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Atomic Structure and Binding of Carbon Atoms

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Abstract: Carbon is a versatile element due to having many allotropes. Depending on the processing conditions of a carbon precursor, a carbon atom changes its state behavior. Converting carbon atoms from one state to another is under the electron transfer mechanism. In conversion, the dash-shaped energy bits involved transferring electrons to nearby unfilled states. The involved dash-shaped energy bit has partially conserved behavior. The forces exerted on the transferring electrons also remain partially conserved. Under only attained dynamics of atoms, a two-dimensional or amorphous graphite structure forms. To form a structure in one dimension, two dimensions, or four dimensions, graphite, nanotube, or fullerene state atoms perform electron dynamics, respectively. In these structures, binding is due to the dash-shaped energy bits involved while the electron transfer mechanism. The structural formations in diamond, lonsdaleite, and graphene state atoms involve differently shaped bits of energy. The bit of energy has a shape like a golf stick. Each outer ring electron of a depositing diamond atom undertakes a clamp of the outer ring energy knot of the deposited diamond atom by involving a golf-stick-shaped energy bit. A depositing diamond atom binds to the deposited diamond atom from the east-west poles to the south pole. Growth is from the south pole to the east-west poles, so the structure of the diamond is a tetra-electron topological structure. The lonsdaleite atoms bind from the east-west poles to a bit south pole. In glassy carbon, the layers of gaseous, graphite, and lonsdaleite state atoms bind simultaneously. The order of the layers repeats in the growth of glassy carbon. Differently processed carbon materials also study hardness under a new insight. Thus, this study develops an understanding of the fundamental and applied science of carbon-based materials.

Keywords: Carbon; Atomic structure; Electron dynamics; Structure; Binding energy

1.0. Introduction

New strategies are required to process and synthesize carbon-based materials in selective sizes. Characterizations and analyses of carbon-based materials can explore a new science at both primary and applied levels. A force exerted at the electron level should also explain the role of energy at the electron level [1–3].

In the structural formation of those carbon atoms where partially conserved energy involves at the electron level, a partially conserved force should also engage at the electron level. It should be the case in the structural formation of graphite, nanotube, and fullerene state atoms.

In the structural formation of those carbon atoms where non-conserved energy involves at the electron level, a non-conserved force should also engage at the electron level. It should be possible in the structural formation of diamond, lonsdaleite, and graphene state atoms. In the carbon atoms where neither energy involves nor force engages at the electron levels, force energy, a chemical in nature, should together contribute at the atomic level to form a structure.

The involvement of the energy at the electron level directs the force to engage at the electron level. As a result, atoms bind to form nano or micro-sized grains. The outer ring electrons of carbon atoms in any state do not entertain a conservative force because of having a very close distance to the center. The nature of the involved energy should depend on the allotrope of a carbon atom. In the literature, several studies discussed the allotropic forms of carbon.

When the conservative forces exert on the electron in a silicon atom, an uninterrupted execution of its dynamics generates a photon of unending length [2]. It indicates that the built-in interstate gap of electron dynamics in the carbon atom differs from silicon. Both carbon and silicon atoms possess equal numbers of filled and unfilled states in the outer ring. But from the center, the outer ring electrons of a carbon atom have different distances from the outer ring electrons of a silicon atom.

Gaseous and solid atoms deal with the transitions while undertaking the liquid states, where the electrons remain within their occupied energy knots [3].

The atoms which execute confined interstate electron dynamics evolve structure instead to develop it [4]. Atoms belonging to all elements do not ionize [5]. Carbon films in tiny-sized grains got deposited due to the synthetic protocol [6]. Carbon films of different morphology of grains got deposited at varying process conditions [7].

At different chamber pressures, the deposition of the carbon films shows different morphology and structure [8]. At different inter-wire distances, a carbon film was deposited in diamond and graphite phases [9]. Thus, the electron transfer mechanism is responsible for changing an atom's chemical nature regardless of whether it belongs to the same element.

The force entering from the north pole and leaving the ground surface for the south pole behaves differently than the force exerted at the ground surface [10]. A recent study shows the transformation of graphene film into a diamond-like carbon film, where the elastic deformations and chemical natures were changed [11]. Wu *et al*. [12] reviewed the developments in Raman spectroscopy of graphene materials.

Carbon nanofibers were grown without a catalyst using a vapor deposition method [13]. Different applications related to graphene hybrids were reviewed [14]. Nitrogen-incorporated carbon dots merged to modify a glassy carbon electrode [15]. A novel energy dissipation system was investigated by gathering the features of both carbon nanotubes and fullerenes [16]. Different carbon allotropes, in comparison, were studied for dehydrogenation of temperature [17]. Precise positioning of the vacancies in a diamond crystal was studied [18]. Liu *et al*. [19] presented an efficient strategy to fabricate the graphite-graphene Janus architecture. Some parameters under optimized conditions of the process chosen to deposit the diamond [20].

