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Hard Coating is Because of Oppositely Worked Force-Energy Behaviors of Atoms

Mubarak Ali [a] *, Esah Hamzah [b], Mohd Radzi Mohd Toff [c]

[a] Department of Physics, COMSATS University Islamabad, Park Road, Islamabad-45550, PAKISTAN, *E-mail: mubarak74@comsats.edu.pk, mubarak74@mail.com

[b] Department of Materials, Manufacturing and Industrial Engineering, Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor, MALAYSIA, E-mail: esah@fkm.utm.my

[c] Advanced Materials Research Center (AMREC), SIRIM Berhad, Lot 34, Jalan Hi-Tech 2/3, Kulim Hi-Tech Park, 09000 Kulim, Kedah, MALAYSIA, E-mail: mradzit@sirim.my

Abstract –Coatings of reliable materials of thickness in few atoms to several microns on a viable substrate is the basic need of society which attend regular attention of scientific community working in various fields. Decorative and protective coatings, transparent and insulating coatings, coatings of medical implants and surgical instruments, coatings for drug delivery and security purposes, ultra-precision machine coatings and coatings of other miscellaneous uses are in routine demand for research and commercial purposes. Different hard coatings develop with significant composition of different nature atoms where their force-energy behaviors when recovering certain transition states provide provision for electron of outer ring belonging to gas atom to react for another clamp of energy knot clamping unfilled state of outer ring belonging to solid atom. Set suitable process conditions regulate switching force-energy behaviors of different nature atoms, which are nearly opposite to the ones originally existing in them. Thus, different nature transition state atoms locate points of developing hard coating between their original ground points as the gaseous nature atoms increase their potential energy as per increasing the gravitational force exerting at electron level while the solid atoms decrease their potential energy as per decreasing the gravitational force exerting at electron level. Ti-atom to Ti-atom binding is taken place under the difference of expansion level of lattice in the just land atom and landed atom where the position of nitrogen atoms becomes nearly at their interstitial site. Thus, different nature transition state atoms accommodate to be deposited at substrate surface positioned in the deposition chamber under suitable set parameters. In random arc-based vapor deposition system, depositing different nature atoms at substrate surface depends on the supplied energy where non-conserved forces are remained engage to keep adherence. On undertaking electron (of gas atom), another clamp of energy knot (of solid atom) is being endorsed by the mutually adjusting expansion-contraction of lattices belonging to two different nature atoms developing structure in the form of hard coating, which is known since antiquity. Different properties and characteristics of hard coatings emerged as per engaged forces under the set conditions of involved energy. The present study sets new trends not only in the field of films and coatings but also in the diversified class of materials, wherever, atoms recall their roles.

Keywords: Hard coating; TiN; Atomic nature; Expansion-contraction; Potential energy; Force-energy behaviors; Ground point; Structure evolution

1. Introduction

Hard coatings are the integral part of scientific research for researching and technological advances. Marketable hard coatings for different purposes are learnt routinely where their ingredients and deposition technique are in the hot topics. In this context, several materials involving different ingredients and deposition techniques are available in the literature discussing and explaining their deposition history along with the features of substrate material. In coatings, a minute deposited quantity of materials over less-important (or not viable practically) material solves the purpose where giving the value-added results.

A variety of techniques are involved to deposit different sorts of hard coatings at the surface of suitable substrates. Coatings are mainly employed with two targeted approaches; in the first case, the potential use of external coated part, which is not

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subjected to a great deal in the uncoated case and in the second case, potential use of internal surface where inner uncoated surface of material was not the subject of great concern but on coating, it became a great deal. Overall, coating the surface of a certain substrate results into deliver its different behavior of functioning, often in an astonishing way.

Solid atoms of unfilled states do not elongate and those belonging to inert gases split under the excess propagation of photons characteristic current [1]. A neutral state silicon atom transformed heat energy into photon energy as discussed elsewhere [2]. Atoms of suitable solid behavior evolve structures of different dimension and format as per the nature of built-in electronic gauge where conservative forces involved to execute confined inter-state electron-dynamics [3]. The origins of atoms of certain elements to be in gas state while the origins of atoms of certain elements to be in solid state are discussed elsewhere [4]. A gas state carbon atom originates several different physical behaviors, which is under the involvement of non-conserved energy where confined inter-state dynamics of electron to attain its certain state engaged non-conserved forces as well [5]. Depending on the atomic behavior of tiny sized particles, their role for nanomedicine can either be beneficial or harmful [6].

Developing different hierarchical tiny particles under varying conditions of the process is under differently attained dynamics of gold atoms [7]. A monolayer triangular-shaped tiny particle was considered as the model system discussing the elongation behavior of one-dimensional arrays of gold atoms and their conversion into structure of smooth elements under the joint application of surface format force and travelling photons of adequate wavelength [8]. At suitable precursor concentration, many tiny particles shape-like equilateral triangle developed as discussed elsewhere [9]. Shapes of tiny sized particles and large sized particles were controlled under the application of different ratios of pulse OFF to ON time [10]. Particles of different anisotropic shapes developed in less than millisecond time [11]. Developing tiny sized particles of certain shape tapped in different precursors [12]. Predictor packing while developing highly geometric anisotropic gold particles is discussed elsewhere [13] where controlled force-energy behaviors regulate the shape.

