Chapter

Introductory Chapter: Assorted Dimensional Reconfigurable Materials

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1. New trends in futuristic 2D material matrixes: to graphene and beyond it

The reconfigured matrixes begin a crucial research domain, as it is a need and necessity of new materials to crack challenges in domestic, food-packing industry, environment, computer, engineering and technological for twenty-first century and beyond [1]. Functional material matrixes play a major role in tackling such confronts, solution to the harmful environmental pollution, for light-weight aerocraft components, sustainable constructions, energy-generation/storage, food-packaging, and space journey [1, 2]. Finding of materials endure non-stop R&D as growth and usage of novel multifunctional materials is quite vast. Identifying the worth and prospective of functionality for the progress of futuristic materials, global researchers ever explores many materials milieu. Without doubt, lots of fields apprehend merit of functional reinforcements in materials to derive varied utility including nanotechnology, shape memory, ferroelectric, electronic, thermal, conductor, insulator, opto-electric, magnetic, phase-change and biology [1–3]. Science and technological progressions were persistent from past few millenniums and amplify with great tempo in twenty-first century. In this advanced nanotechnology era discovery of more practical and sustainable novel materials are significantly augmented.

Profuse 2D materials can capably alter into splendid matrixes in practical mode with innate development in nano-scale and atomic-level applications [4]. Graphene's 2D skeleton has inspired great interests in reinforcement of many 2D/3D templates famed as recent "alchemy" attempts to modify all possible periodic table elements into creative and applied matrixes. Such reconfigured 2D/3D matrixes endowed diverse devices, tools and gadgets leads to finer quality and superior optical encoder outputs for assorted industrial usages. Yet, core stability and large size restraints applicability of graphene, which can be overcome by some changes like functionalization and substrate-based reinforcement in 2D frameworks. 2D/3D materials seek special innovations to correct limiting features through synthetic reconfigurations due for device-production approach like hetero-structure advancements being practical for novel applications and opportunities [5]. Introductory chapter is an overview of recent avenues for 2D/3D matrix owing assorted alterations, reconfigurations and designing to get diversified applications in advancement of S&T in twenty-first century.

2. Modern matrixes in development of S&T

New matrixes owing manipulated modern functionalities yield through reconfigurations offer progressive applications in S&T. Many comprehend materials endure in matrix reinforcement through precise and rational designing can endow novel characteristics as missing in usual materials. Modern science and nano-technology assisted diverse reconfigurations in material skeleton so as to produce assorted nano-materials, decisive-particles, species and devices both at atomic and molecular levels [5]. Logical reconfigurations in material cut down its spatial dimension in local crystallographic phases via augmented features including mechanical, physical, chemical, thermal, optical, electrical, electronic and rheological. Many reconfigured matrixes own mentioned nano-porous frameworks as zero dimensional/3D (particle, grain; shell; capsule; ring; colloidal), one dimensional/2D (quasi crystal, nano-rod; filament; tube; quantum wire) and two dimensional/1D (disc; platelet; ultrathin film; super lattice; quantum well/dot). Nowadays, many 1D/2D/3D matrixes like graphene, germanene, silicene, carbide, nitride, MXene, spintronic, etc. are employed in creation of advance devices and tools as reconfigured through respirocyte, nano-dendrimer micelle, drug conjugate, carbon nanotube, quantum-dot/well [1–6].

3. Reconfigured magnetic 2D materials beyond graphene

Graphene is mere a tip of iceberg and finding of optional 2D materials like metal oxides, metal hydroxides and chalcogenides and metal-organic framework is the opening to spot rest of whole iceberg. Magnetic materials hold significance in diverse fields such as; data storage, electronic, and bio-medical. Many 2D materials like, h-BN, metal dichalcogenide, metal hydroxide and carbon nitride are reconfigured via attenuated features like strain, void, defect/vacancy, tangible magnetism, doping, adatom, dangling and bond induce low-dimensional magnetism [5, 6]. Certain layered material like $CrXTe_3$, CrI_3, trisulfide and 2D metal oxide such as MoO_3, $Ni(OH)_2$ beside perovskites viz.; $CaTiO_3$ ($^{XII}A^{2+}{}^{VI}B^{4+}X^{2-}{}_3$) are reinforced through unusual strain-and-layer govern anisotropic magnetic ordering [4–6]. A few framed matrixes hold extra degree of freedom called valley state are best reinforced with precise tasks like spintronics, and photoelectronic potential to be employed for fast processing and huge data storage next-generation devices [6]. Diverse reconfigured 2D matrixes show quasi magnetism induced between few-atom-thick layers, e.g., MXene, metal-organic framework, metal carbide, nitride and carbo-nitride. Lots of synthetic reinforcement are feasible in 3D lattice which consumes innate crystalline imperfections like interfacial-defect, interstitial ion, substitution impurity, imperfection, dislocation in order to tackle the exigent dimensional and structural changes.

