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THE ATOMIC SWITCH AND ITS APPLICATONS : A REVIEW

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Abstract:

An atomic switch is a nanoionic device that controls the diffusion of metal ions/atoms and their reduction/oxidation processes in the switching operation to form/annihilate a conductive path. Since metal atoms can provide a highly conductive channel even if their cluster size is in the nanometer scale, atomic switches may enable downscaling to smaller than the 11 nm technology node, which is a great challenge for semiconductor devices. Atomic switches also possess novel characteristics, such as high on/off ratios, very low power consumption and non-volatility. The unique operating mechanisms of these devices have enabled the development of various types of atomic switch, such as gap-type and gapless-type two-terminal atomic switches and three-terminal atomic switches. Novel functions, such as selective volatile/nonvolatile, synaptic, memristive, and photo-assisted operations have been demonstrated. Such atomic switch characteristics can not only improve the performance of present-day electronic systems, but also enable development of new types of electronic systems, such as beyond von-Neumann computers.

Introduction

Resistive switching memories based on the formation and dissolution of a metal filament in a simple metal/oxide/metal structure are attractive because of their potential high scalability, low-power consumption, and ease of operation. From the standpoint of the operation mechanism, these types of memory devices are referred to as gapless-type atomic switches or electrochemical metallization cells. It is well known that oxide materials can absorb moisture from the ambient air, which causes shifts in the characteristics of metal-oxide-semiconductor devices. However, the role of ambient moisture on the operation of oxide-based atomic switches has not yet been clarified. In this work, current–voltage measurements were performed as a function of ambient water vapor pressure and temperature to reveal the effect of moisture on the switching behavior of Cu/oxide/Pt atomic switches using different oxide materials. The main findings are: i) the ionization of Cu at the anode interface is likely to be attributed to chemical oxidation via residual water in the oxide layer, ii) Cu ions migrate along grain boundaries in the oxide layer, where a hydrogen-bond network might be formed by moisture absorption, and iii) the stability of residual water has an impact on the ionization and migration processes and plays a major role in determining the operation voltages. These findings will be important in the microscopic understanding of the switching behavior of oxide-based atomic switches and electrochemical metallization cells.

somers by definition are the molecules of identical atomic compositions, but with different bonding arrangements of atoms or orientations of their atoms in space i.e., isomers are two or more different substances with the same molecular formula.[3–5]

Three types of isomerism are possible – Constitutional, Configurational, and Conformational. The terms configuration and conformation are often confused. Configuration refers to the geometric relationship between a given set of atoms, for example, those that distinguish L- from D-amino acids. Interconversion of configurational alternatives requires breaking covalent bonds. Conformation refers to the spatial relationship of every atom in a molecule. Interconversion between conformers occurs without covalent bond rupture, with retention of configuration, and typically via rotation about single bonds.[4]

Constitutional isomers are also called structural or positional isomers. Theses are molecules with same atomic composition but different bonding arrangements between atoms. Examples of constitutional isomerism are catechol, resorcinol, and hydroquinone; all of these compounds having the same atomic compositions ($C_6H_6O_2$), but different bonding arrangements of atoms. These are distinct chemical entities with different chemical and physical properties.[6] Configurational isomers are defined as molecules with identical atomic composition and bonding arrangements but with different orientation of atoms in the space. These different orientations cannot interconvert freely by bond rotation. Example is d- and s- amphetamine. Conformational isomers are different by relative spatial arrangements of atoms that results from rotation about sigma bonds. Thus, unlike configurational isomers, conformers are interconverting stereoisomers of a single compound

Yu et al. reported the bis anthryl compound and its DNA binding and cleavage studies. The bis anthryl compound shows more binding constant than the mono anthryl compound [14]. Tolpygin has reported the photo induced electron transfer effect in the amino methyl anthracene derivatives. The amino methyl anthracene derivatives could give rise to photo-induced electron transfer in the excited state from lone pair on nitrogen atom to the anthracene fragment, which leads quenching of fluorescence in the latter. Interaction of such compounds with metal cations or proton inhibit photo-induced electron transfer, thus inducing strong fluorescence of the sensor [15]. Kraicheva reported the biological activities of anthracene with amino phosphonic acids. These are quite promising as anticancer agents. Anthracene derived amino phosphonates might be of particular interest in this direction taking into account that the DNA intercalating anthracene ring is the main pharmacophoric fragment of some cytostatic drugs [16]. Phanstiel et al. reported the anthracene containing polyamine compounds. These compounds show a selective drug delivery (cell surface protein) [17].Metal-free DNA cleaving reagents have been studied by Gobel and co-workers, these compounds are thought of as safer agents for cleaving the P-O bond of phosphodiesters in nucleic acids, showing clinical potential [18]. Small organic molecules, such as guanidinium derivatives [19], cyclodextrin derivatives [20], dipeptides [21] and especially macrocyclic polyamines [22], have also been used as cleaving agents of nucleic acids. The anthraquinone group, as a fine intercalator of DNA, has been frequently adopted in certain anticancer drugs, such as doxorubicin, anthracyclines, mitoxantrone and anthrapyrazoles [23].