Cheng and Zong [21] observed a structural evolution of damaged carbon atoms for a deeper surface layer. Maruyama and Okada [22] investigated the electronic and magnetic structures of a two-dimensional network of carbon atoms. Narjabadifam *et al*. [23] studied carbon nanocones' elastic and failure properties through molecular dynamics simulation. Levitated nanodiamonds burn in the air because of the amorphous carbon on their surfaces [24]. Uncertainty in the temperature measurement of levitated nanodiamonds was removed [25].

Heat treatment improves the mechanical properties of carbon films deposited by magnetron sputtering [26]. A carbon nanotube film improves electrode stability [27]. Carbon films are deposited in a pulse-based CVD system to improve tribological properties [28]. By establishing covalent bonds between the substrate and carbon film, the electronic states of carbon-based materials are controlled [29]. The relation of different parameters with the formation of carbon films was studied [30]. High negative bias voltages reduce the hydrogen content in depositing carbon film [31].

The carbon films deposited with an enhanced thickness are not beneficial for all purposes [32]. The structure and electrochemical properties of carbon films deposited by the electron cyclotron resonance sputtering method have been discussed elsewhere [33]. A graphitic phase of deposited carbon films reduces the friction coefficient in the vacuum medium [34]. Carbon films have lowered hydrogen content deposited by tuning the ratio of the graphitic and diamond phases [35].

The hardness of a single-walled carbon nanotube has been discussed [36]. Carbon nanotube thin film deposited by the floating catalyst CVD technique offers potential application as a thin film transistor [37]. Carbon nanotube films discussed their high thermal conductivity [38]. A recent study suggests the photochemical conversion of the graphitic phase into the diamond phase [39]. In the deposition of diamond-like carbon films, the sp^2 carbon or graphitic phase increased by introducing titanium [40]. A structural and electrical relationship establish between amorphous carbon and graphene in deposited carbon films by hot filament CVD [41]. A recent study investigates porous carbon films for efficient electromagnetic applications [42]. Vertical mesoporous carbon films were investigated by studying their electrochemical sensors application [43]. Thermal stability and diffusion characteristics of ultrathin amorphous carbon films have been investigated [44].

How do the different allotropes of carbon form? How do the same-state carbon atoms bind in the formation of their structures? This study explores fundamental and applied science about carbon atoms. If one looks at the published studies of carbon, it is possible to predict the models related to different allotropes of carbon.

The current study discusses the formation of different states of carbon atoms along with their binding mechanisms. The present work also discusses the formation mechanism of the glassy carbon structure. The current study identifies the kind of energy involved and the nature of forces engaged in the binding of same-state carbon atoms. This study also sketches the Mohs hardness of carbon materials.

2.0. Experimental details

Many published studies on carbon films and other carbon-based materials describe their experimental details. To deposit carbon films is extensively discussed in the literature. There are several techniques in the literature showing the deposition.

The focus of the current study is to explore the underlying science of the different states of a carbon element. A binding mechanism in identical-state carbon atoms is also a subject of this study. The discussed science here is the central subject of every study considering the depositions of carbon materials in any form.

A carbon element not only contributes to describing the experimental detail of the dynamics of the environment but also describes the experimental detail of many other phenomena. The current study also charts the Mohs hardness of different carbon materials under a new insight.

3.0. Atomic Structure Models and Discussion

3.1. Carbon lattice and different carbon states

Presently, the atomic structures of different carbon states do not present a clear picture despite the fact each carbon state keeps a name. The construction mechanism in the carbon lattice is also yet awaited.

Different-state carbon atoms rely on the same number of electrons. A carbon atom has a fixed number of filled and unfilled states in any state. Changing the position of the electrons gives birth to the new chemistry of that atom. However, a separate study discussed the atomic structure of different elements and their transitional behaviors [3].

When overt photons intercrossed to form the twelve energy knots, they shape the carbon lattice. In intercrossing, overt photons keep the centers of their lengths at a common point. Figure 1 (a) shows the lattice of a carbon atom. Two energy knots from each side of the center remained compressed from the neighboring states.

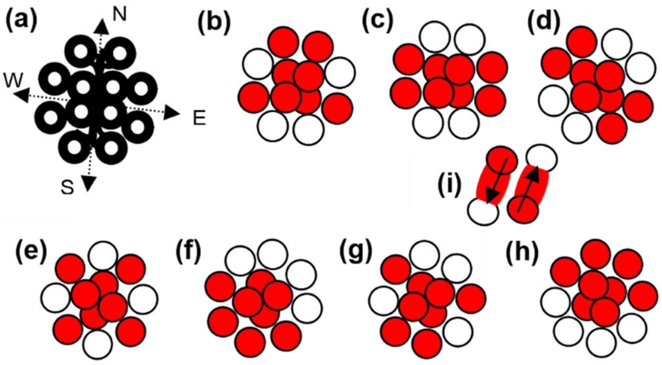

Figure 1. (**a**) Lattice of a carbon atom, atomic structure of carbon atom when in the (**b**) gaseous state, (**c**) graphite state, (**d**) nanotube state, (**e**) fullerene state, (**f**) diamond state, (**g**) lonsdaleite state, (**h**) graphene state, and (**i**) transferring electron (red circles indicate filled states, and white circles indicate unfilled states).

