Available online at www.rajournals.in

RA JOURNAL OF APPLIED RESEARCH

ISSN: 2394-6709

DOI:10.47191/rajar/v7i11.08

Volume: 07 Issue: 11 November-2021

International Open Access

Impact Factor- 7.036

Page no.- 2669-2671

Microcructure of Polycrystal Silicon Heated by Sunlight

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ARTICLE INFO

Published online: 16 November 2021

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ABSTRACT

The article describes the method of obtaining polycrystalline silicon by combining silicon particles with sunlight, its microstructure and the mechanisms of formation of intergranular boundary areas. The results of the study show that the microstructure of the surface areas where sunlight falls (a) and does not fall (b) differs from each other. This is explained on the basis of the formation of temperature differences in the surface areas (a) and (b) for the uniform accumulation of silicon particles.

KEYWORDS: Sunlight, Silicon Particles, Powder Technology, Polycrystalline Silicon, Intergranular Boundary, Temperature, Microstructure.

INTRODUCTION

It is known that the physical properties of polycrystalline silicon (PC) manifested under certain conditions only the specificity of PC and its structure and the relationship between the granular boundary (DC) field microstructure increase the interest in such materials. To date, several studies have been conducted to study the structure of the PK and the microstructure of the DCh (e.g., [1–10], see also the references given there). Various models and mechanisms have been proposed to explain the results obtained [1-5]. The potential for the production of relatively inexpensive and radiation-resistant solar cells or semiconductor devices, as well as thermoelectric materials, has been revealed through the control of PC dimensional defects and introductory conditions in the field of DC and charge transfer processes. Studies have shown that PC volume defects and DC microstructure depend on PC extraction technology, properties of residual or specially introduced input atoms, and segregation processes [1-9].

Today, there are several technologies for the production of PC, from which the microstructure of PC based on powder technology and the mechanisms of formation of DC fields are one of the unsolved problems. In this regard, this paper discusses the microstructure of PC and the mechanisms of formation of DC fields obtained on the basis of powder technology.

RESEARCH METHOD

It is known that powder technology is one of the promising methods in obtaining polycrystalline semiconductor devices and thermoelectric materials due to its simplicity and the fact that it does not require complex technologies [4, 7-9, 11]. The novelty of the research is that for the first time the study of the mechanisms of formation of DC areas in the volume of which is obtained by PC by heating and bonding silicon particles prepared on the basis of powder technology with sunlight. PC production consists of the production of silicon particles using powder technology, which is heated by sunlight at a temperature of 1250°C. This allows you to get a PC. This method is a relatively inexpensive technology compared to technologies such as molecular light or cast silicon extraction. X-ray spectral analysis was used to study the microstructure of the PC.

SPECIFIC PROPERTIES OF POLYCRYSTALLINE SILICON EXTRACTION.

PC production is based on the production of silicon particles in a powder method, followed by heating and bonding of silicon particles with sunlight [11]. Unlike traditional powder technology, in this work, the data for the preparation of silicon particles used dielectric materials that are heat-resistant and do not contain metal compounds. This prevents the silicon particles from becoming contaminated with various impurities that can enter from the outside environment. Samples of single crystal silicon KDB-10 were selected as raw materials. This method allows the preparation of silicon particles up to 0.5 micrometers. The prepared silicon particles are washed with ethyl alcohol and dried under vacuum.

The bonding of silicon particles by solar heating is carried out in a "solar box" with a focal temperature of 1300°C. For this, a heat-resistant dielectric housing base can be used (Fig. 1). Initially, a mixture of silicon particles (2) is prepared using 70% ethyl alcohol and it is poured into the tray (1). This process is done by pressing with a small force using the hand. As a result, the silicon particles take the form of a base. It should be noted that the use of a base of any shape as a base allows the preparation of samples of arbitrary shape.

It should be noted that the thickness of the mixture of silicon particles in the substrate should not exceed 2.5÷3 mm. When the thickness of the mixture is less than 2.5÷3 mm, the level of liquefaction increases instead of the accumulation of silicon particles. Conversely, when it is higher, the temperature is not evenly distributed across the volume. Due to the temperature difference, the adhesion in the surface areas is high and the adhesion at the bottom is weak. As a result, this pattern results in the formation of a brittle surface area that is not firmly adhered to the bottom or surface exposed to sunlight and the silicon particles are retained in a powder state.

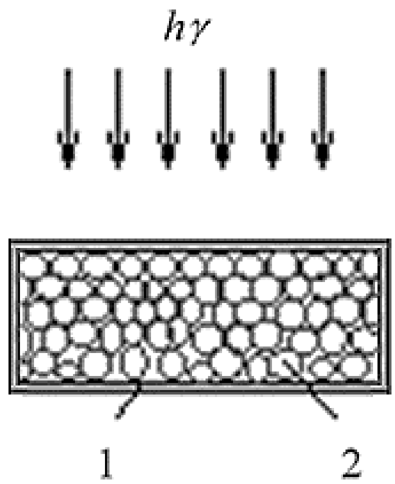

Figure 1. Scheme of bonding of silicon particles by heating with sunlight.

