

# Atomic Structure and Binding of Carbon Atoms

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**Abstract:** Many studies discuss carbon-based materials because of the versatility of carbon. These studies include different ideas for the scientific problems and discuss them within the scope and application. Depending on the processing conditions of a gaseous carbon, it exists in various allotropic forms. The electron transfer mechanism is responsible for converting the gaseous carbon atom into various states – graphite, nanotube, fullerene, diamond, lonsdaleite and graphene states. A typical energy shaped like parabola trajectory enables transfer of the electron in carbon atom by preserving its equilibrium state. In the conversion of carbon atom from one state to other state, the energy trajectory links to suitable filled state and unfilled state of the east side and the other energy trajectory links to suitable filled state and unfilled state of the west side. In this way, filled state electrons simultaneously transfer to nearby unfilled states through the paths provided by the involved trajectories of typical energy. Here, involved typical energy remains partially conserved. So, the force exerted to the electrons is also partially conserved. Carbon atoms when in graphite, nanotube and fullerene states, they ‘partially evolve and partially develop’ the structures. Atoms form structures of one dimension, two dimensions and four dimensions, respectively. Binding atoms in such structural formations involve the typical energy shaped like parabola, where partially conserved forces also engage at the electron level. The graphite structure under only attained dynamics of atoms is also formed, but in the order of two dimensions and amorphous carbon. Here, a binding energy among graphite atoms is due to the small difference between their east force and west force. Structural formations in diamond, lonsdaleite and graphene atoms involve a different shaped typical energy to control the orientation of electrons undertaking one more clamp of the unfilled energy knot. Here, an involved typical energy has shape like golf-stick, which is half of the trajectory shaped like parabola. To undertake double clamping of energy knot, all four targeted electrons of the outer ring (of depositing diamond atom) aligned along

the south pole and all four unfilled energy knots of the outer ring (of deposited diamond atom) positioned along the east-west poles. So, a growth of diamond is found to be south to ground. Here, depositing diamond atom binds to deposited diamond atom ground to south. Thus, diamond atoms form a topological structure of tetra-electron. Graphene atoms can form structure oppositely when compared to structural formation in diamond atoms. Binding of lonsdaleite atoms can be from ground to a bit south. To nucleate the structure of glassy carbon, three layers of carbon atoms having different state for each layer (gaseous, graphite and lonsdaleite) bind in the successive manner. Mohs hardness of nanostructures and microstructures of different carbon materials is also sketched.

**Keywords:** Carbon; Atomic structure; Electron dynamics; Potential energy; Forced exertion; Atomic binding

## 1. Introduction

Developing materials of selective size and investigating their characteristics for various applications solicit new approaches. The exertion of force at the electron level should also detail the energy at the electron level. In the structural formation of different state carbon atoms, an involvement of the partial conservative energy and the non-conservative energy should also engage the partial conservative force and the non-conservative force, respectively. In this context, involved energy at the electron level should oversee the engaged force at the electron level.

A partial conservative energy should be involved in the structural formation of those carbon atoms engaging a partial conservative force for the electrons. (This can be the case in carbon atoms having graphite, nanotube and fullerene states.) A non-conservative energy should be involved in the structural formation of those carbon atoms engaging a non-conservative force for the electrons. (This can be the case in carbon atoms having diamond, lonsdaleite and graphene states.) So, in the case of glassy carbon, too.

Due to the presence of filled and unfilled states very near to the center of carbon atom, it appears that electrons of the outer rings do not deal with the conservative force. The relation of energy and force in such atoms should be anticipated either in partially conserved mode or in non-conserved mode. This should depend on the state of a carbon atom.

Carbon has different states, which are known in the allotropes, i.e., starting from the gaseous state to graphite state, and then diamond state, lonsdaleite state, fullerene state followed by the nanotube state, graphene state, and finally glassy carbon. Several studies on the carbon-based materials are available in the literature explaining the conditions of deposition. Those studies mainly study the parameters influencing the morphology, growth rate, quality and application, etc.

In different state carbon atoms, electrons of the outer ring should follow transfer mechanism because of the feasibility of built-in interstate electron gap. When forces in the conservative mode are exerted to electron of a silicon atom, an uninterrupted execution of electron dynamics generates a photon of continuous length [1]. This indicates that the built-in interstate gap of electron dynamics in case of carbon atom is different as compared to silicon atom. Although, both carbon atom and silicon atom have the same numbers of filled and unfilled states in the outer rings. However, the distance of electrons of the outer ring from the centre of carbon atom is different as compared to silicon atom. In different gaseous and solid elements, atoms also deal with the different distance of outer rings from their centers [2]. Atoms when in neutral states, they execute confined interstate electron dynamics to evolve structures in the relevant formats of exerting forces [3].

Atoms belonging to any element do not ionize [4]. Various spectroscopic analyses of 'tiny grains carbon film' show peaks at different positions, which indicates that different state carbon atoms amalgamated to form (or develop) tiny grains [5]. Depending on the conditions of the process, carbon atoms deposit in different morphology and structure of grains and crystallites [6]. A different morphology of grains and particles was resulted at the different chamber pressures identifying the role of arresting typical energy near the substrate surface [7]. The deposition of graphite and diamond in separate regions of the single substrate is due to different set inter-wire distance of dissociating gases [8]. Different carbon-based materials have atoms of the same element (carbon) but indicate the different behaviors during the analysis [5-8]. This specifies that transition of the electron for new state changes the chemical nature of atom resulting in a new phenomenal state.

It is also observed that the force entering from the north pole and leaving the ground surface for the south pole behave differently as compared to the force on the ground surface (east-west poles) [9]. In suitable gaseous and solid atoms, transitions take place to undertake liquid states [2]; electrons undertake infinitesimal

displacements while remaining clamped in the energy knots. But, depending on the state of an atom, it deals with the different ground point [3].

