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TECHNOLOGICAL VALUE OF SILICON IN MODERN ELECTRONICS USEFUL FOR DEVELOPMENT IN POST COVID-19 ERA

AMAKA IMMACULATA CHIJIOKE (Ph.D)
makasjioke@yahoo.com
DEPARTMENT OF COMPUTER SCIENCE
FEDERAL POLYTECHNIC OKO, NIGERIA
+2348030439228

GRACE UDUNEHI IBEH
gracejoeibeh@gmail.com
DEPARTMENT OF SCIENCE LABORATORY TECHNOLOGY
FEDERAL POLYTECHNIC OKO, NIGERIA
+2348064741028

ENGR. FREDERICK CHUKWUEBUKA NWOSU (Ph.D)
jirebus@gmail.com
DEPARTMENT OF ELECTRICAL/ELECTRONIC ENGINEERING
FEDERAL POLYTECHNIC OKO, NIGERIA
+2347062506457, +2348024672385
&
AMARACHUKWU NKECHI NWOYE (Ph.D)
an.nwoye@unizik.edu.ng
DEPARTMENT OF SCIENCE EDUCATION
NNAMDI AZIKIWE UNIVERSITY AWKA; NIGERIA
+2348038771515

Abstract

Covid-19 is a global pandemic that brought social and economic hardship in Nigeria and other nations of the world. So, in post covid-19 era, Nigeria can apply technology such as electronics for social and economic wellbeing of people. Modern electronics involves the use of silicon. The focus of the paper is how silicon as a chemical element and prominent semiconductor has made technological impact in modern electronics, which in turn can be utilized for development of Nigeria society in post covid-19 era. The paper is a theoretical/opinion one with empirical information and it discussed on issue of post covid-19 era, scientific understanding of chemistry of silicon, technological impact of silicon in modern electronics and importance of modern electronics in boosting development in post covid-19 era. It was pointed out that: Silicon is the most familiar semiconductor used in formation of PN junction useful in production of solid state devices like diode, transistor and integrated circuit (IC) utilized in modern electronics; modern electronics can bring about development in post covid-19 era

for it can be utilized in computerization of work, transmitting and receiving information, creation of job, acquisition of education, supply of energy, safeguarding of life and properties, and recreation. The paper concluded that technological value of silicon can be witnessed in modern electronics; and modern electronics offers social and economic value useful in ensuring well being of Nigeria people in post covid-19 era.

Key Words: Post covid-19 era, silicon, modern electronics, technology, development.

Introduction

A recent pandemic that hit nations of the world is covid-19. In Nigeria covid-19 negatively affected social and economic life in the nation as a result of lock-down ordered by the government in the year 2020. The Covid-19 lock-down was over after some months. For Nigeria, the period after the lock down can be regarded as post covid-19 era, even though covid-19 still exists in the world. In post covid-19 era, Nigeria can apply technology to restore the economy to normalcy for the wellbeing of the populace.

Technology is aimed at utilizing scientific principles and techniques in making human environment enjoyable, for the environment naturally displays some degree of displeasure and discomfort to man. A prominent technology in this modern era is electronics. Modern electronics has brought about technological devices which can enable people experience a pleasant environment as can be seen in its application in computerization, telecommunication and information technology (Nwosu, 2013). Thus, modern electronics can be useful in post covid-19 era.

Emergence of modern electronics is as a result of semiconductors existing in human environment. The most familiar semiconductor is a chemical element called silicon. Silicon can be seen as a chemical element greatly used in modern electronic technology needed in fostering development in post covid-19 era.

The thrust of the paper is a discussion on the role of silicon in emergence of modern electronics which can be utilized in fostering development in post covid-19 era. The content of the paper are: Issue of post covid-19 era, scientific understanding of chemistry of silicon, technological impact of silicon in modern electronics, importance of modern electronics in boosting development in post covid-19 era, conclusion and recommendations.

Issue of Post Covid-19 Era

It is a noble desire that human society should be characterized with good health for it is a wealth that serves as an essential resource for effective performance of various human activities. Good health can be denied in human society in era of pandemic. Pandemic is a public

health issue for it is concerned with spread of disease among human population. Examples of pandemic disease are ebola and coronavirus. The pandemic called coronavirus is known as covid-19 for it originated in 2019 from China.