Different behaviors of tiny grains carbon films registered under Raman spectroscopy and energy loss spectroscopy indicated several phases of tiny grains [14]. Switching morphology-structure of grains and crystallites under a bit altered locally operating parameters in developing carbon films is discussed elsewhere [15]. Under varying chamber pressure, a discernible change in the morphology and growth rate of carbon films was observed [16].

Depositing TiN coatings on different substrates under varying process conditions while employing a technique known as 'cathodic arc physical vapor deposition', a different morphology-structure along with hardness, surface roughness, friction coefficient, adhesion strength and overall performance of coated tools were studied [17-28]. In addition to these studies, there are several other available studies in the literature targeting TiN coating along with the processing technique and their analysis [29-36]. In addition to TiN coating, different types of hard coatings developed under various employed conditions have also been published, extensively [37-48]. The basic idea discussed in those studies is related to the properties and characteristic of deposited coatings, which are subjected to the change of process parameters, type of material and processing approach, mainly.

The prosperous assembling of colloidal matter into meaningful structure will result into deal atoms and molecules as tomorrow's materials [49] and understanding in the individual dynamics of tiny sized particles formation is essential before enabling their assembling to the useful large sized particles [50].

In addition to the discussed scientific details available for hard coatings, coatings are in the way to express relation between their counterparts. This study reports the fundamental aspect of developing hard coatings with emphasis on TiN coating while depositing on a high-speed steel (HSS) disc where random arc-based vapor deposition technique was employed. The aim of this work is to present the fundamental aspect of depositing hard coating, in general, and to investigate the mechanism of developing TiN coating, in specific.

2. Experimental details

HSS discs were utilized as a substrate material for the deposition of TiN while employing the commercially available coating unit known as 'cathodic arc physical vapor deposition', which is now termed as 'random arc-based vapor deposition' in the present study. After the required cleaning, the samples having diameter: 10 mm and thickness: 6 mm were loaded in the coating system mark Hauzer Techno Coating (HTC) 625/2 ARC. The complete deposition procedure along with metallographic process of samples has been described in our earlier work [28].

Surface morphology and interface studies were done using FE-SEM (Model LEO-1525). The thickness of the deposited coatings was measured by using the application of FE-SEM under the fractured cross-sectional image. Prior to go for coating TiN, an interlayer of Ti was deposited for 15 minutes time to enhance the adhesion strength of the following coating. At start of depositing inter-layer, chamber pressure was 5×10^{-6} mbar. While depositing inter-layer, 50 sccm nitrogen gas flow rate was maintained by mass flow controller meter. To deposit TiN in the form of coating, substrate temperature was maintained at 300°C where N gas flow rate was 250 sccm. The bias voltage was 50 volts where rotational speed of the substrate holder was set 60%. Current for igniting arc to eject Ti-atoms from their target was 100 A. Total duration of the deposition process was set 90 minutes.

3. Results and discussion

Figure 1 (a) shows surface morphology of deposited TiN on HSS disc where coating is partially covered with macrodroplets (MDs), size ranging from few hundred of nanometers to few microns. The distribution of MDs is uniform throughout the surface. A large sized macrodroplet (MD) in the central vicinity shows mapping of the region where the concentration of both Ti and N atoms is appeared in different colors. Figure 1 (b) shows fractured cross-sectional view of the coating where initially deposited Ti layer shows thickness less than one micron. Atoms of Ti-interlayer first adhere to surface atoms of substrate under the favorable conditions.

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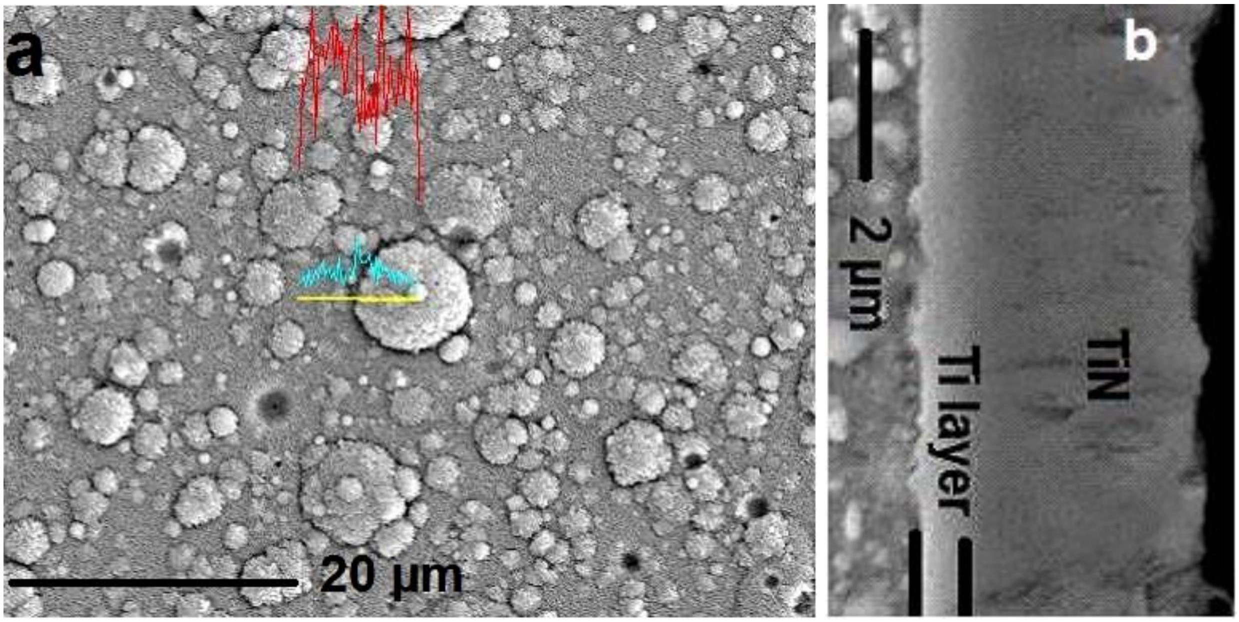