A recent study shows transformation of graphene film into a diamond like film, where the elastic deformations and chemical natures were changed [10]. Wu *et al.* [11] also reviewed the developments in Raman spectroscopy of graphene-based materials from both fundamental research and practical perspectives. Uniform carbon nanofibers were grown by vapor deposition method without involving the catalyst [12]. Different applications related to graphene hybrids were reviewed recently in the study [13]. Nitrogen incorporated carbon dots were used to modify a glassy carbon electrode [14]. A novel energy dissipation system was investigated by combining the carbon nanotube and buckyballs [15]. Different carbon allotropes were studied for the dehydrogenation of temperature in their comparison [16]. A precise positioning of the vacancies within the diamond crystal was studied by Chen *et al.* [17]. Liu *et al.* [18] presented an efficient strategy of electrochemical activation to fabricate the graphite-graphene Janus architecture. Repeated large-area doped nano-crystalline diamond layers were prepared under optimized conditions of microwave-based vapor deposition system [19]. Cheng and Zong [20] observed a structural evolution of damaged carbon atoms for deeper surface layer. Maruyama and Okada [21] investigated geometric, electronic and magnetic structures of a two-dimensional network of carbon atoms. Narjabadifam *et al.* [22] studied both elastic and failure properties of carbon nanocones through the application of molecular dynamics simulation. Levitated nanodiamonds burn in the air because of the presence of amorphous carbon on their surfaces and they deal with uncertainty in the measurement of their temperature [23]. This leads to the removal of the 'uncertainty in temperature measurement' of levitated nanodiamond, which paves the way for considerable applications [24].

A layout of atomic structure in different state carbon atoms is not clear along with the binding mechanism in identical state carbon atoms. The formation mechanism of glassy carbon is also not clear. Here, atomic structures of various carbon allotropes along with their structural formations are studied.

## 2. Experimental Details

This work does not include the experimental details on the processes dealing with the formation of structures related to carbon-based materials. However, a preliminary

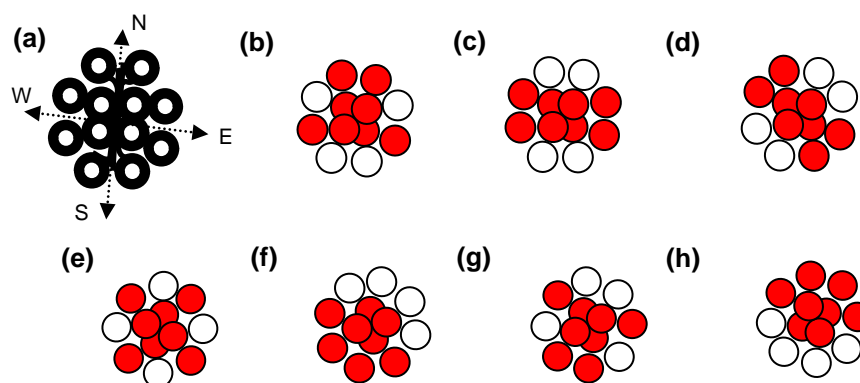
knowledge on the process dealing with the synthesis of different allotropic forms of carbon can be found in the studies cited above. But, the processes utilized to synthesize various carbon-based materials require optimization to single out the particular form of a carbon material. In this context, this study purely deals with the science of originating different carbon allotropic forms along with structural formation in each possible state of carbon.

### **3. Results and Discussion**

#### **3.1. Formation of atomic structure in different states carbon**

Understanding the mechanism of formation of electronic structure in different state carbon atoms relies on the same number of electrons. A carbon atom in any of the state has fixed numbers of filled states and unfilled states. A change in the position of filled state and unfilled state gives birth to new chemistry of the atom.

In formation of the lattice of a carbon atom, overt photons having the suitable length and number intercrossed to design the twelve states of energy knots. In the intercrossing, overt photons keep the centres of their lengths at a common point. Energy knots of filled and unfilled states are designed by the precisely intercrossing of overt photons. Overt photons are equal in lengths. The lengths of overt photons are in such a manner that their schedule crossing design filled and unfilled states required to form energy-knot-net of a carbon atom. Two pairs of overt photons (having characteristics of current) intercross along the east and west sides. Two pairs of photons (having characteristics of current) also intercross along the north and south lines. All intercrossed overt photons kept the position of their mid-lengths at the same (common) point. Here, two energy knots from each side (from the centre of the carbon lattice) remained compressed. The compression is due to the presence of adjacent filled and unfilled states. In this way, a total number of eight states are designed to form the outer ring of carbon atom. Here, four states are related to the filled states and four states are related to the unfilled states. Four unfilled states (energy knots) of the inner ring are related to the zeroth ring. The lattice or energy-knot-net of a carbon atom is shown in Figure 1 (a). Upon intercrossing the overt photons, the trough of one is in front of the crest of other. So, overt photons freeze the element of force wrapped by the energy [1].



**Figure 1:** (a) Lattice or energy-knot-net of carbon atom, atomic structure of carbon atom when in (b) gaseous state, (c) graphite state, (d) nanotube state, (e) fullerene state, (f) diamond state, (g) lonsdaleite state and (h) graphene state; red colored circles indicate filled states and white colored circles indicate unfilled states (drawn in estimation)

In the gaseous carbon atom, required four energy knots of the outer ring are filled by the electrons. The states belonging to the zeroth ring are also filled by the electrons. A detailed study on the atomic structure in gaseous, semisolid and solid elements can be found elsewhere [2]. In the outer ring, four states remained filled and four vacant. This order of the states provides the option to originate six different states of the carbon atom in addition to the one in gaseous state. In Figure 1 (b), a gaseous carbon atom is shown. Other different states of the carbon atom are shown in Figure 1 (c-h); positions of the electrons belonging to the outer ring inter-changed in the carbon atom to form (c) graphite state, (d) nanotube state, (e) fullerene state, (f) diamond state, (g) lonsdaleite state and (h) graphene state. In each state of the carbon atom, centered four electrons form the zeroth ring. A zeroth ring is related to the helium atom [2]. In Figure 1, atomic structure of carbon in different states are shown, where electrons and energy knots are symbolized.

