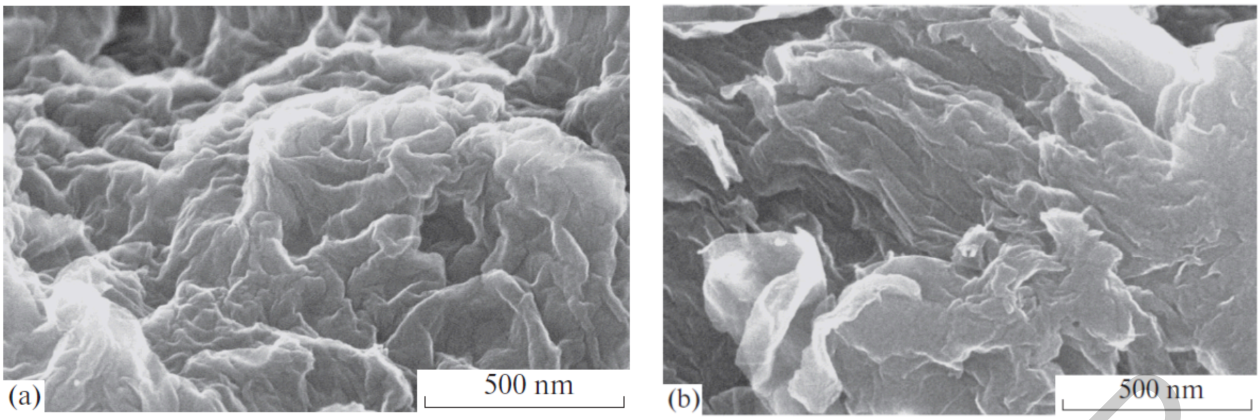

Figure 2 – SEM images of (a) graphene oxide, (b) and material obtained from graphene oxide via reduction in Ar/H_2 at 1000°C, respectively

III. CONCLUSIONS

Our study of features of the reduction of graphene oxide from graphene at different temperatures and in various media indicates that this process is proceeds only upon high-temperature annealing in an inert atmosphere containing hydrogen. This results in [12, 13] complete removal of physically adsorbed water from the micropores in a graphene oxide array and contributes to the destruction of mobile oxygen-containing carbon groups in the structure of flakes, generally enhancing the effect of hydrogen reduction on them. This leads to dramatic changes in the chemical composition and structure of this material, producing single-layer graphene flakes.

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SOLUTION-BASED HOT-CASTING TECHNIQUE TO RECEIVE A MICROMETER-SCALE CRYSTALLINE GRAINS OF PEROVSKITE

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I. INTRODUCTION

The use of organometallic halide perovskites as an absorbing layer of photovoltaic cells (PC) made it possible to increase the efficiency from 7% to 20%, which corresponds to the level of the traditional cells on silicon. At present, the main requirements for the development and fabrication of a FW based on perovskites are an increase in the efficiency of solar cells, reduction in their cost, as well as an increase in their service life and stability in severe atmospheric conditions (high humidity, temperature extremes, UV radiation). One of the solutions of these problems is the development, investigation and modification of methods for the formation of perovskite films. The purpose of this work is to research perovskite films obtained by applying a precursor solution to a hot substrate at different substrate temperatures.

II. EXPERIMENTAL

Figure 1 shows the scheme of the process of depositing organometallic halide films of perovskite on a hot substrate. The method of depositing perovskite films on a hot substrate is to irrigate the hot (~80 °C) mixture of lead iodide solution (PbI_2) and methyl ammonium iodide (CH_3NH_3I) onto the substrate at a specified temperature (120 °C, 200 °C) and then centrifuge for 15 s to obtain a homogeneous film.

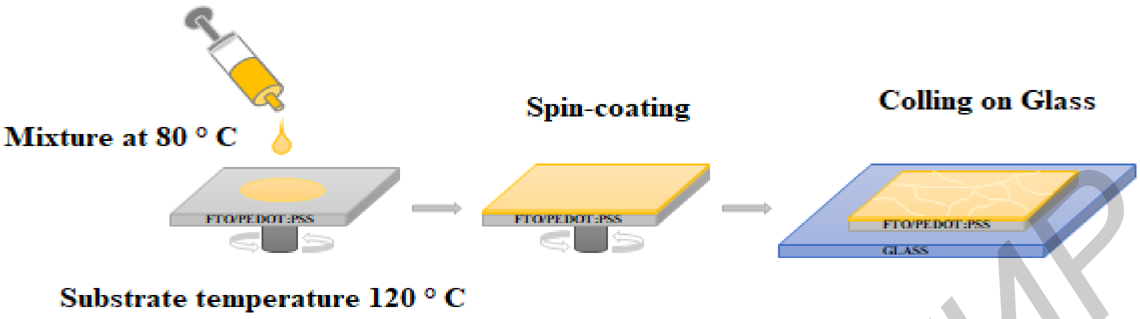

Figure 1 – Scheme of the process of depositing organometallic halide films of perovskite on a hot substrate

To achieve the best morphology, the molar ratio of precursor components PbI_2 / CH_3NH_3I 1: 1 was chosen. Figure 2 (a-d) shows photomicrographs of perovskite films obtained at substrate temperatures of 120 °C and 200 °C (optical and scanning electron microscopy). The film obtained at 120 °C (Figure 2 (a, c)) consists of nanocrystallites with dimensions from 1 to 50 µm. Nanocrystallites are densely packed, holes and punctures are absent. Films obtained at a substrate temperature of 200 °C (Figure 2 (b, d)) have the same dense structure, but consist of microcrystalline grains with sizes from 100 µm to 500 µm. The dense nature of the structure is confirmed by micrographs obtained by scanning electron microscopy (Fig. 2 (c, d)). The perovskite film has a thickness of 1.47 µm for 120 °C and about 2.5 µm for 200 °C.