Figure 1: *(a) topography view of TiN coating on HSS and (b) titanium interlayer in few hundred of nanometers shows contrast to TiN coating deposited in thickness ~4 µm (a cross-sectional view of coating prepared under metallographic cross-sectioning procedure)*

Substrate surface comprises different elements like W, Mo, Cr, V, C and Fe enable binding to Ti-atoms [17, 24]. Ti-atoms bound to substrate surface for introducing the favorable conditions of depositing TiN coating. In this context, the nature of substrate can possess different elements where their certain force-energy behaviors can introduce appreciable binding to the depositing atoms resulting into produce value-added features of the resulted coating. There are several studies studying the reduction of MDs under varying the process parameters in vapor deposition technique along with different employed strategies [17-20, 23-25]. Adhesion strength of TiN coating deposited under certain conditions in random arc-based vapor deposition system is discussed elsewhere [26, 28].

Figure 2 shows the mapping of Ti-atoms present in TiN coating at point of MD (shown in Figure 1a) in the form of histogram where the content is around 70%. This indicates that the area covered by Ti-atoms in the TiN coating at top front surface not only contained 70% of the content but the distribution of atoms in MD also remained dense and uniform. This indicates that MD contained less concentration of N-atoms.

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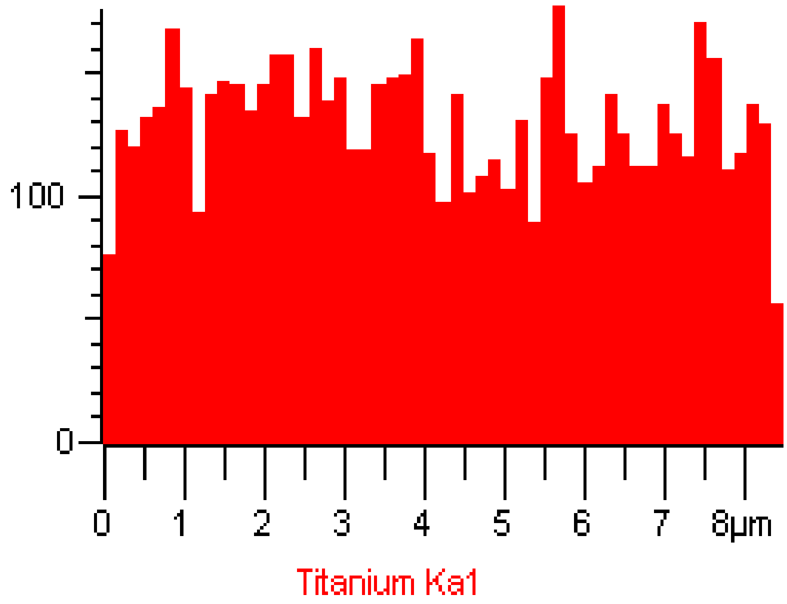

Figure 2: *Mapping of Ti-atoms distribution along with the ratio of content*

Figure 3 shows the mapping of N content in TiN coating in the form of histogram, which is around 30% at the central point of MD shown in Figure 1 (a). This indicates that the area covered by N-atoms in the TiN coating at top front surface not only contained 30% of content but also contained uniform distribution, however, not in the dense manner. This describes that MD contained approximately three times less concentration of N-atoms as compared to Ti-atoms.