4. Metal-organic frameworks (MOFs)

Metal organic framework is a matrix reinforced with organic linker amid metal node own unique features like, huge surface area, great porosity, tuneable pore-size and lithe functionality leads to various modern and multi-functional utility in S&T [1–6]. MOFs advanced usages includes gas-storage, oil-water separations, hetero-catalysts, sensors, proton-conductivity and biomedicines. Past few decades have reconfigured many matrixes to establish strong perceptive in buildup of progressive MOFs for desired utilities. Advance MOFs are formulated as periodic, convenient,

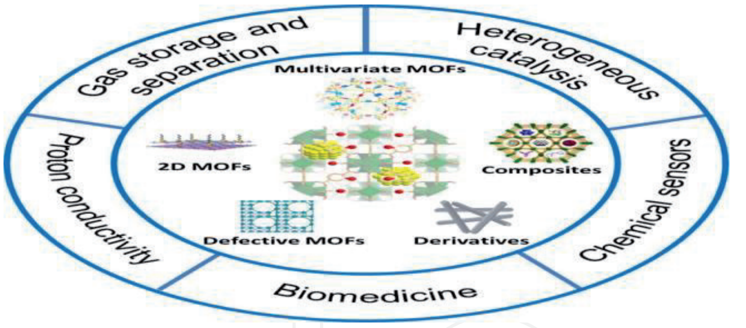

Figure 1.
Possible utility of metal-organic frameworks (MOFs) in S&T.

nano-scaled matrixes owing large specific surface area from single/grouped metal which leads to diverse applications including organic strut, linker, ligand, sensor, marker, gas/energy-storage, CO_2 confiscation, electro-catalysis, and drug delivery besides filtration, oil-spillage/radioactive sludge clearance. Reconfigured MOFs have prospective tasks in tackling critical issues in the future era. MOFs have creditable control on movement of one moiety in concern to another as best for exploitation in separation and catalysis beside own innate ability of holding precise molecules being practicable for chemisorptions, high and low-pressure adsorption testing besides storage. Such capacities in MOFs are derived honestly through reconfigured internal skeletons, so careful and precise investigations get invoked for progressive matrixes offering characterized functions. MOFs owe unique features like surface strengths and molecular interactions need to reconfigure for native functionality like hydrophobicity, hydrophilicity and superior catalytic activity. Possible utility of MOFs in S&T as shown in **Figure 1** includes testing many gases like NOx, H_2S and SO_2 and volatile organic compound with control repeatability.

5. Formulated liquid metal matrix

Binghamton University, USA have formulated such liquid metal lattices embraced mutually via silicone covering which crushing/heating get back to its native form [4]. Many liquid metal matrixes are reconfigured to discover myriad applications including soft optoelectronics, liquid metal robots, foldable antennas and aerospaces, etc. Caltech Institute, California, have developed amorphous liquid-metal alloy called Vitreloy (trade name) in 2003, for making industrial things, golf-club, watch and cell-phone covers [6]. First liquid metal lattice was reinforced in rubber shell as fields alloy from bismuth, indium, and tin metal leads to superior usages like; portable/grid energy-store, rechargeable battery electrodes nuclear plants/reactor coolant, 3D printing, vacuum casting and electronic circuitry as shown in **Figure 2**. They owe pied characteristics like high tensile strength, deformability, corrosion resistive, electronic conductance, superior electrochemistry and anti-wear capacity thus provides conformal coat/guard against humidity, dirt, chemicals and temperature. Some liquid metal matrixes are amorphous at NTP and induce heat during its processing thus workable as substitute to thermoplastics [7].

Some liquid metal matrixes are safe, sturdy and suck huge energy on crushing, besides regain usual shape after heating/cooling, thus reuse without further processing as shown in **Figure 3**. Many liquid metal matrix tenders great prospect to NASA satellite missions, space-crafts and rockets as designer can group “spider web” into tiny package being easy to open out as transmitter in rotator orbits [6, 7] (occupy less area onboard vessel, expand on lands at target). Scientists fabricate

Figure 2.
Room-temperature liquid metal alloy matrix for flexible battery/energy store.