Covid-19 became a pandemic that exist in the globe in the year 2020, resulting that nations in the world, which includes Nigeria, got terrified and embarked on lock down that year. During the lock-down in Nigeria, people's movement from one location to another was restricted for some months. The movement restriction negatively affected social and economic wellbeing of most Nigerians for there were reduction in social ceremonies, closure of academic institutions, decrease in religious gatherings, immoral and illegal acts, lost of jobs, hunger, and financial breakdown. Fortunately, after some months, there was a lift of the lock down in Nigeria and people began to move about.

In Nigeria, the period after the lock-down that allows free movement in the nation can be termed post covid-19 era, even though the world still experiences the presence of covid-19. Since covid-19 still exists, the era of post covid-19 is a period of observing certain protocols (such as wearing of face masks, hand washing and social distancing) to avoid contacting of the disease. Due to the ill and negative effects of covid-19, it is expected that post covid-19 era should be a period of serious human development and economic empowerment for restoration of human activities to normalcy. To cushion the effect of the pandemic, involvement in science and technology is very vital in post covid-19 era. Economic development exists and social and infrastructural amenities are well created and maintained in a nation when science and technology are highly appreciated and utilized (Nwoye, 2011). It can be said that acquisition of scientific understanding will equip people for survival and ensure an improved economy in the post covid-19 era.

Scientific Understanding of Chemistry of Silicon

Silicon is a chemical element; its chemical symbol is Si. Silicon makes up approximately twenty-eight percent (28%) of the earth's crust, resulting that it is second to oxygen in terms of abundance (Nwosu, 2016). Nnabuenyi and Nzekwe (2019) explicate that silicon does not occur free in nature but exists as a compound in form of quartz and silicate minerals: silicon (IV) oxide (SiO_2); metallic trioxosilicates (IV) like sodium trioxosilicate (IV) (Na_2SiO_3), silane (silicon hydrogen compound) eg SiH_4, silicon halide eg $SiCl_4$, silicon carbide (SiC), silicones eg $Si(CH_3)_2Cl_2$. Silicon (IV) oxide, which is commonly called silicon, may be found in pure crystalline form as quartz, and in less pure forms as flint, opal, horn-store and jasper. Silicon is the main constituent of sand and kieselguhr (which is a porous material formed from the

remains of the small plant organisms known as diatoms). Metallic trioxosilicates (IV) are found in slate and igneous rocks like granite and basalt; clay and kaolin consist mainly of hydrated aluminum trioxosilicate (IV).

Production of silicon is through chemical reaction. Ababio cited in Nnabuenyi and Nzekwe (2019) explained how silicon can be produced in amorphous, crystalline and very pure form. Amorphous silicon may be prepared by heating a mixture of pure dry sand and magnesium powder in a free-clay crucible (see equation 1).

$$SiO_2(s) + 2Mg(s) \longrightarrow 2MgO(s) + Si(s) \text{ ---------- (1)}$$

Crystalline silicon is obtained by heating crushed carbon and an excess of sand in an electric furnace, and the product has a purity of 98% and suitable for making alloys (see equation 2).

$$SiO_2(s) + 2C(s) \longrightarrow Si(s) + 2CO(g) \text{ ---------- (2)}$$

Very pure silicon is manufactured by heating silicon tetrachloride ($SiCl_4$) with zinc or reducing tricholosilane ($SiHCl_3$) with hydrogen at a high temperature (see equation 3a & 3b).

$$SiCl_4(l) + 2Zn(s) \longrightarrow Si(s) + 2ZnCl_2(s) \text{ ---------- (3a)}$$

or

$$SiHCl_3(l) + H_2(g) \longrightarrow Si(s) + 3HCl(g) \text{ ---------- (3b)}$$

Silicon belongs to group 14 in the periodic table, just as carbon. Si has atomic number and atomic mass of 14 and 28.0855 respectively. The electronic configuration of Si is $1S^2 2S^2 2P^6 3S^2 3P^2$. Silicon has the same valency as carbon and form analogous compounds. Oxidation states in which silicon can exist are 4,3,2,1,-1,-2,-3,-4 and its stable isotopes are ^{28}Si (92.2%), ^{29}Si(4.7%) and ^{30}Si(3.1%) (Nnabuenyi & Nzekwe, 2019). Nwosu (2016) noted that silicon can exist in two allotropic forms: An allotrope of shiny grayish-black, neddle-like crystal or flat plates; the other allotrope is amorphous and usually occur as brown powder. However, amorphous silicon is more reactive than graphite and crystalline silicon.