A gaseous carbon atom is processed for transferring two electrons of filled states to nearby unfilled states. Here, one electron from the east side and one electron from the west side transferred to originate the new state of carbon atom. To transfer electron on any side, an involved typical energy provides the path to electron, where a partially conserved force engaged. That partially conserved force does not let the transferring electron to drop. A typical energy keeps the electron restricted to follow the trajectory till occupying the targeted unfilled state. Each binding energy plot provides the path to transferring electron – one from the east side and one from the west side of the atom, thus enabling the conversion of gaseous carbon atom into the graphite state.

When a gaseous carbon atom converts into the graphite state, engaged forces under the involved energy for the relevant electrons remained partially conserved. The engaged forces are mainly related to the surface format and space format. Transferring required electrons in graphite atom to convert into the lonsdaleite atom, parabola shaped energy along the west to south and an energy with the same shape along the east to south are involved. Exerting forces for the electrons are partially conserved, which are related to the surface format and a bit grounded format. During the conversion of graphite atom into lonsdaleite atom, only two electrons are transferred to the nearby positioned unfilled states. To convert lonsdaleite atom into diamond atom, two electrons are further transferred to the nearby positioned unfilled states. The ground point in the diamond atom goes further below the ground surface as compared to the ground point in the lonsdaleite atom. Upon transferring all four electrons of the outer ring to the energy knots available below the east-west line, a ground point in the diamond state carbon atom becomes fully grounded. A partial conservative energy is involved as well as a partial conservative force is engaged. Electrons are in the maximum potential energy, where their clamped energy knots also keep the maximum expansion.

Involved energy and engaged force to transfer electrons for another state of the carbon atom are due to the originally built-in distance of the outer ring from the centre of atom. Thus, involved energy shaped like parabola provides the path for the transferring electron to originate a new state of the carbon atom. In this way, the engaged forces only influence in a partial conservative manner, where the involved typical energy to transfer electron from the side of atom also behaves in a partial conservative manner. Thus, a carbon atom originates the new state by preserving the equilibrium.

A graphite atom is converted into diamond, lonsdaleite and graphene atom by involving the energy shaped like a parabola trajectory and engaging the partially conserved force for each electron. A gaseous carbon atom converts into nanotube and fullerene atoms, where the involved energy and engaged force for transferring electrons to the positioned unfilled states behave in the same manner as for the case of other states. Energy knots forming the unfilled and filled states expand or contract depending on the state of carbon atom.

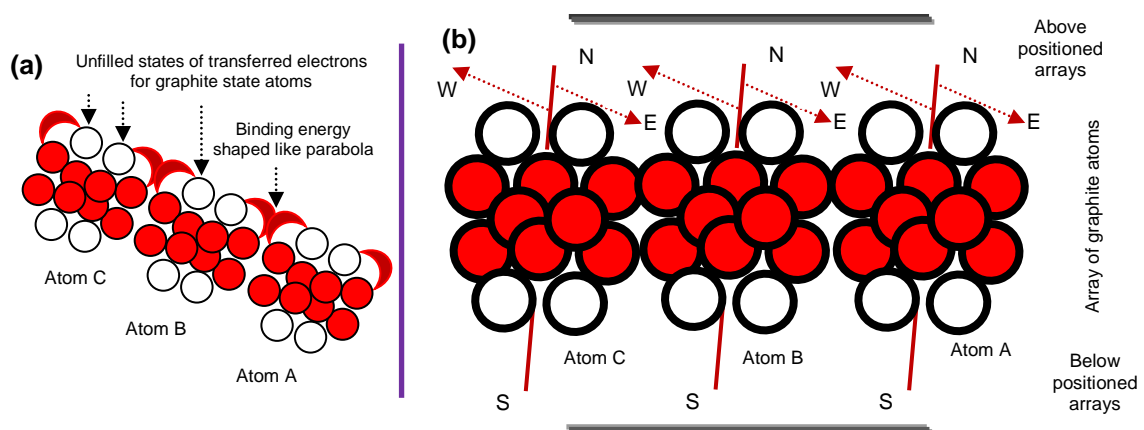
An occupied or unoccupied position of the electron in atom is termed as 'state'. Based on newly occupied state of the electron, a newly originated allotrope of the



carbon atom is also termed as 'state', but in this case, it is the atomic state instead of electron state. Expansion and compression of atoms depend on the potential energy and orientation of the electrons.

### 3.2. Formation of graphite structure

In Figure 2 (a), binding of carbon atoms in graphite state is shown, where one amalgamated atom has attained the graphite state (atom A) and the other (atom B) is in the transition to attain the graphite state. Energy shaped like parabola trajectory is involved to transfer suitable electrons of filled states to the nearby suitable unfilled states, so the atom A binds with the atom B. In the binding of atom A and atom B, a typical energy shaped like parabola is involved. Here, the role of the forces remained partially conserved. Upon binding atom C, a growth of graphite structure is started. A graphite structure grows nearly along the same axis as shown in Figure 2 (a). Graphite structure grows in one dimension, which is mainly along the line of east and west poles. The binding of graphite atoms can be from the both sides of X-axis. But, all the electrons of bound atoms orientate along the same axis where forces of north-south poles diminish. So, the structure appears to be termed as one-dimensional structure. In tiny grain carbon film, atoms of arrays elongate by the exertion of forces, so they convert into the structures of smooth elements [5].



**Figure 2:** Structure formation in graphite atoms when (a) interstate electron dynamics executed and (b) weak forces contributed under attained dynamics of graphite atoms

When carbon atoms amalgamate under the preservation of graphite state, they only bind through the attained dynamics. In this case, atoms do not execute interstate electron dynamics. A structure of graphite in two dimensions is developed. A parabola shape energy curve remains no more involved in the binding of graphite



atoms. Based on the slight difference of forces exerting along the east and west poles of amalgamating graphite atoms, they bind only under attained dynamics to form the arrays as shown in Figure 2 (b). So, carbon atoms of graphite state naturally come into the order when bind from the east-west sides or west-east sides. Forces at atomic level introduce the weak application to preserve the structure of graphite. Though existing forces of opposite poles of atoms do not work for a greater difference to enable the firm binding of graphite atoms, but the contributing (weak) forces also do not allow bound atoms to separate. As shown in Figure 2(b), upper and lower layers also formed by the amalgamation of graphite atoms only under the attained dynamics. (Amalgamated atoms remain bound under contributing force and energy of only attained dynamics.)