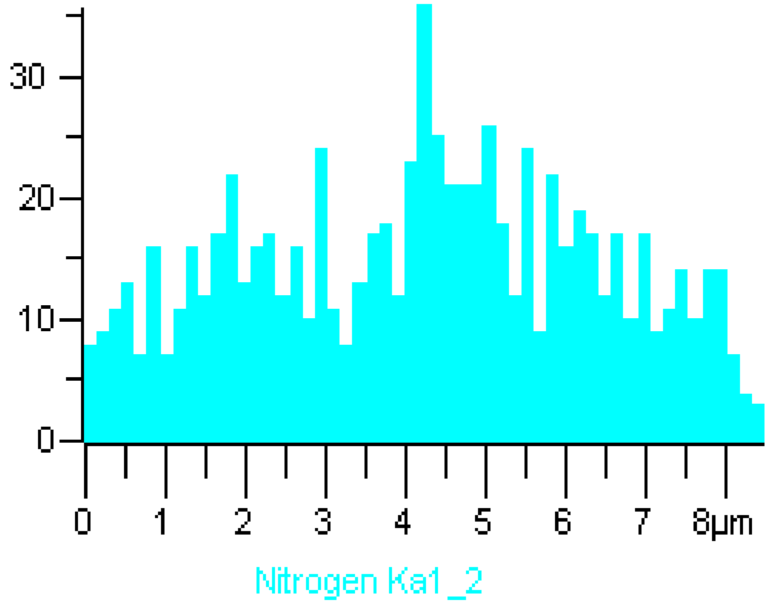

Figure 3: *Mapping of N-atoms distribution along with the ratio of content*

Hard coatings mainly fall in the category of refractory materials and they are no more the candidates of conductive behavior despite of the fact that major component of those coatings still involve metallic nature atoms. On adhering gas atoms to metallic atoms, the resulted coatings become poor in conduction because they work nearly as an insulator where field of propagating photons characteristic current is interrupted to a large extent. This is because of locking inter-state electron gap for metallic nature atoms by means of reacting to gas atoms and then binding in metallic-to-metallic atoms. These result into display irregular structure of the resulted coating, if that is an ordered structure, it is only within the short-range order. The incorporated N-atoms built the bridges *via* their certain electrons where undertaking another clamp of energy knot (for electron of each atom) clamping to unfilled state of certain Ti-atom. This resulted into lower the propagation of photonic current. A detailed study is given elsewhere [1] discussing the significance of inter-state electron gap in atoms of different class of categories; propagation of current no more requires the band gaps between conduction bands and valence bands as they don't exist for explaining the science of semiconductor materials or other types of materials.

In random arc-based vapor deposition system, atoms of Ti (or other metallic nature atoms) are ejected from the surface of different shaped targets where arc is utilized to supply the energy a bit in non-uniform manner depending on the strength of applied field per unit area (or volume). At high concentration of N-atoms, a random arc is steered to eject Ti-atoms both in atomic form and tiny sized cluster (droplet) depending on the nature of Ti targets along with employed conditions of vapor deposition process. The basic layout of ejecting Ti-atoms and entering N-atoms to deposit TiN coating is sketched in estimation, which is shown in Figure 4.

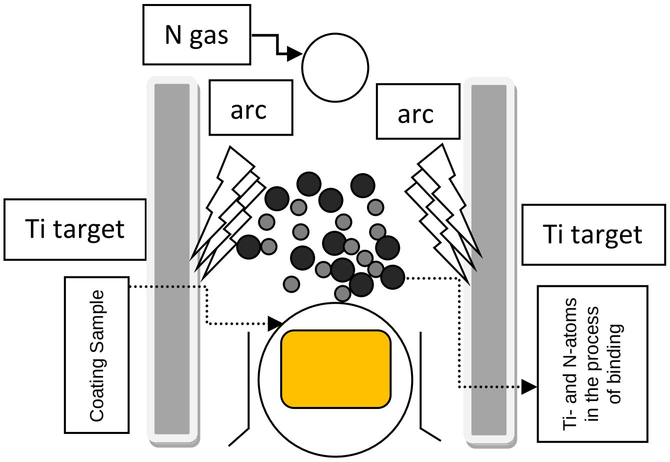

Figure 4: *The basic layout of depositing Ti-atoms and N-atoms to develop TiN coating at the surface of HSS substrate*

Expected atomic structure of Ti and N is shown in Figure 5. The tinniest sized particles called electrons are filled in the hollow space constructed by the inter-crossed overt photons in certain symmetry having wavelength in photons characteristic current. In the case where electrons don't fill those hollow space, they are termed as the unfilled states of atoms. For Ti atom, total 32 states of electrons are available, but 24 states are filled by the tinniest sized particles (called electrons) while 8 states are remained unfilled. In the case of inner unfilled states of the atom, they are being remained pressed by the covered filled states as indicated in Figure 5. Both filled and unfilled states of Ti atom are constructed by the inter-crossed overt photons having their dedicated length. The required number of overt photons are being inter-crossed with full understanding of their atoms related to each element by involving the three-dimensional space. However, unfilled states are belonged to outer ring where electrons don't occupy the position, which are at the end of certain DNA-like shape as shown in Figure 5. From oppositely-sided crossed two overt photons comprising eight unit-photons construct DNA-like shape. As shown in the bottom part of Figure 5 where five such shapes are drawn and their precise inter-crossing at a common centre form the lattice of Ti-atom in which 24 states are remained filled. Expanded and contracted energy knots clamping electrons in Ti-atom and N-atom, respectively, is also shown in Figure 5.