The lengths of the overt photons are so that their schedule crossing shapes the filled and unfilled states required to construct the energy-knot-net of a carbon atom. Two pairs of overt photons, which have characteristics of photonic current, intercross along the east and west sides. Two pairs of photons, which have characteristics of photonic current, intercross along the north and south lines. All the intercrossed overt photons keep the positions of their mid-lengths at the same point. The lattice of a carbon atom is related to the energy-knot-net, as shown in Figure 1 (a). The overt photons preserve their force by wrapping the energy [2].

The outer ring of the carbon atom has four filled and four unfilled states. This order of the states provides the option to originate six different states of the carbon atom in addition to the gaseous state and glassy carbon. Figure 1 shows a gaseous state in (b), a graphite state in (c), a nanotube state in (d), a fullerene state in (e), a diamond state in (f), a lonsdaleite state in (g), and a graphene state in (h). In different states of a carbon atom, four electrons at the center form the zeroth ring. The zeroth ring is related to the helium atom [3]. Figure 1 symbolically shows the electrons and energy knots in different states of carbon atoms.

3.2. Electron Transfer Mechanism

To convert one state of the carbon atom to another, the etching of carbon precursors, carbon atoms, or methyl radicals remain the main topic of study previously. In a new idea, it is not the case. As discussed [8], photon energy is etched into binding energy under the application of atomic hydrogen.

When the gaseous carbon atom converts into the graphite state atom, the engaged forces are mainly related to the surface and space formats. Here, a one-bit energy shape like a dash involves along the left side, and a one-bit energy shape is like a dash along the right side.

The transferring electrons of the graphite atom convert it into the lonsdaleite atom. A bit of dash-shaped energy along the west to south involved, whereas a bit of dash-shaped energy along the east to the south involved. The exerted forces on the transferring electrons remain partially conserved. The exerted forces are related to the surface and grounded formats.

Two electrons are transferred to the nearby positioned unfilled states to convert the lonsdaleite state atom into the diamond atom. As a result, the ground point in the diamond atom goes further below the ground surface than the ground point in the lonsdaleite atom. A carbon atom fully expands under its diamond state.

In the conversion of a carbon atom from one state to any other state, two dash-shaped energy bits involve one along the left side and one along the right side.

Figure 1 (i) shows an electron of a filled state transferring to the nearby unfilled state. Dash-shaped energy is like a pipe through which force can pass. Dash-shaped energy from one end connects to the tip of transferring electron and from the other end connects to the nearby unfilled state. Figure 1 (i) shows the downward arrow increasing the potential of the electron and the upward arrow decreasing the potential of the electron. In this way, transferring electrons only engage the partially-conserved forces. Forces only exert on the two poles of an electron as its two sides remain hidden during the transfer. An energy bit covers the transferring electron from both sides. Energy bit does not permit force to exert on an electron from those sides.

Therefore, during the transfer, only the forces of two poles exert on the left-sided electron or right-sided electron. The expansion and contraction of a carbon atom under different states depend on the electrons' potential energy and orientation.

4.0. Structural Formation in Identical-State Carbon Atoms

Graphite is famous for being a layered structure or two-dimensional structure. As studied widely in the literature, carbon atoms form an sp^2 hybridized state. It is an amorphous structure when the arrangement of graphite atoms is not in order. A nanotube structure is famous for being a one-dimensional structure. In fullerene, a buckyball or cage-like structure forms.

A diamond structure is famous for being a tetrahedron structure. It forms an sp^3 hybridized state. Previously, in lonsdaleite, a hexagonal structure is discussed. In graphene, a honeycomb-like structure forms. A glassy carbon structure named turbostratic type structure. In the published literature and due to having different opinions, there can be more information on the structures of carbon allotropes.

As discussed below, in a structural formation under the new idea, the carbon atoms having the same state bind by studying the detail of force energy at the electron level except in two-dimensional and amorphous graphite structures.

The structural formation under electron dynamics is different. It is not published yet. In the two-dimensional and amorphous structures of graphite, the detail of force energy exists at the atomic level. It is also not published yet like the way presented in this study.

4.1. Formation of graphite structure

4.1.1. Formation of graphite structure under the electron dynamics of atoms

Figure 2 (a) shows the binding of the carbon atoms when just in the graphite states. Atom A binds to Atom B and Atom C by involving the dash-shaped energy of two bits in each case. The exerted forces on the transferring electrons remain in the partial conservative mode. Figure 2 (a) shows the nucleation stage of the graphite structure.