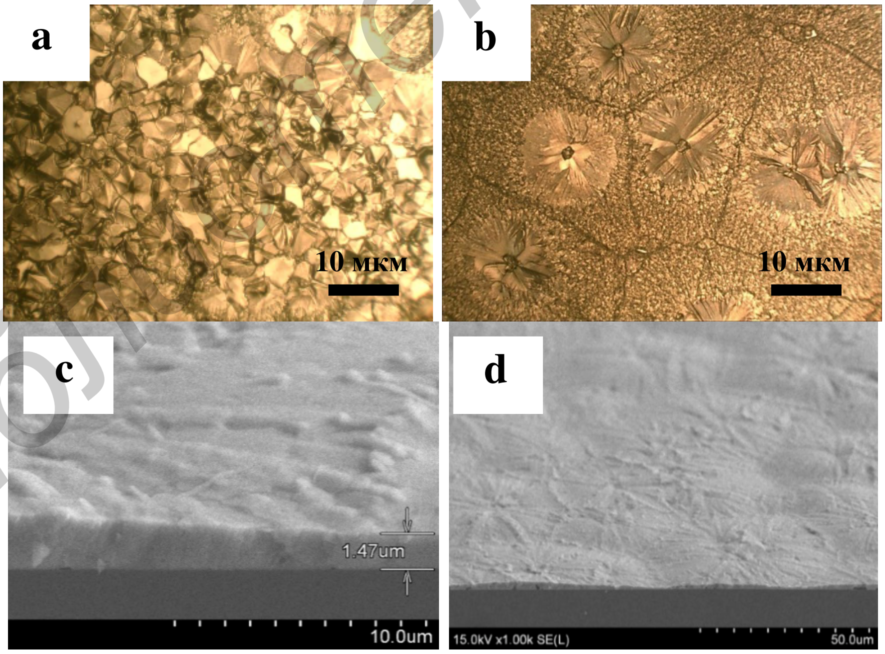

Figure 2 – Photomicrographs of perovskite films obtained by deposition on a hot substrate:
a, c – at a substrate temperature of 120 °C, b, d – at a temperature of 200 °C.
a, b – optical microscopy, c, d – scanning electron microscopy

III. CONCLUSIONS

It is established that the temperature of the substrate directly affects the size of microcrystallites in the perovskite film deposited on the hot substrate. With increasing temperature, fine crystallites coalesce and form crystallites of much larger size. The resulting crystallites have a leaf-shaped structure. It is also found that the size of microcrystallites when deposited on a hot substrate varies from 1 µm to 50 µm (at a substrate temperature of 120 °C) and 100 ÷ 500 µm (for 200 °C).

It has been established that as a result of experimental studies, the method of depositing a layer of perovskite on a hot substrate is very promising. Since the substrate temperature is maintained at the boiling point of the precursor solution with this method of deposition, the solvent evaporates very rapidly, which makes it possible to obtain large crystalline grains. From these data, it can be concluded that the use of high-boiling solvents can provide ideal conditions for the growth of large crystalline grains.

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NANOSTRUCTURED THIN FILM OF HALIDE PEROVSKITES VIA TWO-STEP SOLVENT-SOLVENT EXTRACTION

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I. INTRODUCTION

The combination of electrical properties and absorption characteristics of hybrid perovskites made it possible to increase the efficiency of energy conversion of solar cells on their basis during 2012-2013 from 7.2 % to 20 % [1]. It can be used in solar cells instead of silicon or as an upper-layer of silicon solar cells to increase energy production by absorbing light from a part of the spectrum, that silicon can not absorb.

The key problems of the perovskite solar cells (PSCs) are the uniformity of the films, the lack of stability and the durability of perovskite solar cells, which are directly related to the methods of film formation on the substrate. Among the methods of obtaining perovskite films, an interesting method is the solvent-solvent extraction from solution (SSE) [2]. The advantages of the SSE method – room-temperature process, rapid crystallization, uniform application, film-thickness control, film smoothness and compounds versatility.

However, there are a number of disadvantages in this method. There are through holes between the individual crystals of the film, the materials of hole-transporting and electron-transporting layers meet, forming parasitic contacts, which are shunting the organometallic perovskite and reducing the open-circuit voltages of the solar cell. And a small grain size, which reduces the effectiveness of PSCs. In this article we proposed and researched a two-step SSE method with following thermal annealing.

II. EXPERIMENTAL

A schematic illustration of the two-step SSE method for obtaining perovskite films is shown in Figure 1.

The perovskite solution obtained by mixing CH3NH3I and PbI2 in an organic solvent of N-methylpyrrolidone is spin-coated to a previously applied ITO template on a glass substrate and immediately immersed in a bath of diethyl ether (DEE). After two minutes, the perovskite film acquires brown color, after which the sample is removed from the bath and dried in the oven. After that, the sample was returned to the spin-coating, where the second layer of perovskite was applied to the sample. Further, the extraction and drying operations were carried out in the same way as the first step. It was found that during rotation on a spin-coating, the perovskite film began to change color from pale yellow to light brown, which may indicate the onset of crystallization of perovskite already at the centrifugation stage. In this case, the start time of the color change of the film is inversely proportional to the rotational speed of the spin-coating.