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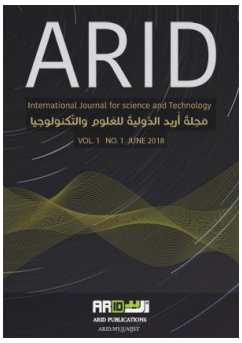

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GROWTH OF SOLAR CELLS ARTICLES AT ELSEVIER JOURNALS

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نمو الخلايا الشمسية في مقالات مجلات السيفير

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ABSTRACT

The knowledge of researcher on the growth of published articles in any subject represented an important thing which enables him to follow the importance of the subject, which aims to work on it through the global research trend. In this paper, a systematic method for researchers was presented for researchers especially postgraduate students to help them determine the importance of the research they have chosen. A quick look regarding solar cells and the development of the number of researches that published in Elsevier in the period from 2009 to 2017 has given. Some types of solar cells namely the silicon, organic, dyes, nanocrystalline, carbon nanotube, quantum dot silicon and graphene are selected, and the number of researches published for these types is followed. It is noted that the number of most types of the solar cells papers have been tripled during the specified period and the highest ratio of publication was for the organic solar cells followed by silicon and dyes cells.

Keywords: Silicon solar cells, organic solar cells, dyes, nanocrystalline, carbon nanotube, quantum dot silicon and graphene

الملخص

يعد اطلاع الباحثين على النمو في عدد البحوث المنشورة في أي تخصص ما من الأمور المهمة التي تمكن الباحث من متابعة أهمية الموضوع الذي يروم العمل عليه من خلال التوجه البحثي العالمي. في هذه الورقة، نقدم طريقة منهجية للباحثين وخصوصا طلبة الدراسات العليا بغية مساعدتهم في تحديد أهمية البحث الذي اختاروه والاهتمام العالمي به. قدمنا نظرة سريعة حول موضوعة الخلايا الشمسية وتطور عدد الأبحاث المنشورة في دار النشر السيفير للفترة من 2009 ولغاية 2017. تمَّ اختيار أنواع محددة من الخلايا الشمسية لنمو النشر العلمي، منها خلايا السليكون البلوري الشهير، والخلايا الشمسية العضوية ، خلايا الأسلاك النانوية، وخلايا الصبغات الحساسة للضوء، وخلايا النقطية الكمومية، وخلايا الأنابيب الكربونية، وخلايا الكرافين.

تم تتبع عدد البحوث المنشورة لتلك الانواع ولوحظ أن أغلب أنواع البحوث قد تضاعف عددها ثلاث مرات خلال الفترة المحددة، وأنَّ أعلى نسبة نشريات كانت للخلايا الشمسية العضوية، وتليها الخلايا السليكونية وخلايا الصبغة.

1. Introduction

Solar cell or Photovoltaic devices absorb sunlight and enable the conversion of solar radiation into useable electrical energy [1]. With the expansion of industry and population growth as well limiting resources of fossil fuels, the world needs to new energy sources. In addition, new energy sources must be environmentally friendly to reduce the increasing pollution of the air such as solar energy that is gaining more and more importance. Thus, photovoltaic (PV) is a fast-growing market. The Compound Annual Growth Rate (CAGR) of PV installations was 40% between 2010 to 2016. Concerning PV module production in 2016, China &Taiwan hold the lead with a share of 68%, followed by Rest of Asia-Pacific & Central Asia (ROAP/CA) with 14%. Europe contributed with a share of 4% (was 5% in 2015); USA/CAN contributed 6% [2]. For example, in 2016, Germany accounted for about 13% (41.3 GWp) of the cumulative PV capacity installed worldwide (320 GWp) with about 1.6 million PV systems installed in Germany. Moreover, the cost of production PV is significantly reduced, Figure 1 shows the global cumulative PV installation until 2016 (includes off-grid) and Figure 2 represented global cumulative PV installation by region. In this summarized overview, selected type of solar cells articles growth at Elsevier journals is addressed. Elsevier is the information and analytics Company and one of the world's major providers of scientific, technical, and medical information. Its products include journals such as the Lancet and Cell, the ScienceDirect collection of electronic journals, the Trends and Current Opinion series of journals, the online citation database Elsevier and the clinical key solution for clinicians. Elsevier publishes around 420,000 articles annually in 2,500 journals and archives contain over 13 million documents and 30,000 e-books.