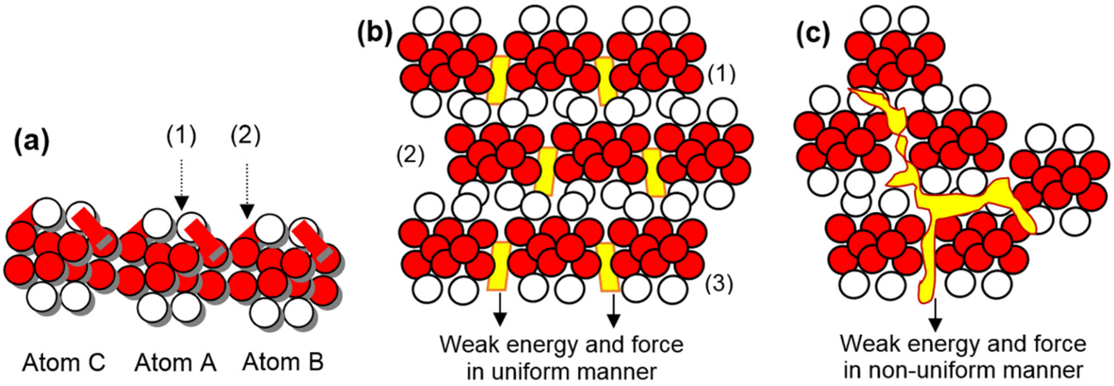

Figure 2. (**a**) Formation of graphite structure under interstate electron dynamics (1) unfilled state of a transferred electron and (2) involved dash-shaped energy bit, (**b**) formation of graphite structure when weak energy contributed under uniformly attained dynamics of graphite atoms, and (**c**) amorphous graphite structure when weak energy contributed under non-uniformly attained dynamics of graphite atoms.

Under electron dynamics, a graphite structure grows in one dimension. The binding graphite atoms can be from both sides of the X-axis. However, electrons of the bound atoms get their orientation along the same axis, which is an adjacent orientation. The exerted forces on the electrons along the north-south poles almost diminish. In tiny-grain carbon film, atoms of arrays elongate and convert into the structures of smooth elements [6].

A nucleated structure of graphite grows by further binding the graphite state atoms. The graphite structure nucleated along the same axis. Figure 2 (a) also shows the layer of the graphite structure from the rear side. The dash-shaped energy bits get involved in binding graphite atoms. To transfer electrons from the left and right sides of the gaseous carbon atom in attaining the graphitic state, the potentials of the transferring electrons from upper states to lower states increase.

The potentials of both left and right electrons change in an equalized manner [45]. Thus, that atom maintains the equilibrium in the journey to get the conversion.

4.1.2. Formation of graphite structure under the attained dynamics of atoms

When carbon atoms amalgamate without executing the electron dynamics, they can only bind through the attained dynamics. In this case, dash-shaped energy is no more involved in the binding of graphite atoms. The slight difference of forces remains along the east and west poles of just amalgamated graphite state atoms.

A slight difference in the forces between graphite state atoms facilitates keeping them bound as they were amalgamated only under the attained dynamics, which is shown in the arrays as labeled by (1), (2), and (3) in Figure 2 (b). Therefore, weak energy remains and keeps binding to the graphite state atoms.

Graphite state atoms naturally come into the order of two dimensions. The found force and energy among graphite state atoms bind them from east-west or west-east sides. Force and energy at the atomic level introduce the weak application to preserve the graphite structure. Due to uniformly attained dynamics in graphite state atoms, amalgamated atoms bind under uniform force and energy. When force energy together contributes, a structure forms in two dimensions.

4.1.3. Amorphous graphite structure

An amorphous graphite structure is when the amalgamation of graphite state atoms is under the non-uniformly attained dynamics. Atoms do not position exactly from the east-west sides or west-east sides. Figure 2 (c) shows the graphite state atoms bind under the non-uniformly attained dynamics where weak energy and force contribute. However, their contribution is in a non-uniform manner.

A structure of graphite state atoms can also be the amorphous carbon structure when the ground surface is not flat. Due to the amalgamation of graphite state atoms without order, force, and energy, a chemical in nature, contribute in non-uniform manners. Due to non-uniformly attained dynamics in amorphous graphite structure, amalgamated graphite atoms also bind under the non-uniform force and energy.

The amalgamation of graphite atoms is under non-uniformly attained dynamics. However, weak force and weak energy are contributed together in a non-uniform manner. Nevertheless, to understand the structural formation in graphite state atoms, there is a need to conduct more research. Atomic arrangement in amorphous carbon forms continuous random networks [46].

4.2. Formation of nanotube and fullerene structures

A nanotube structure forms by converting the carbon atoms into the nanotube state atoms. A nanotube atom can convert from the fullerene state atom before binding. In conversion, transferring electrons to the unfilled states is under the involved dash-shaped energy. A partial conservative force is engaged in the transfer of electrons.

Atoms of the nanotube state bind into a structure by involving partially conserved energy and engaging partially conserved force. On one quadrant electron, forces exert in the space and surface formats. The forces exerted on the electron of the opposite quadrant remain in the surface and grounded formats. In this manner, the carbon atom keeps equilibrium during the conversion from one state to another.