Silicon has multifunctional properties for it is a chemical material utilized in polymers, fiber optics, glass production, ceramics, modern electronics and other industrial processes. It can be deduced that silicon acts as a chemical material with technological value in modern electronics.

Technological Impact of Silicon in Modern Electronics

In this modern era (21st century), most development greatly pertains to electronic technology and the technology deals with scientific study and use of electronics for an improved economy in human society. Nzekwe (2016) averred that electronic technology is the practical application of electronics in production of materials, devices and systems that will make human environment conductive and less harsh to live. Chiwetalu cited in Amechi, Chukwulobe and Nwosu (2016) pointed out that electronics involves the study, design, construction and application of devices, whose operations are based on the conduction of electricity in vacuum (vacua), or gases or semiconductors. In the early stage of electronics, valves were greatly employed in production of electronic devices and use of valves generates a lot of heat that reduces efficiency. Nowadays, modern electronics mostly involve the use of semiconductor materials in production of technological devices and systems.

A semiconductor is a solid-state material whose electrical conductivity lies between that of a conductor (eg copper) and an insulator (eg rubber). Pit cited in Nzekwe (2016) stated that semiconductor is a material having a resistivity between that of conductors and insulators and having a negative temperature coefficient of resistance. A pure semiconductor is called intrinsic semiconductor but it becomes an extrinsic semiconductor through doping. Doping is adding impurities (foreign atoms) into the intrinsic semiconductor in a carefully controlled manner to increase its conductivity. Semiconductor materials are almost insulators, but become conductors if free electrons are made available, for example, when exposed to light or heat, or when impurities are added (Ijomah, cited in Amechi, Chukwulobe & Nwosu, 2016). Meadows cited in Amechi, Chukwulobe and Nwosu (2016) explained that a wide range of materials acts as semiconductor: Silicon, germanium, gallium arsenide, selenium, cadmium sulphide, indium antimonide, and the oxides of copper, iron, zinc, cobalt, manganese, and nickel. However, the best known and most widely used material is silicon, followed to a lesser extent by germanium.

Silicon usually having four valence (outer) electrons and it is a functional material based on its nature as a solid state material. Usually, functional materials are important based on their special electrical, optical and magnetic properties and they include different materials

such as semiconductors, polymers, molecular crystals and nanoparticles. Haripriya (2017) pointed out that functional materials are generally characterized as those materials which possess particular native properties and functions of their own; for example, ferroelectricity, piezoelectricity, magnetism, or energy storage functions. To act as functional material, electrical conductivity of pure silicon can be increased by doping. Doping with trivalent foreign atoms having 3 outer electrons (eg atoms of boron, aluminum, gallium and indium) or pentavalent foreign atoms having 5 outer electrons (eg atoms of phosphorus, arsenic and antimony) results to production of P-type or N-type silicon (extrinsic semiconductor) respectively. The use of N-type and P-type semiconductor gives rise to modern electronics (Nnabuenyi & Nzekwe, 2019).

Modern electronics makes use of silicon as the basic building element in majority of electronic systems. The use of silicon in electronics has resulted that thermionic valves have now be replaced by solid state (semiconductor) diodes, transistors, and integrated circuits as the basic building block in the majority of electronic equipment, which include scanners, computer, television, radio, telephone, video machine, and calculator (Nwosu, 2016). Construction of solid state devices like diodes, transistors, and integrated circuits demands formation of P-N junction, usually by diffusing process or alloying process. A P-N junction is a piece (single crystal) in which a section of P-type material (P-region) is joined to an N-type material (N-region) such that there is an interface between the P and N-type region. When metallic terminals are joined to each side of a P-N junction material, diode is formed. Diode acts as a rectifier for it allows easy flow of charges in one direction but restrains the flow in the opposite direction. When two P-N junction diodes are connected back-to-back a bipolar junction transistor (BJT) is formed. Transistor is used as an amplifier (to produce voltage, current and power gain in a circuit) and also as a switching elements. Diode and transistor are discrete elements distinguish from integrated circuit (IC). IC is a collection of discrete elements like diode, resistors, capacitors and transistors produced using a single construction process in which there is creation of all elements. Theraja and Theraja cited in Nwosu (2016) explained that an integrated circuit is a complete and packaged electronic circuit in which both the active and passive components are fabricated on an extremely tiny single chip of silicon; its advantages are very small size and weight, reduced cost, extremely high reliability, suitability for small-signal operation, low power consumptions, easy replacement, and improvement in speed. Indeed, silicon has lead to emergence of modern electronics directly or indirectly associated with the various developments being witnessed in this 21st century. Amechi, Chukwulobe and Nwosu (2016) asserted that in this modern era, most development greatly pertains to advancement in electronic technology for it gears towards socio-economic wellbeing in a society or nation.