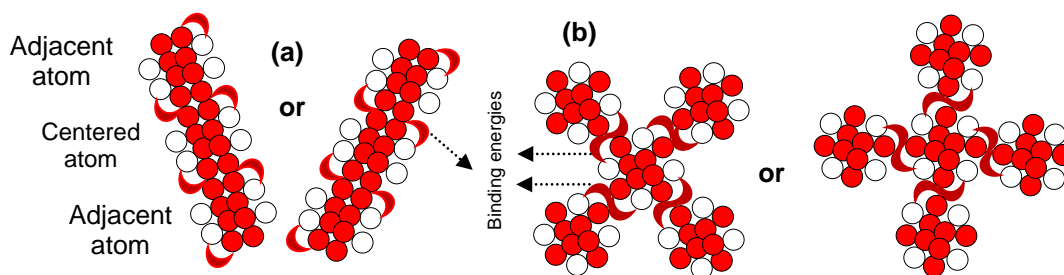
The formation of the amorphous graphite structure can be anticipated when binding atoms is under a bit inconsistent placement. Atoms do not position exactly from the east-west sides or west-east sides. (This was because of the attained dynamics of the graphite state carbon atoms. An amorphous graphite structure is more likely a “developed structure” rather than a “formed structure” as graphite atoms do not obey the consistency in attained dynamics. Therefore, in the synthesis of different carbon films, a word ‘develop’ is also suitable.) When the surface of graphite structure is not flat at the electron level, the influences of exerting north and south forces are also included, where developing structure of graphite atoms is also related to the amorphous carbon structure. (An amorphous graphite structure and an amorphous carbon structure is the same thing.) Nevertheless, further studies can be conducted to understand the mechanism of binding atoms in graphite structure and amorphous graphite structure while employing the different syntheses’ processes.

### **3.3. Formation of nanotube and fullerene structures**

A nanotube state atom can be converted from the fullerene state atom (or from another suitable state of carbon atom) prior to binding. Therefore, transfer of the electrons from suitable unfilled states is also under the involved energy shaped like parabola. Here, the execution of dynamics of electron is neither under non-conservative force nor under conservative force, but rather under the partial conservative force. Nanotube atoms form a structure based on the involvement of partial conservative energy and based on the engagement of partial conservative force, which is shown in Figure 3 (a). Here, a fullerene state atom converts into a

nanotube atom on transferring electron (to nearby unfilled state) of one quadrant and transferring electron (to nearby unfilled state) of other quadrant located oppositely. Forces of the electron of one quadrant are engaged in the space and surface formats. Forces of the oppositely sided quadrant are engaged in the surface and grounded formats. In this way, carbon atom keeps the equilibrium state. The energy shaped like parabola is involved to transfer both electrons, so carbon atoms in nanotube state can bind on the both sides to centered nanotube state atom as displayed in Figure 3 (a). This is called a nucleation stage of nanotube structure. A nucleation of nanotube structure can be with two options as shown in Figure 3 (a). In either way, the formation of the structure is two-dimensional. The binding of atoms is not nearly along the same axis, i.e., x-axis. (However, in the electron dynamics of graphite atoms, the binding of atoms is nearly along the x-axis, where electrons largely deal with the surface force. So, the formation of structure in graphite state atoms was considered in one dimension.) But the overall shape of nanotube structure under the both options appears in the one dimension as shown in Figure 3 (a).

In the formation of nanotube structure, exertion of forces related to the space format and surface format remained engage for one electron situating the suitable quadrant, whereas exertion of forces related to the surface format and grounded format remained engage for other electron situating the oppositely-sided quadrant. In each case, one electron dealing with the exertion of forces depends on the manner of linked typical energy for the relevant quadrant. So, the behavior of both energy and force in the formation of nanotube structure is related to partially conserved. A surface format constitutes force of two poles, i.e., force from the east pole and force from the west pole. So, in each case of the formation of nanotube structure, two forces behave for the exposed sides of the electron, whereas forces of two poles do not behave due to facing the sides of linked typical energy. Upon obeying the path of linked typical energy, an electron transfers to the unfilled state without facing any disturbance. Further studies can be performed to study the formation of nanotube structures by different processes and methods.



**Figure 3:** (a) nanotube structure – a two-dimensional structure where the involved energy of electrons (of opposite quadrants) of targeted/centered atom binds with the involved energy of electrons (of opposite quadrants) of amalgamating(ed) atoms and (b) fullerene (buckyballs) – a four-dimensional structure where the involved energy of four electrons of targeted/centered atom binds with the involved energy of electrons of four amalgamating(ed) atoms

Upon transfer of electron for each positioned state, a carbon atom converts into the fullerene state atom. Electrons of the outer ring (belonging to all four quadrants) involve typical energy shaped like parabola. So, transferring electron of each quadrant engages the partial conservative force along the relevant poles. Here, the engagement of forces can be in the space and surface formats for electrons of two quadrants. The engagement of forces can be in the surface and grounded formats for electrons of remaining two quadrants. An involved energy (at the electron level) shaped like parabola to bind fullerene state atoms for each quadrant is shown in Figure 3 (b); a formation of fullerene structure in two different ways is shown. Binding of fullerene state atoms for all four quadrants of centered atom form a fullerene structure. So, the structural formation in fullerene atoms is four-dimensional. The exerting forces along the relevant poles of electrons at the instant of transferring remain partially conserved.

