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MANIPULATION OF (PEROVSKITE-POLYMER) NANOFIBERS PROPERTIES FOR OPTOELECTRONIC APPLICATIONS

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In this paper, we analyze the relation between the properties of electrospun (perovskite-polymer) nanofibers and various parameters related to their components, preparing methods and processing conditions that can determine their quality, efficiency and applications.

Introduction. Perovskite materials have attracted a lot of attention due to their unique electrical and optoelectronic properties, which has led to the emerge of fierce competition among researchers for applying them in various applications, such as: solar cells, LEDs, photodetectors, etc. Recently, scientists have worked on electrospinning these materials with polymers, taking advantage of the enhanced properties of these nanostructured materials to improve the performance of perovskite devices. Actually, these properties are influenced by various parameters, e. g. perovskite composition, type and amount of polymer, method and parameters of electrospinning, solvent engineering and thermal treatment (annealing) that will be analyzed in this paper.

Main Part. Perovskites include all materials that have the same crystal structure as calcium titanate ($CaTiO_3$) and the chemical formula ABX_3. The site X can be occupied by halogens (I, Br, Cl), the site B-divalent metal ions (Pb^{+2}, Sn^{+2}, Ba^{+2}) and the site A-organic or inorganic monovalent cations ($CH_3NH_3^+$, Cs^+). The manipulation of the perovskite composition is considered to be an effective method for controling perovskite material properties (i. e. morphology, crystallinity, band gap and trap states density). Furthermore, the type (conductive, nonconductive, functional groups, etc.) and the amount of polymer used play a crucial role in regulating nanofibers diameters, perovskite crystal size and trap density, consequently, in manipulating optoelectronic properties (i. e. band gap, PL and light absorption) will change.

Depending on the electrospinning method used, electrospun perovskite nanofibers can be obtained with two structures: perovskite-polymer composite nanofibers or core (perovskite)-shell (polymer). Actually, the structural and electrical confinement in core-shell nanofibers is higher than in composite nanofibers, which makes the latter a better choice for solar cells and photodetectors, and the former for LEDs. Moreover, electrospinning parameters (e. g. electrical voltage, feed rate, etc.) strongly affect the diameter of nanofibers and the crystallinity of perovskite.

Solvent engineering is another important method that can determine the morphology and crystallinity of perovskite in nanofibers by using various solvents and antisolvents that can be selected depending on their basicity, polarity and boiling point.

Finally, after electrospinning, perovskite nanofibers are annealed in air at temperature (85-100 °C, 10-60 min) for the complete evaporation of solvents and the high-quality crystallization of perovskite. However, annealing parameters (temperature, time and medium) have strong effect on the quality of resulting nanofibers. In terms of the morphology, annealing at a temperature (80-150 °C) makes the resulting nanofibers rougher and thinner. Annealing at high temperatures (>150 °C) leads to lower crystallinity of perovskite nanofibers, and they start to fracture and partially overlap each other. Whereas, annealing at low temperatures (<80 °C) leads to incomplete conversion of the perovskite precursor solution.

Conclusion. We can observe that the structural, electrical and optoelectronic properties of electrospun (perovskite-polymer) nanofibers can be controlled by various parameters related to perovskites and polymers used, elecrospinning methods and processing conditions that can be utilized to increase the quality, effectiveness and technological flexibility of resulting nanofibers. However, the possibility of electrospinning of perovskites and their use in recommended devices without damaging the nanostructure are still the main problems that require deep research and effective solutions.