The solar cells articles that published in Elsevier are increased from about 7000 at year 2009 to around 18900 at 2017 as presented in Figure 3.

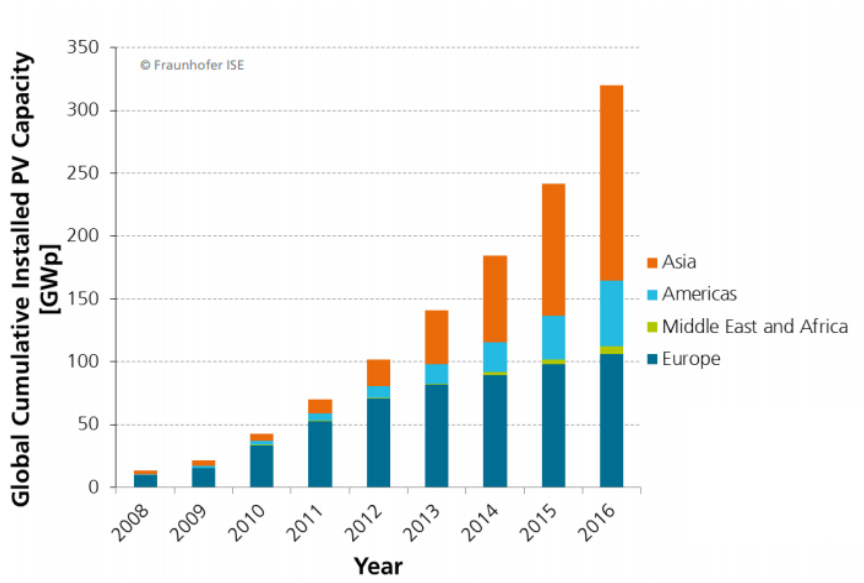

Figure (1): Global cumulative PV installation until 2016 (includes off-grid)

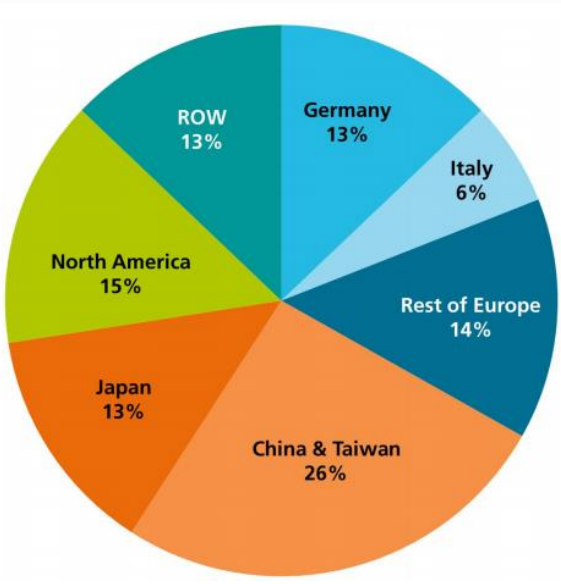

Figure (2): The total cumulative installations amounted to 320 GWp at the end of 2016. All percentages are related to total global installations, including off-grid systems