A dash-shaped energy bit involves transferring the electron. So, carbon atoms having a nanotube state can bind to the central atom having a nanotube state. Figure 3 (a) shows atoms of the nanotube state bind to the centered nanotube atom from both sides. It is a nucleation stage of the nanotube structure. The nucleation of the nanotube structure can be under two options, as shown in Figure 3 (a).

The binding of nanotube atoms is not along the same axis. However, the binding is along the same axis in the graphite atoms. The formation of structure in graphite atoms is considered one-dimensional. However, the nanotube structure forms two-dimensional. Energy force remains partially conserved to form the nanotube structure. Figure 3 (a) shows that two forces exert on the electron in each case.

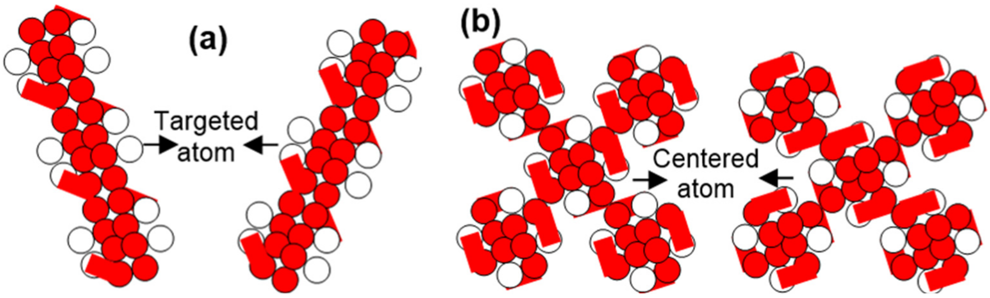

Figure 3. (**a**) nanotube structure in two different options and (**b**) fullerene or buckyballs structure in two different options.

A carbon atom converts into a fullerene state atom on electron transfer for each dedicated position. Electrons of the outer ring involve energy shaped like a dash. So, the electron of each quadrant engages the partial conservative force in transfer.

Involved dash-shaped energy (at the electron level) binds fullerene state atoms for each quadrant of the centered fullerene state atom, as shown in Figure 3 (b). Figure 3 (b) shows the nucleation of the fullerene structure in two options.

In nucleating the structure, the fullerene state atoms bind to all four quadrants of the centered fullerene state atom. The structural formation in fullerene state atoms is four-dimensional. The exerting forces along the relevant poles of transferring electrons remain partially conserved. Figure 3 (b) shows that two forces exert on the electron of each quadrant. In each case, electrons deal with the partial conservative forces. The dash-shaped energy bits also contain partially conserved behavior.

Both energy and force, a chemical in nature, behave partially conserved in forming a fullerene structure. However, more work is required. A carbon nanotube initially referred to a finite carbon structure having the shape needle-like tube [47]. In pioneering work, a fullerene structure was discussed in a football-like shape [48].

4.3. Formation of a diamond structure

Figure 4 (a) shows lonsdaleite and diamond state atoms. The ground point of the lonsdaleite state atom is just below the ground surface. A lonsdaleite state atom is converted into a diamond state atom when electrons from the left and right sides transfer to the downward unfilled states. The lattice of the converted diamond atom also undertakes the same stretch level as the lattice of the deposited diamond atom.

Figure 4 (a) shows the expected binding point of diamond atoms. A diamond atom deals with the maximum solid behavior. So, the ground point of the diamond state atom remains below the ground point of the lonsdaleite state atom. A diamond state atom first gets deposited on a suitably treated substrate. Thus, the electrons of a deposited diamond state atom do not further gravitate. Again, due to the maximum achieved potential energy of the electrons, there is no more stretching of their occupied energy knots. So, the orientationally controlled electrons of a depositing atom are also in the exertion of forces exerted in the surface and grounded formats.

Each outer ring electron of the depositing diamond atom undertakes one additional clamp of each outer ring energy knot of the deposited diamond atom, as shown in Figure 4 (b). By involving the golf-stick-shaped energy bit, an outer ring electron of the depositing diamond atom undertakes the clamp of the outer ring energy knot of the deposited diamond atom. In the structural formation of a diamond, exerting force on each electron also remains non-conserved. Orientation of the zeroth ring electrons adjusted accordingly.