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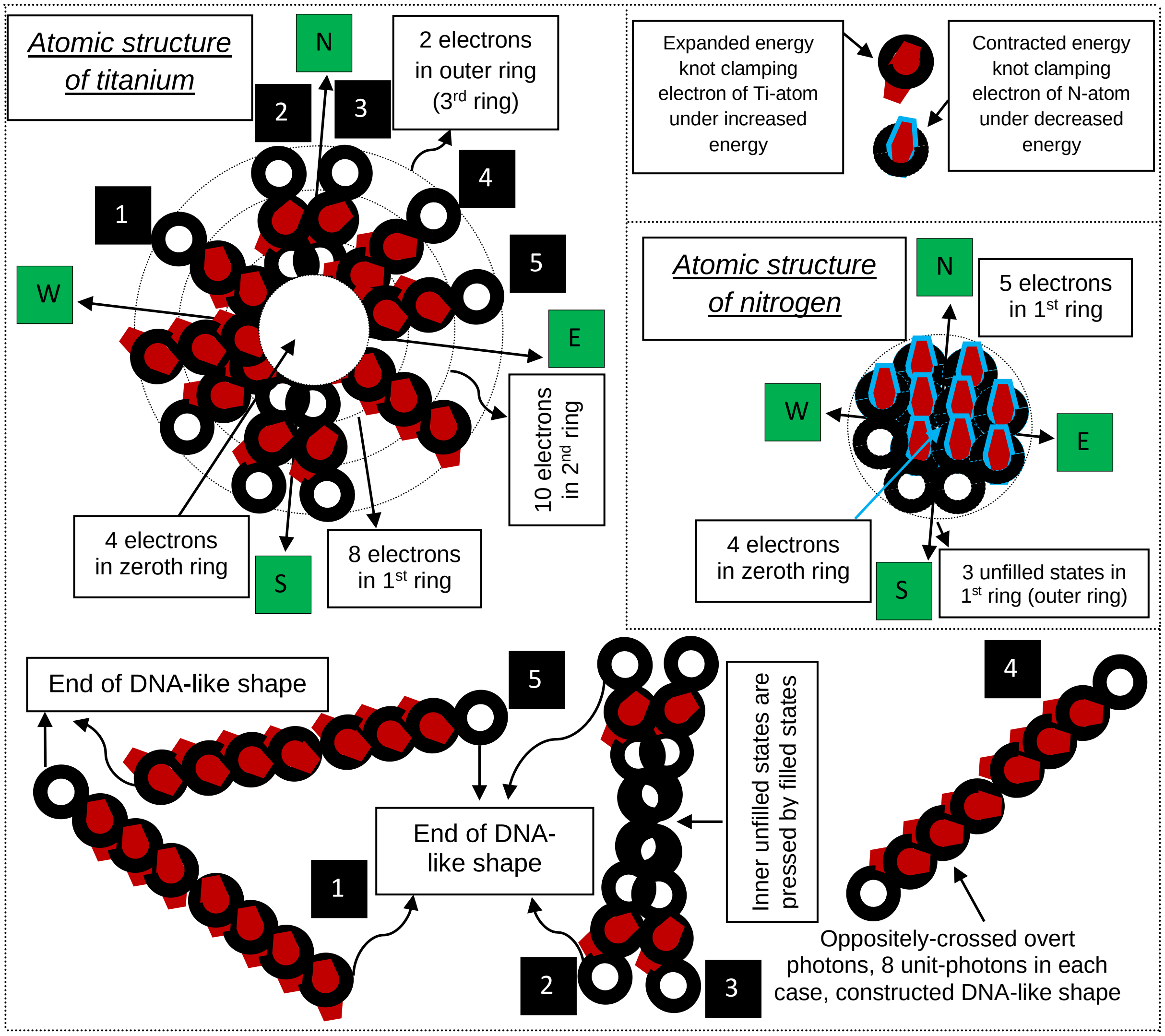

***Figure 5:** Expected atomic structure of Ti and N; in the bottom contributed DNA-like shapes are shown indicating filled states, unfilled states and pressed states for Ti-atom*

Filled states of outer ring in the case of atoms of solid behaviors donate the positive valency while in the case of atoms of gas behaviors donate the negative valency. For the case of Ti atom, valency is +2, so, it has ‘8’ unfilled states. In the case of nitrogen atom, it has valency -3, so, it has ‘5’ unfilled states. Hence, negative sign for valency in gas behavior atoms indicates their ground point at above average level of ground surface and positive sign for valency in solid behavior atoms indicates their ground points at below average level of ground surface. Inner four electrons of atoms belonging to each element form the zeroth ring, whereas, others are related to available consecutive rings as discussed elsewhere [4]. In the case of H atom, the valency

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remains neutral 2 because of pointing one electron toward the north-pole and one toward the south-pole. Availability of the further two electrons form the helium atom where it contains the zero valency is shown in another study [4].

In different coating technology units, regardless of that, required numbers of atoms per unit area or volume are being deposited under set parameters of the process, their involved energy is based on individually attained dynamics plus electron-dynamics, which is the key to regulate their structure, so, there is emergence of properties and characteristics of their resulted coating. However, it appears that evolving structure of TiN coating in the order of certain homogeneity is within the short-range order. Therefore, the deposited coating is developed mainly under the mixed behavior of structure evolving. Each Ti-atom only occupies two electrons in the outer ring. This low number of its filled states enables it to occupy many unfilled states of outer ring since from its existence. Ti being a solid atom is supposed to has its unfilled states at above east-west poles, both at left and right sides of the north-pole. Because atoms of Ti element are belonged to grounded format where electrons of filled states (in the outer ring) are to be remained at below their east-west poles along the south-pole while dealing their original solid behavior. On the other hand, five filled states in outer ring of N-atom allow less number of unfilled states in the outer ring. In this context, a N-atom contains several filled states of outer ring where majority of the electrons (filled states) are expected to be at above the east-west poles along the north-pole while in each dedicated state. This is because of the gas nature of N-atom and further detail regarding why atoms of some elements are in gas state and some in solid state is given elsewhere [4]. The availability of several unfilled states of outer ring in Ti-atom provide provision to work for electrons of filled states of outer ring in N-atom where targeted electron (of gas atom) is being clamped by another clamping of energy knot (of solid atom). The double-clamping of energy knot to the electron of N-atom is by means of energy knot clamping unfilled state of outer ring in the Ti-atom. But the mechanism of double clamping of energy knot by the electron is by means of suitable transition of both gas and solid atoms. Atoms when are in a certain transition state adjust potential energy of their electrons as per exerting the orientating force as discussed elsewhere [4].