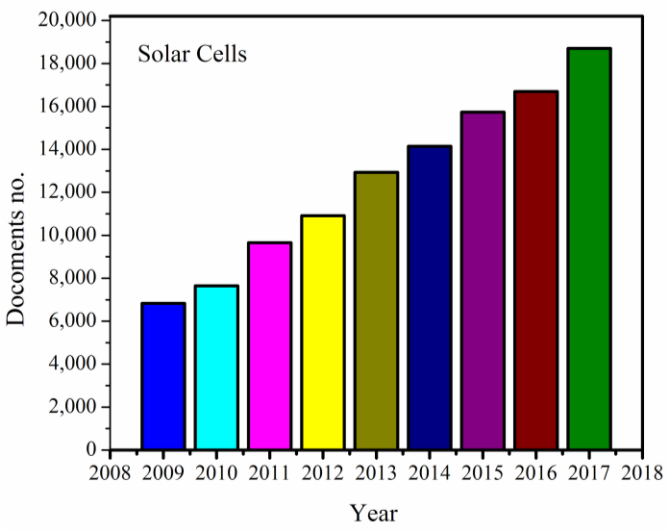

Figure (3): The solar cells articles published in Elsevier from 2009-2017

2. Results and Discussion

In this section, we will review the published articles statistics on selected types of solar cells throughout the period 2009-2017 and analyze their results.

2.1 Silicon Solar Cells

Silicon crystal (wafer) based PV technology accounted for about 94% of the total production solar cells in 2016. However, the share of multi-crystalline technology is now about 70% of total production [2]. The Silicon with crystalline or amorphous structure is the famous material that used to fabricate solar [3, 4] also the articles are tripled annually between 2009 and 2017. The published articles increased from about 1500 at year 2009 to around 4300 at 2017 as seen in Figure 4.

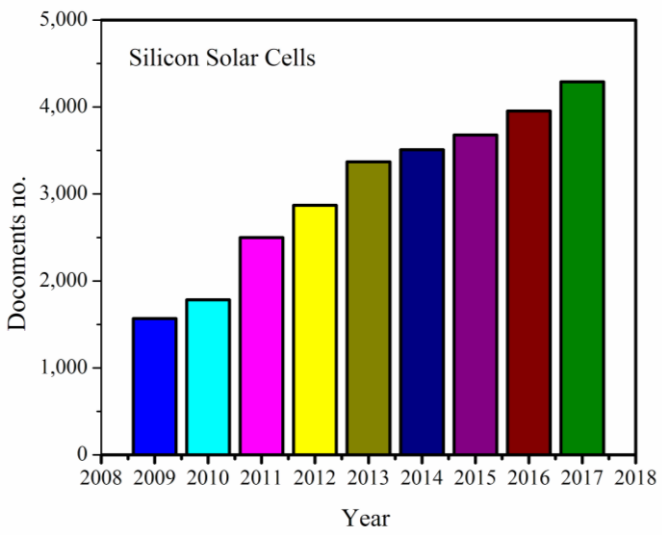

Figure (4): The number of published articles versus years for silicon solar cells

2.2 Organic Solar Cells

Organic solar cells have provided a unique opportunity and gained extensive attention as a next-generation photovoltaic technology due to their lightweight, mechanical flexibility, and solution-based cost-effective processing. However, organic solar cells still suffer from low efficiency and short lifetime. Polythiophenes and specifically poly (3-hexylthiophene) (P3HT) became frontrunners in the research on conjugated polymers. Conversion efficiency (PCE) is grown quickly with the development of new organic materials and has surpassed 12% recently [5].

Total documents in ScienceDirect reached to 8300 articles as shown in Figure 5.

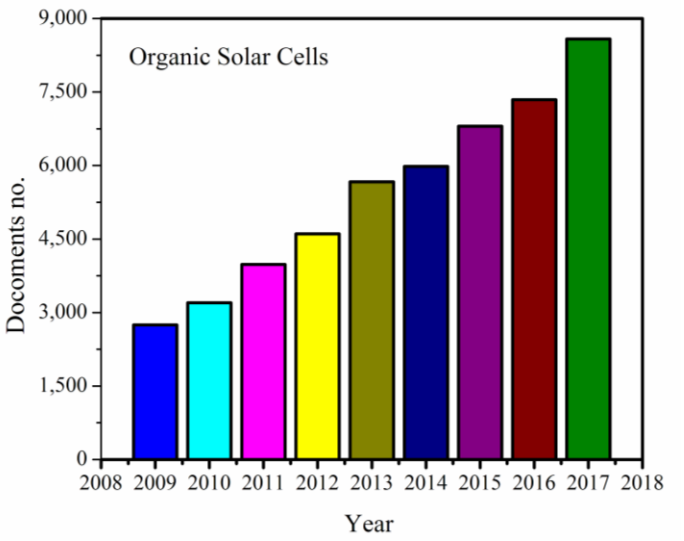

Figure (5): The number of published articles versus years for organic solar cells