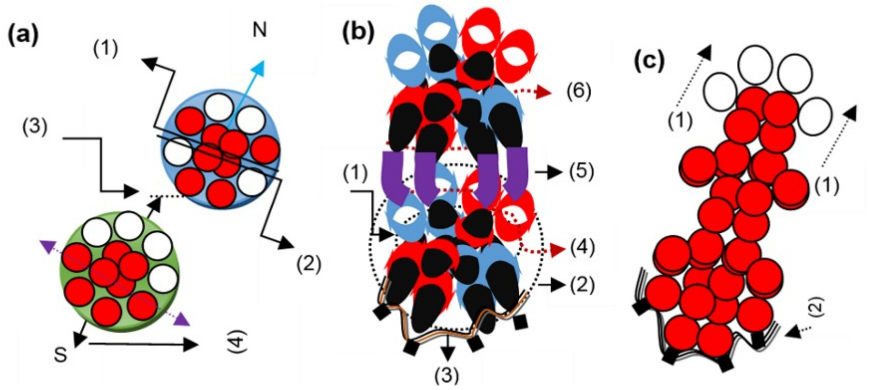

Figure 4. (**a**) Lonsdaleite atom conversion into a diamond atom (1) east-west poles, (2) ground point of lonsdaleite atom, (3) expected binding point of diamond atoms and (4) ground point of a deposited diamond atom, (**b**) binding of depositing diamond atom to the deposited diamond atom (1) zeroth ring of a deposited diamond atom, (2) outer ring of a deposited diamond atom, (3) substrate, (4) positioned outer ring energy knots of a deposited diamond atom, (5) involved golf-stick-shaped energy for each outer ring electron of a depositing diamond atom, and (6) orientated outer ring electrons of depositing diamond atom, and (**c**) diamond growth (1) diamond growth south to east-west and (2) embedded electrons of a deposited diamond atom.

Figure 4 (c) shows the growth behavior of diamonds. In the growth of the diamond structure, the expansion and contraction of the depositing and deposited atoms mutually adjust. Figure 4 (c) also shows the electrons embedded in the substrate surface in the first deposited diamond state atom. On having the maximum stretching of the occupied energy knots, electrons orientated along the east-west poles to the south under the non-conservative force. Thus, two diamond state atoms bind from the east-west poles to the south. It is the nucleation stage of a diamond. A diamond structure can grow with several faces. Red and white circles in Figure 4 (c) designate the filled and unfilled states.

In Figure 4 (c), the overlapping of the circles designates the double clamping of the electrons. On binding two diamond state atoms, the third diamond state atom comes into position to bind. Therefore, the growth of diamonds is south to the east-west poles, but the binding of diamond state atoms is from the east-west poles to south. The binding of diamond atoms remains between the surface and grounded formats. Thus, the structural formation in diamond state atoms is related to the topological structure. Earlier studies discussed diamond structure with the atomic level setting. However, the current discussion is with electron level setting.

At suitable parameters studied elsewhere [49], diamond nucleation at very low-pressure has been achieved, which might be due to the presence of discussed golf-stick-shaped energy bits here. By choosing a suitable dopant, the band gap of the diamond can switch from indirect to direct [50]. However, a band gap is a photonic band gap under a new insight [5].

4.4. Formation of lonsdaleite and graphene structures

The ground point of the lonsdaleite state atom is a bit below the ground surface as it exists below the ground point of the graphite state atom. Electrons of the lonsdaleite state atom keep lower potential energy than electrons of the diamond state atom. Hence, the energy knots are in the lesser stretch, so the lonsdaleite state atom is less expanded than the diamond state atom. A lonsdaleite state atom is mainly in a bit solid behavior. Some historical facts of lonsdaleite structure and its study under conventional insight are given elsewhere [51].

In structural formation, a lonsdaleite state atom also experiences the non-conservative force for two electrons under the involvement of non-conserved energy. Lonsdaleite state atoms bind from the east-west poles to a bit south pole, but the growth behavior is from (a bit) south pole to the east-west poles. However, further studies are required to get better insight into the structure.

The single sheets of graphite are graphene, for which a detailed study is given elsewhere [52]. Under a new insight, the ground point of the graphene state atom exists just above the ground surface. However, the levitational behavior of force is in a non-conserved manner. The binding of graphene state atoms experiences forces mainly in the surface and space formats at the electron level. So, the growth of the graphene structure is opposite to diamond.

The growth of graphene is east-west poles to the north pole. Principally, graphene state atoms should grow with a topological structure. Due to the limitation of forces exerted in the surface and space formats, adherence to only a few layers in the graphene structure is possible. However, further investigations are required. A separate study discusses the exertion of forces on the electrons of suitable element atoms [4].

4.5. Formation of glassy carbon structure

Under conventional insights, a detailed study on glassy carbon reviewing its various aspects is given elsewhere [53]. In the nucleation of the glassy carbon structure under the new insight, three layers of different states of carbon atoms bind successively. By binding simultaneously, layers of gaseous carbon atoms, graphite state atoms, and lonsdaleite state atoms nucleate the glassy carbon structure.

To grow the structure of glassy carbon, layers of gaseous, graphite, and lonsdaleite state atoms repeat in the same order. The energy bits having the golf stick shape or the shape of a half-parabola get involved at the electron levels in binding the different state atoms between the layers.

Layers of gaseous and graphitic carbon atoms bind under the exerting forces in the grounded format and surface format. The orientated outer ring electrons of each gaseous atom undertake one additional clamping of the positioned energy knots of the outer ring of each graphite atom, which is from the rear side in Figure 5. By increasing the potential energy of electrons, the gaseous carbon atoms attempt gravitational behavior.

