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Problems of materials science in additive technologies

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SIMULATION OF INKJET PRINTING PROCESS AND PRINTING OF ORGANIC SEMICONDUCTING MATERIALS

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Printing technologies provide great opportunities for rapid and low-cost technology of creating electronic devices. This technology is especially useful for creation of single devices because it does not require shadow masks unlike thermal vacuum evaporation and photolithography. The solutions of organic polymer semiconducting materials are the most interesting for printing because they can be used for creating different semiconductor devices. There are special requirements for inks used for inkjet printing: viscosity, surface tension, particle size, pH. At the same time, inkjet printing process requires careful selection of operation modes of the printer heads for different inks. Computer experiment allows facilitating this work and helps to understand how different parameters affect the process of droplet formation. Therefore, the aim of this work is to simulate the process of inkjet printing of organic materials on the basis of semiconducting polymers.

Simulation was carried out in a specially developed program. Printing was performed on the inkjet DOD Dimatix DMP-2831 printer (Fujifilm), rheological characteristics were determined using DVT3T-LV+CP rheometer (Brookfield) and surface tension, on DSA 25E (Kruss).

Simulation of acoustic response of the inks driven by pulse in pump chamber of print head was carried out. The study showed the dependence of maximum printing frequency on viscosity, density and sound velocity in the medium. Organic inks based on semiconducting polymeric solutions meeting printing requirements were created.

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NUMERICAL SIMULATION OF SELECTIVE LASER MELTING OF IRON POWDER

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Selective laser melting (SLM) of metallic powders is a complex process. Therefore, computer simulation of this process is a state-of-art problem in modern material sciences. The present work was aimed at formulation of a mathematical model of iron powder SLM, its verification, study of heat transfer in the powder layer during SLM, the alteration of porosity and powder contraction, and at the optimization of the rate of iron powder SLM.

To describe heat and physical processes during SLM, a heat conductivity equation is used with phase transitions with two variables: temperature T and specific enthalpy H of the metallic constituent of a two-phase medium. In addition, the equation is to be solved to find local porosity of a powder layer ε_V.

The conductivity coefficient $k(\varepsilon_V)$ was calculated at the scale level of separate particles and their agglomerations [2]. The model is complemented by the equation determining the contraction of the powder via the location of the upper boundary $\partial\Omega_{Top}$ of the calculation region. At the upper boundary, a boundary heat source F is specified correspondingly to the effect of the laser beam and taking into account cooling via convection and radiation. The numerical model of iron powder melting was programmed in COMSOL MultiPhysics software in the form of reduced integral equations.

The numerical simulation of iron powder SLM are in good agreement with real experiments. The computer calculations helped to analyze the compaction of the powder layer, non-stationary fields of temperature and local porosity; also, the work investigated the influence of controlling parameters of laser irradiation on powder compactions. The SLM problem formalized down to