In the formation of fullerene structure, exertion of forces related to the space and surface formats remained engage for two electrons of oppositely sided quadrants, whereas exertion of forces related to the surface and grounded formats remained engage for remaining two electrons of the suitable quadrants. In each case, two electrons dealing with the exertion of partial forces depends on the manner of linked typical energy for the relevant quadrants. The surface format also constitutes force of two poles. So, in electron of each quadrant, two forces behave for the exposed sides (of the electron) and two forces (of two poles) do not behave due to facing the sides of linked typical energy. So, the behavior of both energy and force in the formation of fullerene structure is related to partially conserved. In different synthesizing systems, more work is required to understand the binding atoms in fullerene structures.

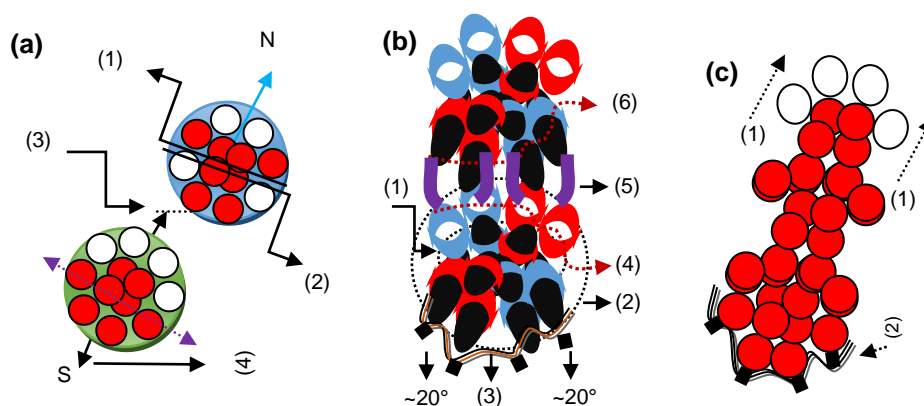
### **3.4. Formation of diamond structure**

A lonsdaleite atom having ground point just below the suitable level of ground surface is shown in Figure 4 (a). It approaches to bind the diamond atom once it is converted into the diamond atom. A carbon atom in diamond state has already attained ground point sufficiently below the ground surface as shown in Figure 4 (a), too. The expected binding point of diamond atoms when the lonsdaleite state atom will also be in the diamond state is also shown in Figure 4 (a). In the nucleation of synthetic diamond, a deposited atom is at highly-heated seeded solid surface, where it does not tend to gravitate the electrons further. This is because of the maximum achieved potential energy of the electrons. Therefore, no more expansion of energy knots clamped electrons occurs. In this way, electrons do not encroach to the resting surface even to the extent of size of an electron. Thus, the diamond atom shows solid behavior to the maximum extent. Moreover, the ground point of diamond atom is sufficiently below the ground point of lonsdaleite atom. In diamond atom, energy knots deal with the maximum expansion due to maximum gravitational force of clamped electrons. So, a carbon atom well behaves when in the state of diamond.

The ground point of lonsdaleite atom is a bit below the suitable level of ground surface as it is below the ground point of graphite atom. Electrons of lonsdaleite atom deal with the lower amount of potential energy as compared to electrons of diamond atom. Hence, the energy knots are in the lesser expansion. So, lonsdaleite atom is in less expansion of energy knots clamped to filled and unfilled states as compared to the ones in the diamond atom.

Upon transfer of electrons from the left and right sides to downward unfilled states, lonsdaleite atom is converted into the diamond atom. Energy knots clamped to electrons of that converted diamond atom also undertake the same level of expansion as in the case of targeted (deposited) diamond atom. Upon depositing diamond atom to already deposited diamond atom, a controlled expansion of energy knots clamping electrons took place. So, the orientationally controlled electrons (of depositing atom) also in the hands of forces exerting in the surface and grounded formats. Here, each filled state electron (of the outer ring of depositing diamond atom) undertakes another clamp of energy knot of each unfilled state (of the outer ring of deposited diamond atom). All electrons of filled states in the outer ring of depositing diamond atom are in position to undertake one additional clamp of energy

knot belonging to all unfilled states of the outer ring of deposited diamond atom as shown in Figure 4 (b).



**Figure 4:** (a) Lonsdaleite atom attempting to convert into diamond atom for binding: (1) east-west poles at ground surface and north pole; (2) ground point of lonsdaleite atom a bit below the ground surface; (3) expected binding point of lonsdaleite atom when converted into diamond atom; (4) ground point of diamond atom below the ground surface and south pole. (b) Binding of depositing diamond atom to deposited diamond atom: (1) zeroth ring; (2) outer ring; (3) substrate; (4) positioned energy knot; (5) typical energy shaped like golf-stick; (6) targeted electrons. (c) South to ground growth of diamond: (1) diamond growth; (2) embedded electrons of first deposited atom. (Red colored circles indicate filled states, white colored circles indicate unfilled states, targeted electrons and positioned energy knots are donated by red dotted line arrows in Figure 4b and overlapped red colored circles indicate double clamping to electrons)

Atoms of gaseous and solid states when in the original states keep the orientation of the electrons approximately  $40^\circ$  along the north pole and  $40^\circ$  along the south pole, respectively [2]. As all the electrons in the outer ring transferred to the unfilled energy knots below the east-west poles that carbon atom is no more in gaseous or semisolid behavior. In fact, a diamond atoms is in the highest state of solid. (Only the graphite state keeps appreciable semisolid behavior.) To undertake another clamp of energy knot by each electron of the outer ring of depositing diamond atom, left-positioned electron orientates along the left side to line drawn normal to the center and right-positioned electron orientates along the right side to line drawn normal to the center. In this way, orientation of an electron approximately becomes  $20^\circ$  along the south side to the line drawn normal to its center. All four electrons of the outer ring in diamond atom, west (left) sided two electrons and east (right) sided two electrons, obey nearly the same orientation as shown in Figure 4(b). (Orientation of electrons of the zeroth ring in diamond atom adjusted accordingly.) In this way, the degree of orientation in electrons of diamond atom becomes half to the

degree of orientation in positioned electrons of gaseous and solid atoms, which is discussed in the separate study [2].