Therefore, two different nature atoms (Ti and N) develop affinity in terms of strong binding under suitable reaction where dealing intrinsically orientating force at electron level depending on the supplied energy influencing at electron level as well.

Atoms of metallic targets are already in the contraction of energy knots clamping electrons because now they are not grounded below the ground surface. On the other hand, injected gas atoms are in the expansion of energy knots clamping electrons because now they are at ground surface instead of being at above ground surface and through given pressure for their entering into the deposition chamber. Therefore, different nature atoms have already switched their force-energy behaviors oppositely. To recover their original solid and gas behavior, they come into reaction upon their suitable coinciding. This results into take reaction of targeted electron of gas atom to deal another clamping of targeted energy knot of unfilled state belonging to solid atom.

Therefore, solid atoms of Ti have already done work negatively (arriving near to ground surface from the south) while gas atoms of N have already done work positively (arriving near to ground surface from the north). Further details of the nature of work done in original gas behavior and original solid behavior atoms is discussed elsewhere [4]. On recovering the state behavior and, so, in two different nature atoms their force-energy behaviors switch oppositely as well where when work done by the gas atom is just in negative while work done by the solid atom is just in positive, they react to deal double clamping of the suitable electron (of the gas atom) through suitable unfilled state (of the solid atom). However, electron (belonging to outer ring) of the solid atom may deal double clamping of energy knot provided by the unfilled state (belonging to outer ring) of the gas atom under certain circumstances. But, the probability is less because of having lower number of electrons belonging to outer ring in the solid atom as compared to the ones belonging to outer ring in the gas atom. This results into their binding secured by the engaged force as per gained energy of different nature atoms where they deal the perfect behavior to land (deposit) at substrate surface, thus, evolving the structure of coating being deposited.

Ti metal is known in metallic character where filled state electrons keep their atoms grounded under the maximum gravitational force and the maximum expansion of their

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clamped energy knots takes place, also. Thus, electrons of Ti-atoms keep original ground point at below ground surface under the normal condition. On the other hand, a N-atom belongs to gas behavior, which remains in the air under the engagement of space format force exerting at electron level, thus, its electrons keep original ground point at above ground surface. The electrons of N-atoms keep their ground point at above ground surface because of the maximum contraction of their clamped energy knots where the maximum orientating levitational force is being exerted at electron level. Therefore, in their joint deposition while employing a suitable coating technology unit, which is meant for this job, electron of outer ring belonging to N-atom takes affinity in terms of dealing another clamp of energy knot by clamping the unfilled state of outer ring belonging to Ti-atom where their atoms are in certain transition states. Under given energy in the deposition chamber enabling another clamping of the energy knot by suitable electron of gas atom and through energy knot of suitable unfilled state of solid atom is by means of engaging the force. This results into search their ground point neither at above ground surface nor at below ground surface. In the search of attaining their ground points, they mutually get ready for the common ground point at the surface of depositing substrate, which becomes nearly at mid-point of two different ground points; at above ground surface (in gas atoms) and at below ground surface (in solid atoms). Under the tailored process parameters of deposition, structure of hard coating deal high hardness because of the maximum ordering of different nature transition state atoms where their attained mid-points kept order to a large extent.

The electrons of N-atoms deal double clamps of energy knots while focusing to unfilled states of Ti-atoms where gas state atoms are being uplifted while solid ones are being grounded. Suitable transition state atoms deal double clamps of targeted energy knots (belonging to solid atoms) to targeted electrons (belonging to gas atoms) under their favorable coinciding. The mechanism of double clamping of suitable energy knots to suitable electrons of N-atoms ground forcefully by the Ti-atoms through suitable energy knots clamping unfilled states as shown in Figure 6. Binding of Ti-atom to Ti-atom under the application of an electron (belonging to less expanded Ti-atom just landing) to deal another (double) clamp of energy knot (belonging to more expanded Ti-

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atom already landed) is also shown in Figure 6 where N-atoms mainly come at interstitial sites of Ti-atoms.

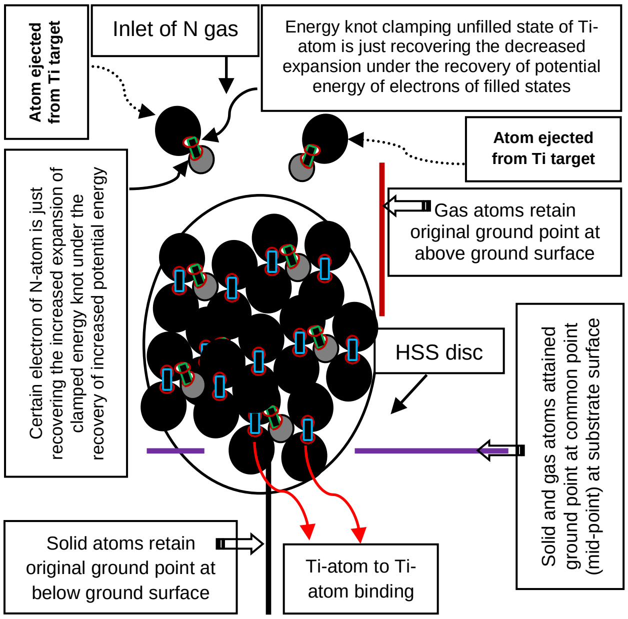

Figure 6: *Mechanism of double clamping of suitable energy knots to suitable electrons of gas atoms through suitable energy knots clamping unfilled states of solid atoms along with Ti-atom to Ti-atom binding*