That applications can reported that the compound formed by conjugating the cis, cis-triaminocyclohexane-Zn2+ complex (cleaving moiety) with anthraquinone (intercalating moiety) via an alkyl spacer led to a 15-fold increase in DNA cleavage efficiency when compared with the cis, cis-triaminocyclohexane-Zn2+ complex without the anthraquinone moiety [24]. Yu et al. reported that macrocyclic polyamine bis-anthracene conjugates showed higher DNA binding and photocleaving abilities than their corresponding mono-anthracene conjugates [14]. Roe et al. showed carcinogenic activity of some benzanthracene derivatives in new born mice [25]. Fabbrizzi et al. explained the redox switching of anthracene fluorescence through the CuII/CuI Couple. Lorente et al. reported concentration dependent interaction studies with DNA and anthracene derivatives

Nanotechnology is the engineering of functional systems at the molecular scale. Generally, nanotechnology deals with developing materials, devices, or other structures with at least one dimension sized from 1 to 100 nanometer. Nanotechnology may be able to create many new materials and devices with a vast range of applications, such as in medicine, electronics, biomaterials and energy production. Molecular nanotechnology is especially associated with the molecular assembler, a machine that can produce a desired structure or device atom-by-atom using the principles of mechanosynthesis. The emphasis of this paper to study of molecular nanotechnology , some of its applications, desired properties in molecular nanotechnology ,development of molecular electronics ,nano-structured materials , molecular nanoelectronics switches and some future scope of it.

Molecular electronics as depicted Figure1, sometimes called moletronics, involves the study and application of molecular building blocks for the fabrication of electronic components. This includes both bulk applications of conductive polymers as well as single-molecule electronic components for nanotechnology. Molecular scale electronics, also called single molecule electronics, is a branch of nanotechnology that uses single molecules, or nanoscale collections of single molecules, as electronic components.

Figure1 : Molecular electronics [1]

Carbon nanotubes as shown in Figure 2 are molecular-scale tubes of graphitic carbon with outstanding properties. They are among the stiffest and strongest fibres known, and have remarkable electronic properties and many other unique characteristics. For these reasons they have attracted huge academic and industrial interest, with thousands of papers on nanotubes being published every year. Commercial applications have been rather slow to develop, however, primarily because of the high production costs of the best quality nanotubes.

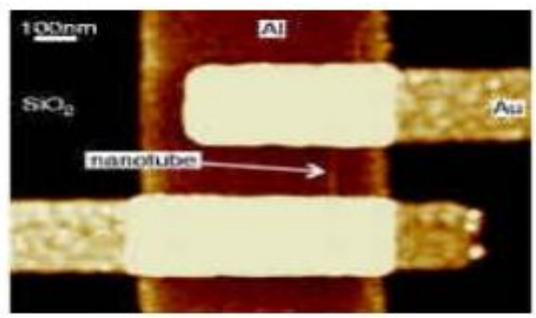

Figure 2: Carbon Nanotube[1]

An 'organic' revolution is unfolding in the electronics industry. From flat-screen TVs and flexible displays to windows, lighting and solar panels, organic electronic components are offering unprecedented features, design flexibility and versatility at relatively low financial and environmental cost , therefore nano organic as shown in Figure3 are boon to electronics

A nanomachine as shown in Figure 4 , also called a nanite, is a mechanical or electromechanical device whose dimensions are measured in nanometers (millionths of a millimeter, or units of 10 -9 meter). The first useful applications of nanomachines will likely be in medical technology, where they could be used to identify pathogens and toxins from

Self-assembly as shown in Figure 6 is a wellestablished concept in physics, chemistry, and molecular biology, and is an important factor in high-volume production of systems made of heterogeneous sub-millimeter components. Molecular self-assembly is the process by which molecules adopt a defined arrangement without guidance or management from an outside source.

Benefits

It will let us make remarkably powerful molecular computers. It will let us make materials over fifty times lighter than steel or aluminium alloy but with the same strength. Molecular surgical tools, guided by molecular computers and injected into the blood stream could find and destroy cancer cells or invading bacteria, unclog arteries, or provide oxygen when the circulation is impaired. It will let us make materials over fifty times lighter than steel or aluminium alloy but with the same strength.

CONCLUSION

Nanotechnology researchers have developed a molecule-sized switch which means that data storage can be dramatically increased without the need to increase the size of devices. The chemical switch is some one million times smaller than the current silicon switches, creating the potential for further miniaturization of computers. Not only IRACST – Engineering Science and Technology: An International Journal (ESTIJ), ISSN: 2250-3498, Vol.2, No. 3, June 2012 466 would the machines be appreciably smaller than anything possible at present, but such molecular computers would be far more powerful than those available now using silicon-based logic gates.

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