Importance of Modern Electronics in Boosting Development in Post Covid-19 Era

The knowledge and use of modern electronics brought about construction and utilization of various products like computer, radio, television, telephone, video machine, calculator, photocopier, audio amplifier and others that can be useful in post covid-19 era. Nwosu (2013) observed that electronics greatly borders on computer technology and telecommunication technology, and integration of computer and telecommunication technologies results to information technology (IT). With respect to fostering development in post covid-19 era, modern electronics can be utilized in computerization for work enhancement, communication, creation of job, acquisition of education, supply of energy, provision of security, and recreation.

Modern electronics has made it possible the use of computer to make works easier for man. Computer enhances work for it is an electronic device that accepts input data and processes the data with a high speed and then generates an accurate result as the output. In this 21st century, computer has been used in replacing numerous manual tasks that may be tedious, thereby servicing as an essential product of electronic technology useful for development. Amechi and Nwosu (2017) acknowledged that computer has technological nature and value that brought about its use in virtually every human endeavour. Computer can be useful in boosting development in post covid-19 era based on its advantageous nature that makes it serves as an electronic device for speeding up problem solving and increasing productivity.

Modern electronics is vital in the field of communication. Effective communication fosters development in human society for it brings about transmission of information for meaningful interactions in human activity. Electronic-based communication, as in telecommunication, makes it possible that issues pertaining to development in post covid-19 era can be broadcasted in the radio and television to the masses. It is also possible to use telephone to communicate and then obtain information that can be useful for human and national development in post covid-19 era. In addition, information technology, as in the use of the Internet, can bring development in post covid-19 era for it enable people communicate from any part of the world at any time using electronic facilities such as e-mail, e-phoning, online charting, e-conferencing and others. Inyiama cited in Amechi, Chukwulobe and Nwosu (2016) asserted that information technology has enabled people easily communicate with one another in multi-media, electronically, from any part of the world and the technology has promoted socio-economic activities.

Modern electronics plays a great role in creation of job. Involvement in a job has economic and social value for it is a means of income generation for a happy and decent living necessary for development in human society. Creation of Job, as a means of development, is essential in Nigeria since the nation experiences high rate of unemployment. Unemployment brings about insecurity that negatively affect development in human society for it leads to immoral and criminal acts such as stealing, duping, prostitution, kidnapping, killing. In this post covid-19 era, it is expedient that people who are not engaged in any employed-job to think of being job creators by engaging in entrepreneurship. Some job opportunities associated with electronics are working as a computer programmer, electronic engineer/technologist or technician, electronic tutor, an operator of electronic system, consultant in electronic-based activities, vendor of electronic products, and manager in electronic-based organization (Nnabuenyi & Nzekwe, 2019). In the same vein, Nwosu (2013) pointed out that employment in electronics and information technology can be in terms of lecturing/teaching, design and construction, maintenance and repair, marketing (sales), processing and management.

Modern electronics makes it possible that computer and communication devices can be utilized for education purpose for development in post covid-19 era. Computer can be used as an instructional material for enhancement of teaching and learning. Chijioke and Chukwuebuka-Nwosu (2019) averred that computer can serve as an audio-visual teaching aid which teachers can use for effective communication among the students in the classroom. Computer is useful in playing of educational games for intellectual and moral development. Nwosu (2011) opined that educational computer game can: Foster learning among the students; enhance acquisition of technological and creative skills by the students; remove the mind of the students from useless and destructive activities; and enable engagement in meaningful and educative activities as well as exposure to ethics. Education software like Computer Assisted Learning (CAL) or Computer Aided Instruction (CAI) can be utilized in acquisition of education in a manner that can bring about easy and better understanding of the subject being studied. Also, electronic media such as television, radio, telephone, audiotape, videotape, projectors and others can be used to impart and acquire education. Likewise, Internet can be utilized in carrying out academic research and obtaining educative information useful for development in post covid-19 era.