In different processing techniques of hard coatings under the supplied energy as per set parameters of the process, gas behavior atoms deal exerting of increasing gravitational force for ground surface-sided tips of their electrons, thus, they increase the potential energy. As a result, electrons of atoms deal infinitesimal displacement from north-sided tip to ground surface-side by remaining clamped in their clamped energy knots. As discussed elsewhere [4], solid behavior atoms deal exerting of decreasing gravitational force to south-sided tips of their electrons where they decrease potential energy to acquire transition state and the maximum decrease when in liquid state. As a result, electrons of atoms deal infinitesimal displacement from their south-sided tip to ground surface-side by remaining clamped in their clamped energy knots. As discussed above, ejected atoms (Ti or other element) of metallic target are already in their certain transition state. So, while just acquiring the recovery of state of solid atoms in their original state behavior and prior to that, they bind to gas atoms which are just in transition to acquire the recovery in their original state behavior also. Under the action of tailored force-energy behaviors of N-atoms and Ti-atoms, they react, which results into their binding to develop TiN coating at surface of the substrate.

Because, solid atoms in their original state behavior dealt fully orientated gravitational force, which is due to their grounded ground points under fully gravitized behavior exerting at electron level, thus, their electrons gained the maximum potential energy where clamped energy knots also dealt the maximum expansion. So, energy knots constructing unfilled states in those atoms also expanded maximally. But, gas atoms in their original state behavior dealt fully orientated levitational force, which is due to their ground points at above ground surface under fully levitized behavior exerting at electron level, thus, their electrons gained the minimum potential energy where clamped energy knots also dealt the maximum contraction. So, energy knots constructing unfilled states in those atoms also contracted maximally.

On landing a Ti-atom at substrate, it recovers its transition state into original solid behavior where electrons start to gravitize. But prior to fully gravitize, an adequate expansion of the lattice under increased (gained) potential energy is taken place. However, Ti-atom afterward landing attains ground point at the surface of previously landed atom, so, kept the lattice in less expansion. Therefore, certain electron of less expanded land Ti-atom (where it is pointing toward the side of ground surface) enter in a suitable vacant energy knot of more expanded landed Ti-atom (where it is pointing toward the north-side). This results into bind the two identical atoms. Now, forcefully grounded nitrogen atoms tend to recover state to go into original gas behavior where their certain electrons are entered in the certain remaining vacant energy knots of Ti-atoms also but from the back-side. In this way, nitrogen atoms are trapped at interstitial position of the Ti-atoms. Binding of nitrogen atoms at interstitial positions of bound Ti-atoms is shown in Figure 6. Energy between electrons and their clamped energy knots is involved under each specific transition state of their atoms is termed as chemical energy [4].

Atoms of both gas and solid engage conserved energies under their original behaviors where in the first case, maximally increased level of energy while in the second case, minimally decreased level of energy, respectively. But, the situation becomes reverse when they deal their liquid transition states where in the solid atoms, energy becomes the minimum under the minimum orientating force of south-pole exerting at electron level and in the gas atoms, energy becomes the maximum under the minimum orientating force of north-pole exerting at electron level. As, nearly this is the case of depositing hard coating of two differently nature atoms, one in the gas transition state and other in the solid transition state, and while just recovering their original state behaviors, they reacted to each other where clamping another energy knot (belonging to unfilled state of solid atom) to the electron of gas atom take place under their appropriate coinciding at substrate surface.

The similar sort of mechanism is being anticipated in bi-metallic composition with gas behavior atoms, for example, TiAlN. Again, low measured-hardness coating of chromium nitride (compared to TiN) involves the mechanism of binding their different nature atoms under similar lines where high probability of binding is involved as Cr-atom contains many unfilled states in the outer ring (compared to Ti-atom). That's why CrN coating exhibits low surface roughness as compared to TiN coating [28] and because of greater level of homogeneity of binding atoms while evolving structure. A similar approach may be validated to explore the science of other hard, moderate hard and even less hard (soft and porous) coating materials. A different originating science mechanism may be anticipated in the case of TiCN coating and because of involving the carbon atoms, which requires additional lines to express the science of their synthesizing materials. Reacting of gas atoms and solid atoms endorse engaging of force exerting by their electrons under the adjustment of expansion and contraction of clamped energy knots, respectively. In this case, the energy is being involved. Therefore, developing hard coating is related to non-conserved energy where non-conservative frictional forces are engaged to sustain the structure of coating. However, where the force element is involved first, the energy is being engaged as for the case of silicon atoms [2]; conservative forces are involved to configure the energy in the form of forcing energy (photon). A photon wavelength in the characteristic current is discussed elsewhere [1]. A unit-photon and an overt photon are discussed elsewhere [2]. The origin of atoms of different elements to be in gas state and to be in solid atoms is discussed elsewhere [4]. Conversion of gas state carbon atom into different states carbon atoms along with binding of identical state carbon atoms is also discussed [5].