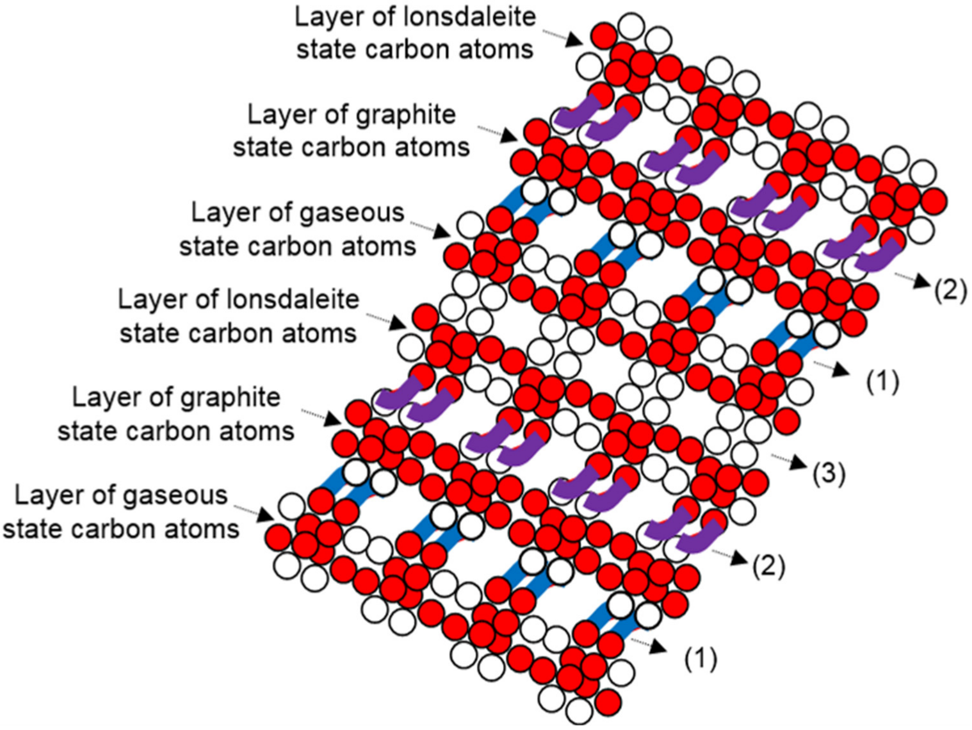

Figure 5. Formation of glassy carbon structure where layers of gaseous carbon atoms, graphite state atoms, and lonsdaleite state atoms bind successively.

Layers of lonsdaleite state atoms and graphite state atoms bind under the joint application of exerting forces in space and surface formats. The orientated electrons of each lonsdaleite atom undertake one additional clamping of the positioned energy knots of each graphite atom, which is from the front side in Figure 5. By decreasing the potential energy of electrons, lonsdaleite atoms attempt levitational behavior.

Under a new insight, binding gaseous carbon atoms of each layer to the graphite state atoms of each layer involves oppositely J-shaped energy (or golf-stick-shaped energy) at the electron level. The clamping of each pair of unfilled energy knots to the half-length of each pair of electrons is from the rear side. The label (1) in Figure 5 shows the binding between the gaseous carbon atoms and graphite state atoms.

Under a new insight, binding lonsdaleite state atoms of each layer to the graphite state atoms of each layer involves J-shaped energy (or golf-stick-shaped energy) at the electron level. The clamping of each pair of unfilled energy knots to the half-length of each pair of electrons is from the front side. Label (2) in Figure 5 shows the binding between the lonsdaleite state and graphite state atoms. Label (3) in Figure 5 indicates the relief in layered structure in terms of atomic expansion and contraction.

5.0. Estimated hardness of carbon-based materials at Mohs scale

In Figure 6, the Mohs hardness of different nanostructured and microstructured carbon materials is an estimation. Gaseous carbon atoms keep the hardness zero at the Mohs scale. Structures of graphite, nanotube and fullerene atoms involve partially conserved energy and engage partially conserved force. So, they only measure the average hardness at the Mohs scale. Structures of lonsdaleite, graphene, and glassy carbon involve non-conserved energy and engage non-conserved forces to measure the hardness at a large scale.

The high hardness of lonsdaleite, graphene, and diamond structures is due to the involvement of golf-stick-shaped energy bits. Orientated outer ring electrons undertaking double clamping of positioned energy knots engage a non-conservative force. The same is the case in the structural formation of glassy carbon.

Figure 6 extracts the drawn hardness at the Mohs scale from the published information. However, the published data on the hardness does not consider the energy force detail discussed here. It is an actual need to re-investigate the hardness of different carbon-based materials. A recent study evaluates the hardness of diamond films by nanoindentation [54]. However, the hardness of carbon films relies on the nature of force and the kind of energy. Pieces of evidence from the published literature and data support the presented models and details here.

