

# REVIEW ON SI AND ITS APPLICATION IN SOLAR CELLS

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## ABSTRACT

*Silicon (Si) is the most important semiconductor of our times. This material has a huge impact on modern civilization development. It is the most used semiconductor for devices, Integrated Circuits, and Photovoltaics. With low band gap, stable formation with oxides, established and effective purification methods, easy doping as p and n type and its ability to synthesize in nano scale, this material still has been favorite choice of the semiconductor industry. This paper reviews various phases of Si and their application especially in photovoltaic solar cells*

## I. INTRODUCTION

Photovoltaic solar cells convert inexhaustible sun energy into usable electricity. The development of photovoltaics has been at breakneck speed in order to help solving the crisis of natural resources and environmental change. As a material silicon is most suitable for solar cells due to its high performance, long life time, and superior stability and also because of its second highest abundance among all the elements found in nature [1, 2, 3, 4, and 5]. Silicon as a versatile material for photovoltaics has been experimented by the workers in its different structural forms like monocrystalline, polycrystalline, amorphous and nanomaterial. This paper reviews the applications of this material in its various forms.

## II. CRYSTALLINE Si BASED SOLAR CELLS

The first Si based crystalline solar cell was designed by Bell Laboratory in year 1953. The first solar cell had an efficiency of 4.5% and it was followed by another cell in 1954 having an efficiency of 6% [6, 7]. Within 10 years, Crystalline Si cells achieved 15% efficiency, which was good enough for them to be used as sources of power for space crafts, lighthouses and electronic calculators. Like many other Si devices, crystalline silicon solar cell is essentially a semiconductor diode. That is why the technology proposed for these solar cells in early years was based on the understanding of semiconductor devices. It was until rapid technological development in the area of integrated circuits (ICs) provided the required synergy between the technology and the equipment developed for

Crystalline Si based solar cells. Photolithography as a process technology further increased conversion efficiency for Solar cells. To obtain solar cells with high efficiency and low process cost is the biggest challenge for the industry as the cost to produce high purity crystalline Si substrate is very high.

## **2.1 Monocrystalline Silicon**

The fabrication of solar cells based on monocrystalline silicon has been based on P type monocrystalline silicon substrate obtained from boron doped ingots (CZ type). In early days of photovoltaic cell production, small size of 2-5 inch in diameter of ingots was used. Since it was expensive, much R&D was devoted to reduce the cost of these ingots and as a result the PV industry today is using CZ ingots of 6-8 inch in diameter. In 2008, monocrystalline solar cells had a share of 38% of the total solar cells produced by the industry and showed the efficiency in 16-18% range [8].

## **2.2 Polycrystalline Silicon**

To further reduce the production cost of silicon CZ ingots, polycrystalline silicon ingots' came into being and were investigated by many workers [9, 10]. Today these solar cells are most widely produced and constituted 48% of total solar cell production of the world in 2008. The energy conversion efficiency of for a polycrystalline silicon cells of 20.3%. is provided by a PERL cell developed by Fraunhofer ISE [21, 8]. Ribbon technology and cast silicon technology are two ways which gave less expensive but also less pure and less efficient solar cell based on polycrystalline silicon. Solar cell efficiency 10 % reported. [53]

## **2.3 Amorphous Silicon**

Solar Cell fabrication results based on amorphous silicon were published in 1960s [11, 12]. Carlson gave first amorphous silicon solar cell in 1976. [13]. Commercial product based on amorphous silicon appeared in the market in the year 1981. These solar cells gave low efficiency initially as they were subjected to light induced degradation called dangling bonds [14] and were known as Wronski effect. These cells were inexpensive as amorphous layers could be deposited on glass, plastic or steel at low deposition temperature. However in today's market amorphous silicon solar cells have their significant share after solving partly the problem of degradation by many workers and achieving a better understanding of the material. Solar cell efficiency of 13% and module efficiency of 6-8% have been reported.

## **2.4 Amorphous and Crystalline Silicon Heterostructures (a-si/c-si)**

In these structures, Silicon wafer had contacts of amorphous silicon on both of its sides. Absorption of light was still occurred in mono or polycrystalline silicon wafers. These configurations had

advantages of high efficiency, lower surface recombination, processing temperature below 2000C and low cost of production. Sanyo of Japan reported the best conversion efficiency of 20.7% using these structures with n-type silicon [15]

## 2.5 Porous Silicon

Porous silicon was first discovered in 1956 at the Bell Laboratories. Much importance was not given to this material until late 1980s when it was known that porous silicon can give quantum confinement effect. This was followed by published experimental results in 1990 onwards by number of workers.[16-27] Quantum dots, quantum wells and quantum wires remained as exotic terms. Last century witnessed progressive reduction in dimensionality of semiconductors and emergence of future technology known as Nano electronics

## 2.6 Black Silicon

Black silicon is known as Nano structuring of silicon surfaces to overcome the problem of surface reflection. Black silicon based solar cells do not require anti-reflection coating. It may lead to enhanced efficiency and reduced manufacturing cost. However the use of black silicon in photovoltaics have resulted in solar efficiency below 20 % which may be due to increased surface carrier recombination. The fabrication method, morphologies, optoelectronic properties and other physical parameters of black silicon and its application solar cells have been widely studied by the workers [28-52]

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