4. Conclusions

This is the provision of solid atom just recovering the transition state allocates energy knot belonging to suitable unfilled state of outer ring to clamp certain filled state electron of gas atom when just recovering the transition state, also. The reacting of gas atom while ground point just at ground surface (instead of at above ground surface) is because of increased orientating gravitational force where potential energy of electrons is increased under the increased expansion of lattice. The reacting of metallic atom while the ground point just at ground surface (instead of at below ground surface) is because of decreased orientating gravitational force where potential energy of electrons is decreased under the decreased expansion of lattice. This results into the binding of two different nature atoms at a common ground point, which is the mid of ground points of gas atom and solid atom when in their original state behavior, thus, engage force as per involved energy to sustain binding to work as a hard coating.

The underlying science of developing hard coating is in the manner that atoms of solid behavior perform negative work when undertaking the certain transition state as they attain ground points at the level of ground surface (instead of being at below ground surface) and atoms of gas behavior perform positive work as they attain ground points at the level of ground surface (instead of being at above ground surface). To develop hard coating, gas atoms when just recovering transition under increased orientating gravitational force (exerting at electron level) expanded lattice to react solid atoms of contracted lattice when just recovering transition under decreased orientating gravitational force (exerting at electron level).

Transition metals govern hard features of coating under affinity to gas atoms because, one is dealing the force of grounded format and other is dealing the force of space format resulting into locate their common ground points having mid-points at the level of ground surface. The electron of outer ring belonging to gas atom (N-atom) reacts to develop TiN where deal another clamp of energy knot clamped by the unfilled state of outer ring belonging to solid atom (Ti-atom). In gas atoms, when dealing the certain transition state, their electrons increase the orientating gravitational force under forcefully decreasing the orientating levitational force, but in solid atoms, when dealing the certain transition state, their electrons decrease the orientating gravitational force under forcefully increasing the orientating levitational force. This turns into bring a certain electron of outer ring belonging to N-atom to orientate under the fixed force of north-side to go for casing of another energy knot clamping unfilled state of outer ring belonging to Ti-atom which orientated under the fixed force also but from the side of substrate surface (south-side).

At the time of recovering transition of Ti-atoms, they are at the substrate surface, thus, react to N-atoms, which are also at substrate surface at the instant of recovering transition. Just the landing Ti-atoms deal less expansion of energy knots clamping electrons which also undertake double clamping of energy knots to their certain electrons by means of energy knots clamping certain unfilled states of Ti-atoms already landed where extended level expansion of their lattices. This results into devise the unit (primitive) cell of hard coating under their appropriate coinciding. Hard coating infers opposite description in force-energy behaviors of solid atoms and gas atoms where they enable binding at the instant of recovering certain acquired transitions. This results into deal nitrogen more like at interstitial positions of Ti-atoms. This is the cause that hard coating presents increased elastic behavior and the decreased plastic behavior.

Appropriate vacuum conditions and high power enhance the hardness level of deposited coatings. Hard coatings introduce certain properties and application due to the developing of non-regular structure where non-conservative energies involve, thus, engaging the non-conservative forces to sustain their structure. But, they are not overwhelming forever where force-energy behaviors are changed largely, and lifetime of hard coatings depends on their developing strategies along with the scope of their application and usage. Thus, hard coatings are inventing new science for opening many areas of research at purely fresh grounds. In line with this, deposition of hard coatings along with other ones requires re-consideration to explain their science and technology.

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Authors' biography:

Mubarak Ali graduated from University of the Punjab with B.Sc. (Phys& Maths) in 1996 and M.Sc. Materials Science with distinction at Bahauddin Zakariya University, Multan, Pakistan (1998); thesis work completed at Quaid-i-Azam University Islamabad. He gained Ph.D. in Mechanical Engineering from 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 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 Government of Pakistan, but he couldn't avail. He is author of several articles available at https://scholar.google.com.pk/citations?hl=en&user=UYjvhDwAAAAJ, https://www.researchgate.net/profile/Mubarak_Ali5.

Dr Esah Hamzah is a senior standing Professor at Universiti Teknologi Malaysia in the Faculty of Mechanical Engineering. Dr Esah obtained her BSc degree from the University of Wales at Swansea, UK, and MSc and PhD in Metallurgy from the University of Manchester Institute of Science and Technology (U.M.I.S.T.) UK. She has over 30 years of experience in teaching the undergraduate and postgraduate courses related to metallurgy and materials engineering. She has also supervised both masters and PhD students and has served as an examiner for MSc and PhD theses. She has held various administrative positions at the Universiti Teknologi Malaysia and remained Head of Department (1999-2005) and Deputy Dean (Academics) of the Faculty of Mechanical Engineering (2005-2010). She has been actively involved in research namely in the areas of phase transformation and mechanical behavior of metals, metal failure, corrosion and coating. She has been awarded many research grants from the University and the Malaysian Government. She has also presented and published more than 200 papers in the national and international conferences and journals. Some of her papers won the "Best Paper" award at various International events. She is also a contributor to the University's Best Publication Award won by the Faculty of Mechanical Engineering in series of years along with Excellent Service for the year 1993 and the University Excellence Award in 2000, 2003 and 2007. Dr Esah is an active Council Member, charted engineer, and in pioneering Fellow members of the Institute of Materials Malaysia (IMM).

Dr. Mohd Radzi Mohd Toff is a General Manager at Advanced Materials Research Centre (AMREC), SIRIM BHD, Malaysia and prior to that worked as head of coating technology group at AMREC and principal scientist. He graduated from Universiti Kebangsaan Malaysian (UKM) and earned PhD in Chemical Engineering from The University of Sheffield, UK.