2.3 Nano crystalline Solar Cells

A nanocrystal is a crystalline particle with at least one dimension measuring less than 100 nanometers (nm) (quantum dot, quantum wire, quantum well). Nanocrystals lead to novel quantum-mechanical effects due to the quantum confinement or quantization [6, 7]. In nanocrystalline semiconductor the relaxation time can be dramatically reduced. This is because in small systems in nanoscale with decreasing size the difference between the energy levels is increasing (this is obtained from the Schrödinger equation). Due to the large band gap hot electrons cannot relax quickly to initial state, because the Coulomb interaction will be very weak, and these electrons can contribute to the current [6]. Further, the very high surface-to-volume ratio of nanomaterials is the most remarkable and could lead to new atomic arrangements that affect the optical properties of this material [8].

Figures 5-9 explained the growth in the article's numbers of different nanocrystalline types solar cells that published by Elsevier from 2009 to 2017. All Figures shows increasing in the

documents number indicating the increase in the interest of the researchers for the nano-solar cells. Different types of quantum dot materials and structures are used to fabricate solar cells [9-11]. “One-dimensional (1D) nanocrystalline semiconductors such as nanowires, nanotubes, nanorods, etc have received attention in recent years because its exhibit multifunctional unique properties such as high crystallinity, high surface-to volume ratio, quantum confinement effects as well high lifetime electron-hole recombination.”"One of the most important 1D nanostructure is silicon nanowires (SiNWs). Silicon nanowires have many splendid properties depending on the surface morphology such as diameter, length, direction of growth and crystallization. In addition, the density of the grown nanowires also affects the characteristics such as optical and electrical properties. The optical band gap of SiNWs turns from indirect into direct due to the quantum confinement effect and the band gap increases with the decrease of the wire diameter; therefore, they are potentially more suitable in optoelectronics applications compared with bulk Si” [12, 13]. Thus, silicon nanowies recently is widely used to fabricate solar cells and other optoelectronic devices [14].

Dye-Sensitized Solar Cells (DSSCs) are one of the types of solar cells that show promising properties such as high conversion efficiency, use of environmentally friendly materials, ease of preparation, and low-cost of production [12, 13]. Further, recently carbon nanotube is used for organic/inorganic hybrid solar cells to enhance the output [15, 16]. “Graphene has been played the role of conductive transparent devices indebted to its unique two dimensional (2D) structures and gained an exceptional opportunity to be employed in energy industry”. In the past two decades, graphene “has been merged with the concept of photovoltaic (PV) material and exhibited a significant role as a transparent electrode, hole/electron transport material and interfacial buffer layer in solar cell devices”[17-19].

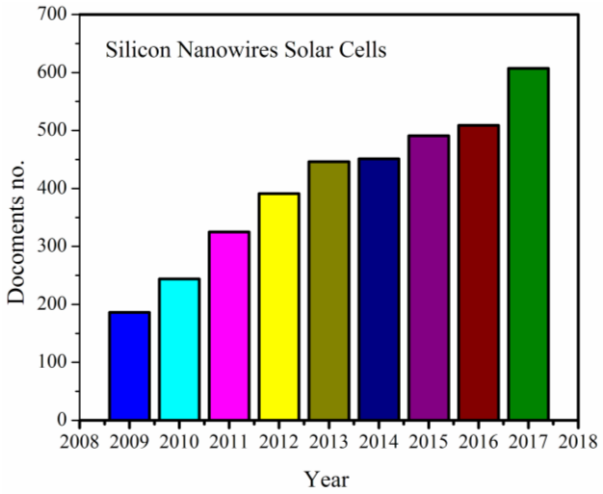

Figure (6): The number of published articles versus years for silicon nanowires solar cells

