irradiation time. Got results indicate about the

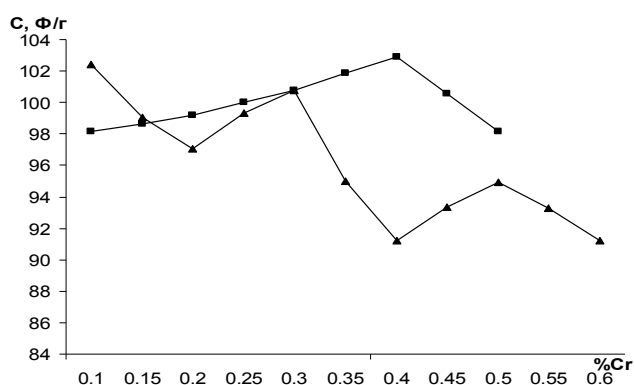


Fig. 3. Dependence of specific capacity of supercapacitors on the quantity of inculcated Cr:
1-NC
2-NC irradiated by the Nd -laser impulses ($\tau_i = 15$ ns, $E = 0,03$ J/sm², $t = 3$ min.)

stabilizing role of laser irradiation, which results in substantial reduction of faraday processes in the NC - electrolyte system.

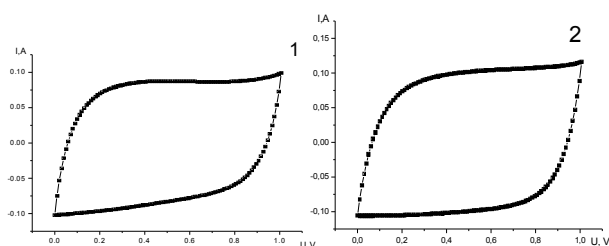


Fig. 4. Potentiodynamic curves receipt for supercapacitors formed on unirradiated (1) and laser irradiated NC (2)

Dependences of supercapacitors properties on the quantity of interstitial chrome, formed on NC basis, were explored also. Laser irradiation results in insignificant increasing of specific capacity at few Cr content. As see from fig. 3, non-monotonous dependence of specific capacity on the size of Cr weight % takes place at Cr content growth, inculcated in a matrix (more than 0,1 weight %), while as such dependence has only one maximum for the unirradiated standards. Probably, Cr atoms can is found in NC structure in a few energy and charge states that results in a volume that there are the observed changes of specific capacity at the constant dose of laser irradiation.

The stabilizing role of laser is confirmed by potentiodynamic curves, got at capacitors research formed on the NC basis irradiated by the laser. As see from fig. 4, potentiodynamic curve for laser irradiated NC is close to the one for an ideal capacitor, while there is current growth at the $U \rightarrow 1$ V for unirradiated standard that testifies to the presence of faraday processes at the charge/discharge of supercapacitors.

Conclusions

Joint thermal and laser modification of NC can substantially improve supercapacitors characteristics formed on its basis.

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