A force of non-conserved behavior is engaged for each electron by the involved energy shape like half of parabola. The involved energy shape like half of parabola has also a non-conservative behavior. A typical energy shaped like golf-stick enables the electron of outer ring of depositing diamond atom to undertake another clamp of the positioned unfilled energy knot of outer ring of deposited diamond atom as shown in Figure 4(b). In the structural formation of diamond, force becomes non-conserved as the energy shape like golf-stick cannot allow it from the side of linkage. (Force in effect from any other side is being controlled by the incurred orientation of targeted electron while undertaking double clamping of energy knot.) This is the case when each targeted electron undertakes another clamp. In the structural formation of diamond, energy becomes non-conserved as the parabola shape energy trajectory is further divided into the shape like golf-sticks. So, it is further difficult to estimate.

A growth behaviour of diamond is shown in Figure 4 (c). In the growth process of diamond atoms, they adjust and compensate expansion and compression. An adjustment of the energy-knot-nets takes place for each time of depositing (binding) diamond atom to deposited (bound) diamond atom. Electrons embedded to substrate surface for first deposited diamond atom are also shown in Figure 4 (c). Upon undergoing the maximum expansion of clamped energy knots, electrons aligned ground to south under the non-conservative force. So, two diamond atoms binds ground to south.

Upon binding two diamond atoms, third diamond atom comes into position to bind. In two diamond atoms, a double clamping of energy knots to electrons (of the outer ring) is apprehended, so adjust the expansion and compression. This occurs prior to the binding of third diamond atom. This is the nucleation stage of diamond. Upon depositing the third diamond atom, a new point of binding is located under the consultation of already adhered two diamond atoms. In this way, a process of growth in diamond is initiated as shown in Figure 4 (c). Therefore, the growth of diamond is south to ground, but the binding of diamond is ground to south. A binding point in diamond atoms remains 'between surface format and grounded format' or 'ground to south'. So, diamond growth forms a topological structure. Upon binding, diamond atoms adjust expansion/compression. The orientation of growing diamond crystal

approximately becomes  $18^\circ$  to the normal axis as shown in Figure 4 (c). A diamond crystal can grow with several faceted faces due to having this degree of orientation.

A lonsdaleite atom is mainly in a bit solid behavior. In structural formation, a lonsdaleite atom experiences the non-conservative force for two electrons under the involvement of non-conserved energy, too. It is mainly in the surface format and a bit in the grounded format, so binding atoms is ground to a bit south, but growth behaviour is a bit south to ground. Further studies can be investigated.

The ground point of graphene atom exists just above the suitable level of ground surface. Electrons of graphene state carbon atoms largely deal with levitational force. However, a levitational behaviour of force is in non-conserved manner. Binding of graphene atoms experiences forces mainly in surface and space formats. So, growth of graphene atoms is opposite to diamond. Principally, graphene atoms should grow a topological structure. However, due to limitation of existing force in surface format and existing force in space format, adherence of only few layers in graphene structure is possible. So, the topological feature in graphene structure is not observed. In this context, further investigations are required to study not only the binding mechanism in graphene structure but the viability of associated forces.

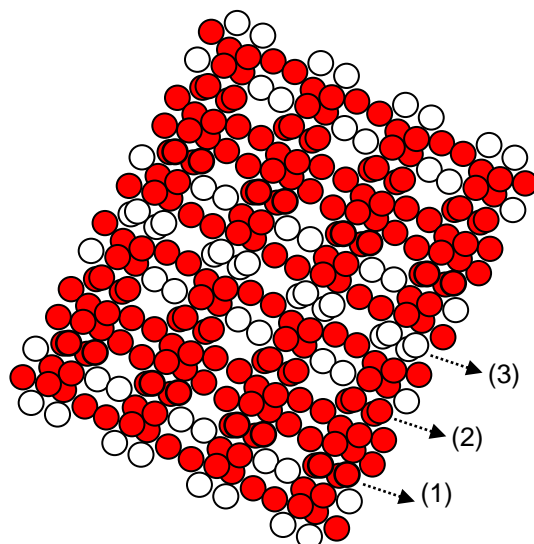
### **3.5. Formation of glassy carbon structure**

In the structural formation of glassy carbon, three layers of carbon atoms having different state for each layer (gaseous, graphite and lonsdaleite) bind in the successive manner. For structural growth of glassy carbon, layers of gaseous, graphite and lonsdaleite state carbon atoms bind in the repeated manner as shown in Figure 5.

Pieces of non-conservative energy having shape like half of parabola are also involved in each layer. Layers of gaseous and graphite atoms bind under the joint application of exerting forces in the grounded format and surface format. Here, orientationally controlled pair of targeted electrons (of each gaseous carbon atom) undertakes clamping of positionally controlled pair of energy knots (of each graphite atom) from the rear side as shown in Figure 5. So, gaseous carbon atoms attempt forceful gravitational behavior under increased potential energy of electrons. Layers of lonsdaleite atoms and graphite atoms bind under the joint application of exerting forces in the space format and surface format. Here, orientationally controlled pair of targeted electrons (of each lonsdaleite atom) undertakes clamping of positionally



controlled pair of energy knots (of each graphite atom) from the front side as shown in Figure 5. So, lonsdaleite atoms attempt forceful levitational behavior under decreased potential energy of electrons.



**Figure 5:** Structure formation of glassy carbon where layers of gaseous carbon, graphite and lonsdaleite atoms bind in the successive manner; (1) two electrons of each gaseous carbon atom (of the layer) undertake clamping of energy knots of two unfilled states of each graphite atom (of the layer) by entering from the rear sides, (2) two electrons of each lonsdaleite atom (of the layer) undertake clamping of energy knots of two unfilled states of each graphite atom (of the layer) by entering from the front sides and (3) layers of gaseous and lonsdaleite atoms compensate expansion/compression in binding layers to intermediate layers of graphite atoms; in double clamping of energy knot to electron is through the involvement of typical energy shaped like golf-stick

Further studies to design various topological structures in glassy carbon can be conducted. Accordingly, underlying science of various topological structures can be explored. In glassy carbon, each electron undertaking another clamping of energy knot is also by the involvement of typical energy shaped like golf-stick.