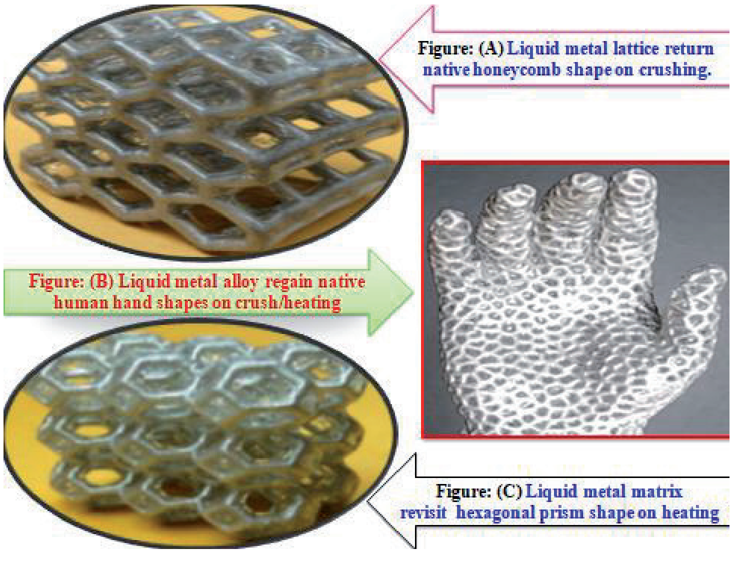

Figure 3.
Some liquid metal matrixes/lattices retrieve native shape on crushing/heating.

an interplanetary ship using designed liquid metal matrixes inbuilt cushion owing spacecraft with crashing chance on planetary landing, since liquid metal absorbs energy and gets deformed but regains innate shape on heating later can be reused [8].

6. Notable reinforcements in 2D graphene

Graphene own long strands of carbon, thin than hairs are stiff and strong which is often used in making stronger synthetic carbon fibers [9]. Experimental studies and computer simulations have confirmed significance of matrixes reconfigured through lightweight, vigor material called 2D graphene carbon-fibers. Although, carbon-fiber is expensive, its reinforced matrix imparts superior safety in fabricated products like light weight-cars, equipment, gadgets and mainstay of aeroplanes. Trace graphene amount 0.08% w/w reinforced carbon fiber offers 225% larger strength and 184% greater stiffness over PAN-derived fibers. Thus, needs to exploit viability of graphene in making advanced and reconfigured carbon fibers from cheaper precursors, in order to reduce production cost even less. 2D graphene reinforcement produces robust fiber matrixes owing high strength and low manufacturing cost, since usual method uses costly polyacrylonitrile/PAN which enhances 50% cost due to energy inputs [9]. Graphene's planar topology aids constitutional alignment all through the resultant carbon fiber, helps reconfigured matrix to squeeze around its edges. Graphene is the strongest known 2D material, but many 3D structures are reconfigured owing unique features such as highly porous, 10 times strengthen than steel, and quite lighter spongy composites/matrixes are achieved through advanced nanotechnology techniques. 2D graphene owes robust skeleton/matrix owing many incredible characteristics, except its innate thinness is incompatible in ensuing 3D matrixes. But, this graphene is prone to diverse artificial alterations in geometric configurations due to reinforcements of assorted materials (like synthetic/natural polymers, metal/non-metals and inorganic) that yields varied 3D matrixes.

Rice University, USA have developed laser-induced graphenes/LIG which shoed labeling ability onto many edible material surfaces including toast, coconuts and potatoes. Multiple laser induce graphene-foam seize cross-linked 2D carbon flake aids marking materials thus leads unique function in numerous fields like supercapacitors, fuel-cells electro-catalyst, RF-recognition antenna and bio-sensors/markers. LIG can turn into paper, cardboard, cloth, coal, and foods beside acts as tag/sensor for *E. coli* bacteria detection. Laser-induce graphene (LIG) foams can reinforced with polystyrene, plastic, rubber, cement, wax materials which tendered smart and robust packaging as significant in many field applications like wearable/flexible electronics, heat-therapy, water cleansing, anti-ice/de-ice shell, antimicrobial surface design and resistive random-access memory devices. LIG in laser burns thin polyimide sheets and yields intercalated graphene flakes which appeared alternative to woods. Many 3D matrixes are sculpted through reinforcement of 2D graphene foam aids blending with many functional composites/bio-composites and emerged vital module to create dynamic objects in electronic, ultra-hydrophobic medical equipment and textiles.

LIG layered 20 μm-thickness electrodes kill bacteria and prevent microbial fouling through antimicrobial action demonstrate several applications like water treatments, hospitals and seawater pipes exemplify surfaces as liable to bio-fouling [10]. LIG reinforced organic additives yield composites expand the range of green and sustainable applications like biomedical films, nanogenerators, puncture detectors, de-icing/anti-ice coats, flexible heating pad and pre-command heat-up garments. Graphene reinforcement in powder sugar and nickel yields foam which is further use to develop novel objects/feedstock for 3D printing/imaging. 2D graphene reinforced carbon nanotube yield 3000 times load supportive 3D rebar framework which is ultra-strong, conductive and protect innate shape best for designing aircraft, battery de-icing nanoopto-electronic, and tissue/bone-implant materials. Laser sintered technique reinforces nitrogen/sulfur in graphene to yield fingertip-block rebar foams carrying 3D matrixes show use in energy storage/damp and sound absorptions [10, 11].

