“Nanochemistry and Nanobiotechnology”

Biomimetic composites reinforced by branched nanofibers

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Nature developed optimal design for biological tissues formed as layered materials reinforced at micro/nano scales by fibers/tubes [1]. The resulted structures possess high strength and durability at total lightweight design. The fibers/tubes may serve for heat/mass transfer. The branched structures of the tubes exhibit special geometry providing minimal energy expenses for transportation and metabolism [2]. Similar design was found in cytoskeleton and intracellular matrix where branched fibers provide intracellular communication and mechanical strength [3]. Here the constructive principles are proposed as nature inspired solutions for reinforcement of engineered composites which can be used for heat, mass and electric current transfer in micro heaters/coolers, fuel cells, lab-on-a-chip.

The modified equations at the nanoscales have the form

$$\tau_q \frac{dq}{dt} + q = -\lambda_q \nabla f_q + \kappa_q \nabla^2 q \qquad (1)$$

where $\vec{q}$ is the flux, f_q is the flux-generating function, τ_q is the relaxation time, λ_q, κ_q are coefficients. When q, f_q are the heat flux and temperature, (1) gives the Guyer-Krumhansl equation. When q, f_q are the fluid flux and hydrostatic pressure, (1) gives modified Darcy’s law. Maxwell-Cattaneo law for diffusion and electric conductivity law at the nanoscale can also be described in the form (1).

The uniform plate reinforced by periodic structure of branched fibers/tubes is considered. Total heat/mass/charge transfer through the fiber is computed on (1) at some simplifications. Stress-strain state of the composite is studied by finite element computations. The patterns providing optimal mechanical and transfer properties are discussed in applications to MEMS devices.

1. *Kizilova N.* Computational approach to optimal transport network construction // Lecture Notes in Computer Sci.-2004.**-3044.-**P. 476-485.
2. *Bejan A.* Shape and Structure, from Engineering to Nature, Cambridge Univ. Press: Cambridge, 2000.
3. *Kizilova N.* Geometrical regularities and mechanical properties of branching nanostructures // Nanobiophysics, Kharkov.-2011.-P.141.