### 3.6. General discussion

A carbon atom is in gaseous state when one electron of the outer ring occupies the state on left side to the north pole and one electron of the outer ring occupies the state on right side to the north pole, and remaining two electrons of the outer ring occupy the states just below the line of east and west poles. The carbon atom is related to graphite state when two electrons of the outer ring retain positions in the states available just above the line of east and west poles and two electrons of the outer ring retain positions in the states available just below that line.

In the structural formation of graphite, nanotube and fullerene, a typical energy (of partial conservative behavior) engages the partially conserved forces to transfer the electrons. An involved typical energy in the formation of graphite, nanotube and fullerene structures is a diligently cut-portion of the unit photon, which is in the shape of parabola trajectory. A unit photon has the shape of Gaussian distribution turned from the both ends [1].

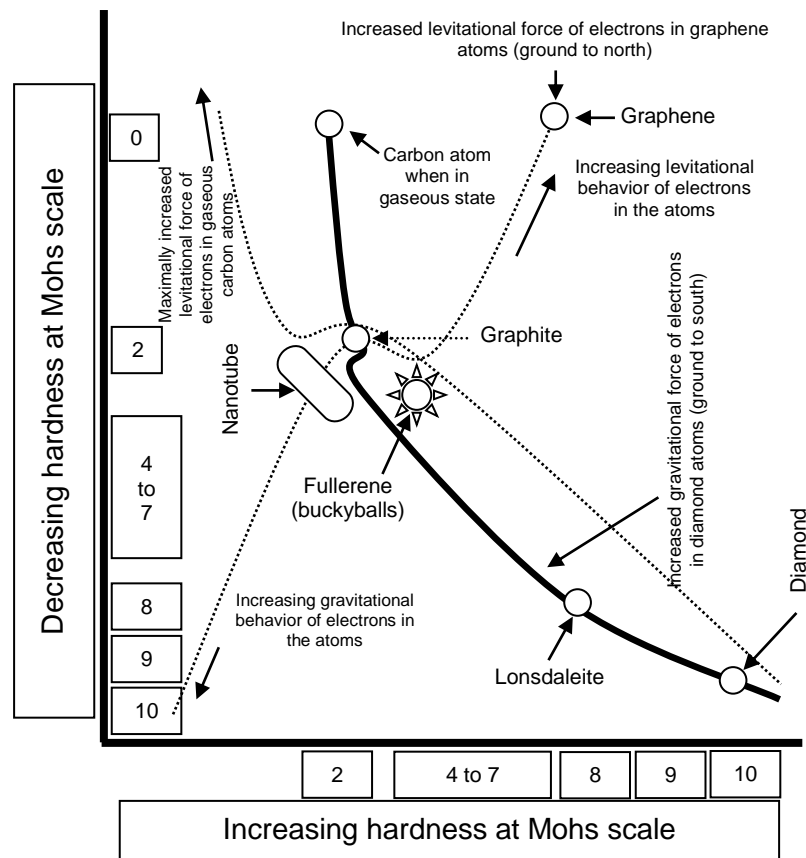
A gaseous carbon atom when converting into diamond, lonsdaleite and graphene states, it also involves typical energy shaped like parabola. Here, engaged forces along the poles of electrons are also partially conserved.

However, in the structural formation of carbon atoms when in diamond, lonsdaleite and graphene states, involved typical (heat) energy controls the potential energy of electrons. So, the structural formation in diamond, lonsdaleite and graphene state atoms engages the non-conservative forces. Again, in the structural formation of glassy carbon, a non-conservative force is engaged by the involved non-conservative energy.

To form the structures of graphite, nanotube and fullerene, the exerting forces to atoms (at electron levels) are under the involvement of partially conserved energy but fairly in the controlled manner. To form structures of diamond, lonsdaleite, graphene and glassy carbon, the exerting forces to atoms (at electron levels) are under the involvement of non-conserved energy but still in the controlled manner.

In Figure 6, Mohs hardness of different nanostructured and microstructured carbon materials is sketched in estimation. The value of hardness cannot be registered when gaseous carbon atoms considered. Gaseous carbon atoms do not even form a soft structure. So, gaseous carbon atoms keep the hardness zero at any scale of hardness measurement. However, in the nanostructures/microstructures of graphite, nanotube and fullerene, involvement of partial conservative energy and engagement of partial conservative forces measure the hardness, but not in very high scale of hardness. However, in the nanostructures/microstructures of lonsdaleite, graphene and glassy carbon, the involvement of non-conservative energy and engagement of non-conservative forces measure the hardness at very high scale. The maximum value of Mohs hardness is in the case of diamond as registered in the published literature. In the Raman spectroscopy, different values of the wave number vs. energy signals indicate different characteristics of carbon

materials [5]; energy loss spectroscopy of carbon nanostructures also validates different characteristics.



**Figure 6:** Mohs hardness of nanostructured and microstructured carbon materials vs. engaged forces at the electron level

In the hardness of nanostructured and microstructured carbon materials, the involved heat energy is half of the parabola shaped energy, which is involved to control the process of undertaking double clamping (of energy knot) by each targeted electron of diamond, lonsdaleite and graphene atoms. So, targeted electrons undertaking double clamping of energy knots engage a non-conservative force in the process. A same is the case in structural formation of glassy carbon, however, layers of gaseous, graphite and lonsdaleite state atoms bind successively.

In the structural formation of different carbon allotropes, the involved energy engages the force in different formats of the exertion. Here, the word “involve” refers to an action of energy for “instant time”, whereas the word “engage” refers to an action of force for “eternal period”. When carbon atoms of gaseous state are converted into another state, the involvement of energy at the first stage is there rather than the force. In each carbon atom, electrons of the outer ring execute

dynamics. Electrons of the zeroth ring do not undertake dynamics. This indicates that atomic radii in different elements along with electronic structure of an atom is the core to elucidate what sort of energy and force is anticipated for that atom.