Part of the effort needed to ensure development in post covid-19 era is adequate provision of energy. Energy is of different kinds and it must be provided for any work to be carried out. Among the forms of energy is electrical energy and it is greatly needed for effective and efficient operations in this modern society. Fortunately, the emergence of modern electronics has lead to provision of electrical energy

from solar energy. Nnabuenyi and Nzekwe (2019) acknowledged that the application of semiconductor in electronic technology has brought about the use of solar energy in generation of electricity through a transduction action by solar cell or solar panel. Generation of electrical energy from solar energy is advantageous for it is a renewable energy, non-polluting and safe. The electrical energy can help to mitigate the problem of inconsistent supply of electrical power from the national grid in Nigeria. Thus, the electrical energy generated from solar energy can be used to carry out domestic and industrial activities in post covid-19 era.

Provision of security is a vital resource for development in post covid-19 era. Modern electronics has security value for it can be applied in production of security systems for safe-guarding and protection of life and properties. Modern electronics can also provide security by helping in reducing or avoiding accidents and transportation risks associated with travelling by communicating to people using telephone and Internet without travelling. Nnabuenyi and Nzekwe (2019) is of the view that security can be provided when travelling is avoided through the use of telephone and Internet to communicate, thereby giving forum for minimization or prevention of transportation hazards like traffic congestions, road accidents, lost/damage of property and robbery attack. Internet can serve as a medium for security in that documentation can be made in a secured website such that vital records and information lost or destroyed in an organization can be retrieved for continuous socio-economic operations in the organization (Nwosu, 2013). Part of security is embracing of ethics. A means to ensure ethics is using electronic communication devices to transmit ethical information to people for observation of good moral that will deter them from acts of insecurity. Nzekwe (2016) opined that computer can be used to store good moral messages (such as scriptural messages) which can empower people to desist from criminal and immoral acts that lead to insecurity. When there is provision of security in a nation, peace is established. Computer can be used to store and communicate knowledge and information to a reader for manifestation of ethical conducts that can enhance peace; also, information technology through the use of internet facilities such as e-learning, online chatting, online phoning, and teleconferencing can enable people in Nigeria acquire peace education useful in fostering sustainable national development (Ezeife, 2020).

In this post covid-19 era, people need to relax their body and mind and desist from worry and stress so as to have good health. Such good health can be achieved by using modern electronics for entertainment during recreation. Among the means of recreation are music, drama and game and they can be installed in the computer. Amechi and Nwosu (2017) acknowledged that computer can be used for recreational activities like watching films and playing games in a manner that can promote intellectual enhancement. It would be nice for people to make

out time in this post covid-19 era and relax from strenuous works injurious to health by enjoying the recreational facilities installed in the computer.

Conclusion

Covid-19 is a pandemic that made Nigeria experience lock-down in the year 2020. The lock-down in Nigeria brought social and economic suffering to a great number of people. Eventually, after some months, the lock-down was over in Nigeria and the nation can be taken to be in post covid-19 era. Post covid-19 era should be a period of making serious effort to overcome the ill effects of the pandemic for the well being and development of Nigeria.

A means to the expected effort for pleasant life is making adequate use of modern electronics. Modern electronics can bring about development in post covid-19 era through effective use of electronic systems such as computer, telephone, radio, television, internet and solar panel. Modern electronics are useful in computerization for work enhancement, communication, creation of job, acquisition of education, supply of energy, provision of security, and recreation. Modern electronics emerges as a result of existence of semiconductors. A familiar and most valuable semiconductor is silicon. Thus, silicon is a chemical element that is a semiconductor with technological value in modern electronics needed for development in post covid-19 era in Nigeria.

Recommendations

Based on the technological value of silicon in modern electronics useful for development in post covid-19 era, it is recommended that:

- Intellectuals involved in material science should embark on researches on the technological values of semiconductor materials especially silicon.
- Students, lecturers, and educational administrators concerned with study and research in electronics should show positive attitude in promoting understanding and application of silicon and other electronic materials for technological development.
- Government, organizations, and wealthy individuals should provide resources and funds to support and encourage study and research on silicon and other semiconductor materials for advancement of electronic technology.
- Nigeria people should have a strong value system that encourages the study and use of modern electronics for development.

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