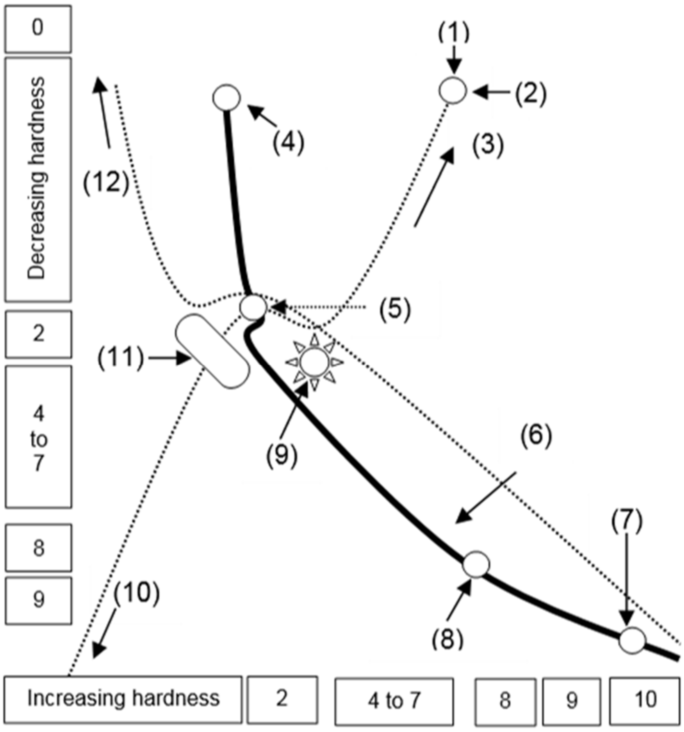

Figure 6. Mohs hardness *vs*. different carbon allotropes; (1) levitational force at the electron level, (2) graphene, (3) increasing levitational force, (4) gaseous carbon, (5) graphite, (6) increasing gravitational

force, (7) diamond, (8) lonsdaleite, (9) fullerene, (10) maximum gravitational force, (11) nanotube, (12) maximum levitational force.

Undoubtedly, the presented models and hypotheses develop a sense of understanding and new insights into all sorts of carbon materials. It is not possible to cite every study though there are many studies. However, it is an acute need to study carbon films along with different carbon materials not only in structural behavior but also in force energy behavior. The mechanisms of converting one state carbon atom into another state and binding carbon atoms for their structures elucidate new ideas. Thus, all sorts of depositions and syntheses need to optimize.

6.0. Conclusions

None of the carbon states refer to neutral force behavior at the electron level. In the conversion mechanism of a carbon atom from one state to another, two dash-shaped energy bits involve, which transfer electrons to nearby unfilled states. The carbon atom keeps an equilibrium state during the electron transfer mechanism.

The structural formation is one-dimensional when graphite atoms execute electron dynamics. A structure is two-dimensional when graphite atoms bind by uniformly attained dynamics. Energy force at the atomic level contributes uniformly.

Energy and force, weak in nature, together contribute to binding the graphite state atoms in two dimensions. In the formation or development of an amorphous graphite structure, the energy force at the atomic level contributes non-uniformly.

The structural formation is two-dimensional when nanotube atoms bind by dynamics of suitable outer ring electrons. In a nanotube, electrons of opposite quadrants perform dynamics. In fullerene atoms, the structure is four-dimensional.

In the fullerene structural formation, all four outer ring electrons of the atoms execute dynamics. In the structural formation of graphite in one dimension, nanotube, and fullerene, bits of partially conserved dash-shaped energy involve at the electron level by engaging the partially conserved force, too. Each outer ring electron of the depositing diamond atom undertakes one additional clamping of the outer ring energy knot of the deposited diamond atom. Here, a bit of energy shaped like a golf stick involves transferring the electron up to half-length to another energy knot. The half-length electron above the clamped energy knot remains under the exertion of non-conservative forces.

The binding in diamond state atoms remains from the east-west to the south, so the growth behavior remains from the south pole to the east-west poles. It is a tetra-electron topological structure. The binding in lonsdaleite state atoms remains from the east-west poles to a bit south pole, so the growth behavior remains from a bit south pole to the east-west poles. It is a bi-electron topological structure.

Layers of gaseous, graphite, and lonsdaleite atoms repeat under the same order, and a glassy carbon structure grows. Binding atoms in glassy carbon, the orientated outer ring electrons of the gaseous and lonsdaleite atoms undertake additional clamping of the positioned energy knots of the outer rings of the graphite atoms. In diamond, lonsdaleite, graphene, and glassy carbon structures, bits of non-conserved energy involve at the electron level by engaging the non-conserved force, too.

The hardness of carbon materials relates to the energy force detail at the electronic level. The study of carbon atoms and their structures from the perspective presented here opens new areas of investigation.

Data Availability Statement: This work is based on the fundamental nature of science.

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