#### **4. Conclusion**

None of the electrons deal with impartial force in carbon atom of any state. In the conversion of carbon atom from one state to other, energy partially manages the force by involving it and force partially manages the energy by engaging it. In the electron transfer mechanism of carbon atom, energy shaped like parabola trajectory enables the transfer of suitable electron of outer ring to nearby unfilled state. Transferring electrons of east and west poles of carbon atom simultaneously occupy nearby suitable unfilled states to preserve the equilibrium state. For the transfer of electrons to attain different state of the carbon atom, the exertion of force remains partially conserved each time. A carbon atom is the diamond state when all four electrons of the outer ring migrates to the states below the east-west line.

When structure of graphite atoms is two-dimensional, it is only through the significantly attained dynamics of amalgamated atoms as atoms deal with the force difference between opposite poles under a minute margin. So, graphite atoms also form amorphous structure when arrange in no specific order. When the graphite atom execute interstate electron dynamics, a structure of one-dimensional is formed. So, both attained dynamics and electron dynamics contribute.

In the structural formation of graphite, nanotube and fullerene atoms, a partially conserved energy involved. Hence, a partially conserved force engages to form the structures in one dimension, two dimensions and four dimensions, respectively. To form the structure of nanotube, a carbon atom involves the partially conserved energy of two electrons in opposite quadrants. To form the fullerene structure, a carbon atom involve the partially conserved energy of four electrons in all quadrants.

In the formation of topological structure, exertion of force to electrons is non-conserved. Involved typical energy in the diamond, lonsdaleite and graphene atoms is in the non-conservative manner. This engages the non-conservative force to control orientation (of the targeted electrons) and position (of the unfilled energy knots). Each electron of the outer ring of depositing diamond atom deals with the force to take another clamp of energy knot belonging to the outer ring of deposited

diamond atom. Binding of diamond atoms is from ground to south, but growth is from south to the ground. So, it is a tetra-electron ground to south topological structure.

Binding of lonsdaleite atoms can be from ground to a bit south, so it can be a bi-electron ground to a bit south topological structure. Binding of graphene atoms can follow opposite mechanism to that of the diamond. Here, involved energy for graphene atom can engage the force (along the relevant poles of electrons) in the surface and space formats. So, graphene atom can also form a tetra-electron topological structure. However, binding graphene atoms can sustain a structure of few layers only. So, the topology of graphene structure is not obvious.

Repeated layers of gaseous, graphite and lonsdaleite atoms nucleate a structure of glassy carbon. Binding atoms of each layer of lonsdaleite atoms to each layer of graphite atoms is under the forceful levitational behavior of electrons. Due to the decreased potential energy of electrons (of each lonsdaleite atom), they undertake another clamping of positioned energy knot (of each graphite atom); engaged force along the relevant poles of a pair of electrons (for binding) is from the front side. Binding atoms of each layer of gaseous atoms to each layer of graphite atoms is under the forceful gravitational behavior of electrons. Due to the increased potential energy of electrons (of each gaseous atom), they undertake another clamping of positioned energy knot (of each graphite atom); engaged force along the relevant poles of a pair of electrons (for binding) is from the rear side.

The structural formation in graphite, nanotube and fullerene atoms is through the partially conserved energy first, and then partially conserved force. Here, in the structural formation, suitable electrons of atoms execute interstate dynamics by remaining partially confined. On the other hand, in diamond, lonsdaleite and graphene atoms, structural formation is through the non-conserved energy first, and then non-conserved force. Here, in the structural formation, suitable electrons of atoms execute interstate dynamics by remaining non-confined. (A same is the case in structural formation of glassy carbon.) A property of hardness in any material should relate to the introduced energy and force at the electron level for that material.

In the structural formation of carbon atoms related to different states, the energy is involved first to engage the force. So, carbon atoms explore their own science. They enable one to understand the nature of electron dynamics in atoms of different class of elements. Their studies open new areas of research investigations. These

investigations enable one to understand different phenomena of nature. A carbon atom enables one to understand the relations of energy and force with electron.

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**Mubarak Ali** graduated from University of the Punjab with BSc (Phys & Maths) in 1996 and MSc Materials Science with distinction from Bahauddin Zakariya University, Multan, Pakistan (1998); his thesis work completed at Quaid-i-Azam University Islamabad. He gained PhD in Mechanical Engineering from the Universiti Teknologi Malaysia under the award of Malaysian Technical Cooperation Programme (MTCP;2004-07) and postdoc in advanced surface technologies at Istanbul Technical University under the foreign fellowship of The Scientific and Technological Research Council of Turkey (TÜBİTAK, 2010). He completed another postdoc in the field of nanotechnology at the Tamkang University Taipei (2013-2014) sponsored by National Science Council now M/o Science and Technology, Taiwan (R.O.C.). Presently, he is working as Assistant Professor on tenure track at COMSATS University Islamabad (previously known as COMSATS Institute of Information Technology), Islamabad, Pakistan (since May 2008) and prior to that worked as assistant director/deputy director at M/o Science & Technology (Pakistan Council of Renewable Energy Technologies, Islamabad, 2000-2008). He was invited by Institute for Materials Research, Tohoku University, Japan to deliver scientific talk. He gave several scientific talks in various countries. His core area of research includes materials science, physics & nanotechnology. He was also offered the merit scholarship for the PhD study by the Higher Education Commission, Government of Pakistan, but he did not avail himself of the opportunity. He also earned Diploma (in English language) and Certificate (in Japanese language) in 2000 and 2001 respectively, in part-time from the National University of Modern Languages, Islamabad. He is the author of several articles available at following links; <https://scholar.google.com.pk/citations?hl=en&user=UYjvhDwAAAAJ>, [https://www.researchgate.net/profile/Mubarak\\_Ali5](https://www.researchgate.net/profile/Mubarak_Ali5), <https://www.mendeley.com/profiles/mubarak-ali7/>, & <https://publons.com/researcher/2885742/mubarak-ali/publications/>