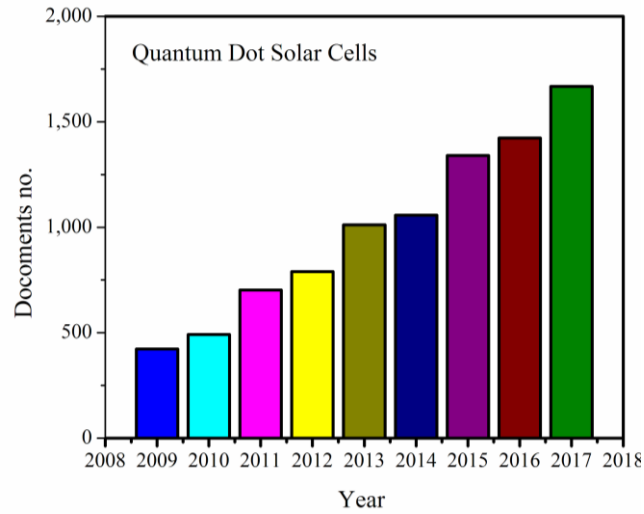

Figure (7): The number of published articles versus years for quantum dot silicon solar cells

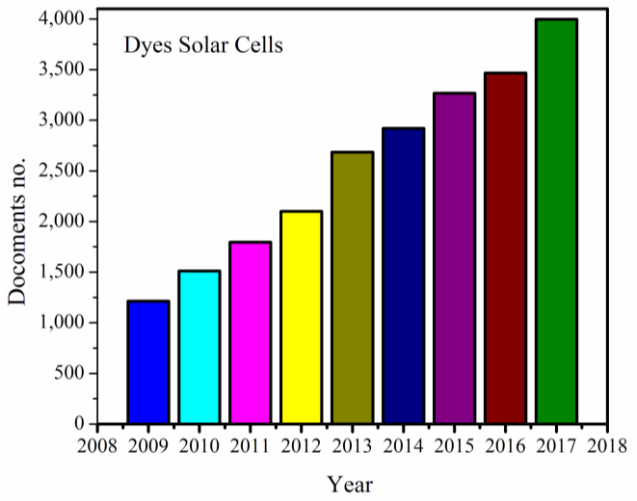

Figure (8): The number of published articles versus years for dyes solar cells

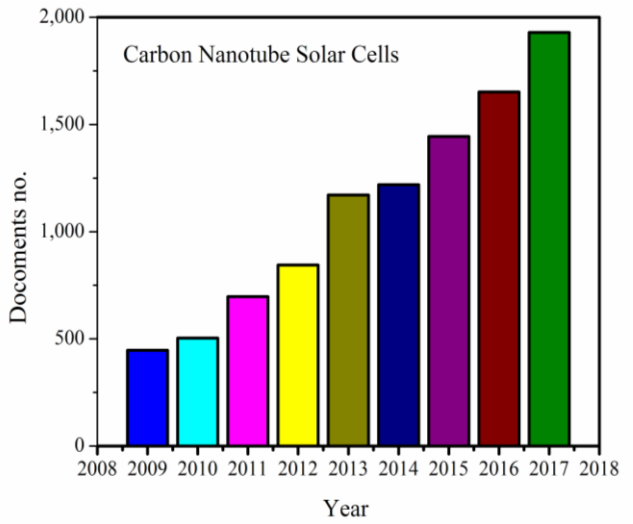

Figure (9): The number of published articles versus years for carbon nanotube solar cells

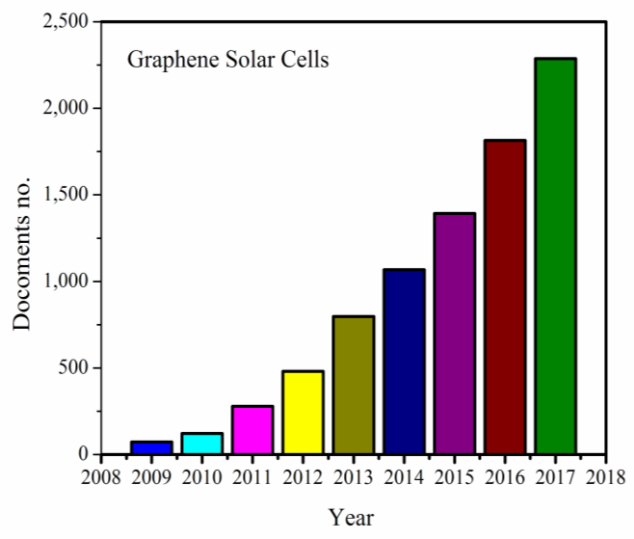

Figure (10): The number of published articles versus years for graphene solar cells

The ratio of solar cells types is presented in Figure 11 where the organic cells have the highest ratio and both silicon and dyes cells come second.