Heating with sunlight ($h\gamma$) is also a specific process. The beam of sunlight ($h\gamma$) falls perpendicularly directly to the silicon particles, and it is moved along the focus of the solar cell. In this case, the temperature of the sun's rays falling on the silicon particles is slowly shifted from 600°C to a distance of 1250°C. This process takes 5-7 minutes. In this method, unlike traditional methods, the processes of heat treatment (specification) using special devices for pressing or large energies are not performed at all.

THE MECHANISM OF FORMATION OF INTERGRANULAR BOUNDARY AREAS

X-ray spectral analysis was used to study the microstructure of the samples. Figure 2 shows the microphotography and X-ray spectral characteristics of the samples. It should be noted that special attention was paid to the surface areas of the sample obtained by attaching silicon particles with sunlight. In particular, the surface on which sunlight falls and the surface on which sunlight does not fall. A surface that is not exposed to sunlight consists of a surface area bounded by a base. In order to facilitate the interpretation of the results of the study, we introduce the designations of the surface area (a) and the surface area (b) where the sunlight falls on the sample.

As can be seen from Figures 2a and 2b, it was found that the microstructure of the surface areas of the sample where sunlight fell (a) and did not fall (b) differed from each other. The results of the X-ray spectral analysis (s) show that both sides of the sample are composed of silicon atoms, and it has been determined that no foreign input atoms can be penetrated by the external environment (Fig. 2c). It can be explained as follows that the microstructure of the surface areas in which sunlight falls (a) and does not fall (b) differs from each other.

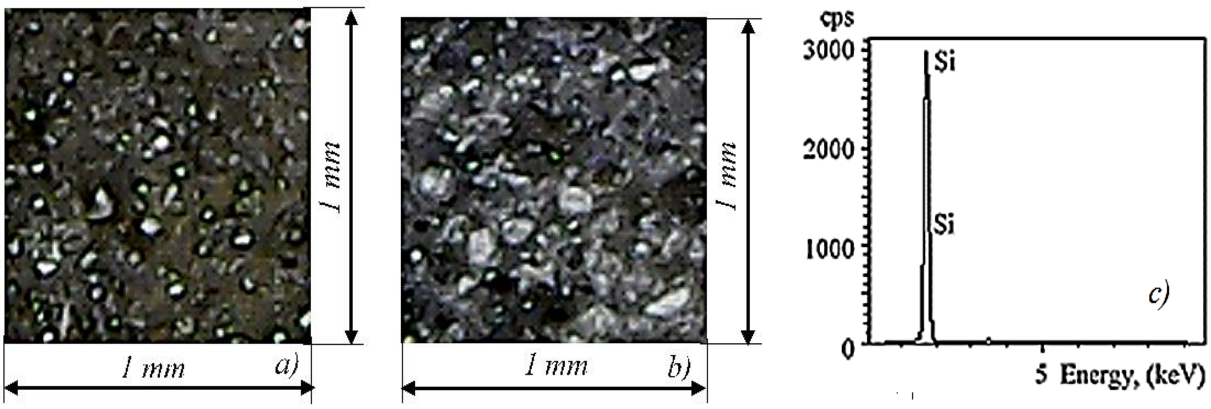

Figure 2. The sample is microphotographed and X-ray spectral characteristics (c) of the surface areas where sunlight falls (a) and does not fall (b).

In our opinion, the temperature in the surface area where the sunlight falls (a) is higher, which is sufficient for the uniform accumulation of 1250°C silicon particles. It is known from powder technology that heat treatment is performed at a temperature 10 ÷ 20% lower than the melting temperature of the powdered crystal, for example, silicon [5, 7]. For example, since the melting point of silicon is ~1420°C, heat treatment at a temperature of ~1200 ÷ 1250°C is required [5, 7, 11]. The main reason for this is that the silicon particles heat up during the powdering process. This causes the silicon particle to be supplied with sufficient energy. This mechanism is also relevant for the surface area where sunlight does not fall (b). However, since the temperature of this field is lower than the surface area to which sunlight falls, the accumulation of silicon particles may not be uniformly ensured. As a result, (b) the surface area is formed more roughly than the surface area (a). This, in turn, leads to differences in the microstructure of the surface areas (a) and (b). A similar situation was observed in the results obtained in the study of the electrophysical properties of the samples. We present the results on the electrophysical properties of the sample in our next work.

In summary, the samples in which sunlight is attached to silicon particles have a polycrystalline structure, and the microstructure of the surface on which the sun's rays fall and do not fall, as well as the DC areas, differ from each other. The method of obtaining PC by attaching silicon particles with sunlight can play an important role in obtaining two structural semiconductor materials for microelectronics and photovoltaics.

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