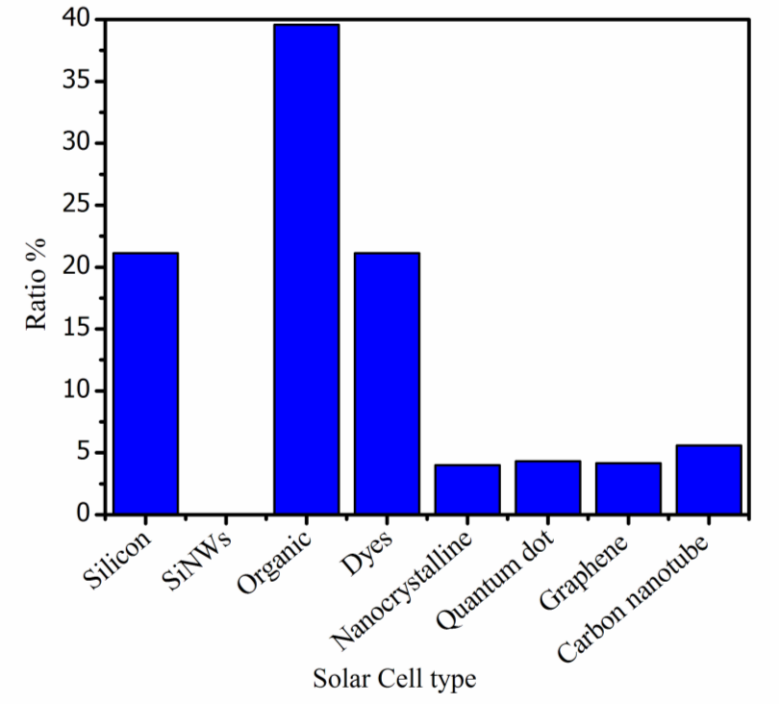

Figure (11): The ratio of different solar cells types articles that published in Elsevier from 2009 to 2017

Table 1 summarizes the number of the published documents from 2009 to 2017 compared to the total publication of articles for different types of solar cells. We can note that the number of graphene solar cell articles that published in the period time represented around 97% of the total articles of graphene solar cells. Moreover, other types such as silicon nanowires, carbon nanotube, as well as dyes solar cell are also showed high publishing ratio in the period of 2009 to 2017. However, we can note that some types of solar cell are grown more than others and the reason of this could be related to the cost production, easy to fabricate, or environmental factors.

Table1: The number of documents from 2009 to 2017 compared by the total number of documents of different solar cells type and nanomaterials.

Types of solar cell	The total no. of documents	The no. of documents in 2009-2017	The ratio (%)
Total Solar Cells Documents	202.468	113253	55.93625
Organic	75394	48413	64.21333
Dyes	33450	27523	82.28102
Silicon nanowires	4187	3650	87.17459
Nanocrystalline	11374	8122	71.40848
Silicon	51206	27523	53.74956
Carbon nanotube	11466	9907	86.40328
Graphene	8560	8313	97.11449

2. Conclusions

The Compound Annual Growth Rate (CAGR) of PV installations was 40% between 2010 to 2016. The solar cell articles that published in Elsevier from 2009 to 2017 period increased for the different types. Solar cell articles that published by Elsevier are increased by a ratio of 170% for the period from 2009 to 2017. However, the articles types are tripled in the same period. Organic solar cells articles were the highest ratio that represented around 40% compared by other solar cells types. We can conclude that nanostructures solar cells articles will grow in the next years specially graphene, dyes, as well silicon nanowires structures.

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