6.1 Reinforced quantum matrixes

Firm quantum matrixes are reconfigured to avail innovative opportunities were unknown earlier [12]. Several metal alloys show surprising performance for traversing potential in 'spin liquid states' as investigative mapping of such quantum materials criticality has established a traveler traverse the final frontier. Here, traveler is metallic-alloy owing ordered constituents following parallel paths which gets altered with applied pressure, temperature and magnetic field, thus knowing concern electron's behavior. Certain *reinforced quantum material matrixes* own self-assembled, tuneable interfaces as observed in plotted journey in their order to disorder pattern. Anti-ferromagnetic interfaces cross solitary border in adjacent zone and marked as paramagnetic materials due to harmony amid trillions of electron amending mutual position. Some reinforced matrixes follow such quantum criticality and it is easy to analyze relative phase changes. Liquid metal alloy acts like of spin liquid, though metallic stress yields quantum matrix. Reconfigured metal alloys are used to study weird electronic excitation that aids designing of high-temperature superconducting quantum materials. Assorted self-assembled, tuneable interfaces are reinforced in quantum materials which have revolutionized modern device developments and thrust innovative highly adoptable electronic devices afar present imagination. In fact quantum materials are more complex than conventional semiconductors; thus lay great task in designing of clean interfaces through advanced designing. Research has revealed incredibly improved and novel functional characteristics arise amongst interfaces of reinforced quantum materials.

Advance techniques yield diverse liquid metal-alloy/matrix that leads to offer designed native electrical features being at par/superior to familiar semiconductors. Certain reinforced metal matrixes have shown incessant shift from metal to semiconductor on varying thermodynamic conditions such as density, admix proportion/ratio and temperature. Some synthetic matrixes like liquid selenium and Cs-Au liquid-alloy are develop with switch metallic-semiconducting performance due to altered native chemical interactions/configuration. Liquid gallium is reconfigured via tri-block organic-copolymer as void elastomeric matrix offering superb electric conductance besides solid to liquid phase changes on small melting being best feedstock to yield ultra-stretched shape memory fibers. Reinforcement induces solidified core transformation in liquid-gallium imparting better stiffness and great deform shape with fiber modulus change (from 4 MPa to 1253 MPa). Elastic energy hoard is seen in such hollow shell of liquid gallium during deformation which relaxes elastomeric fiber and regain usual shape on small heating, thus endowed shape memory features. In fact gallium is used to make shape memory fibers due to many valuable features like; good metal framework, improved electric/heat conductance, ideal fixity and adjustable effectual modulus. Low melting alloys are reconfigured as fusible matrixes permitting metal to reshape into liquid/semi-solid state at low temperatures with subsequent re-solidification. Malleable and elastomeric conductive fibers are reconfigured for opted rigidity and variable shape memory modulus which offered outstanding utilities in flexible electronics, soft robotics, and wearable devices. Many reinforced fibers are crafted in complex geometry via twisting and angular parting which provides deformation with preserved electrical continuity in resultant matrixes. The qualitative properties of material controls reinforcement of matrix and direct designing of various parts, equipment and products for industrial/practical usages. Throughout matrix reinforcements the constituting materials get adjoined and casted to design templates without collapsing further. Nano-technologically brings lithe reinforcements even at molecular level by stirring strong electrical interconnecting targets, so lay basis for assorted matrixes to be used in flexible electronics, light-weight aerospace components and robotics.

Some reinforced matrix seizes magnetic moment allied in unlike directions but parallel to interfaces (unconcern to close-set electrons) lack magnetism due to shielding/screening. Theoretical modeling is use to reinforce complex competitive interactions at quantum levels in such reinforced matrixes. Neutron spectroscopy also illustrated such interactions in metal matrix viable for impulsive pattern wherein electronic and magnetic characters get swapped periodically. Periodic array can attend interfaces amongst swapping layers akin to interfaces seen in reconfigured hetero-structure. Auto/self assembled interfaces attain through quantum engineering impart clean in-situ interface-width directed through applied magnetic field and temperature. Many reconfigured matrixes shown remarkable features like retrieve energy absorption, adjustable rigidity and elasticity and gifted various advance applicability in designing web-mesh antenna, aerospace, soft-robotic,

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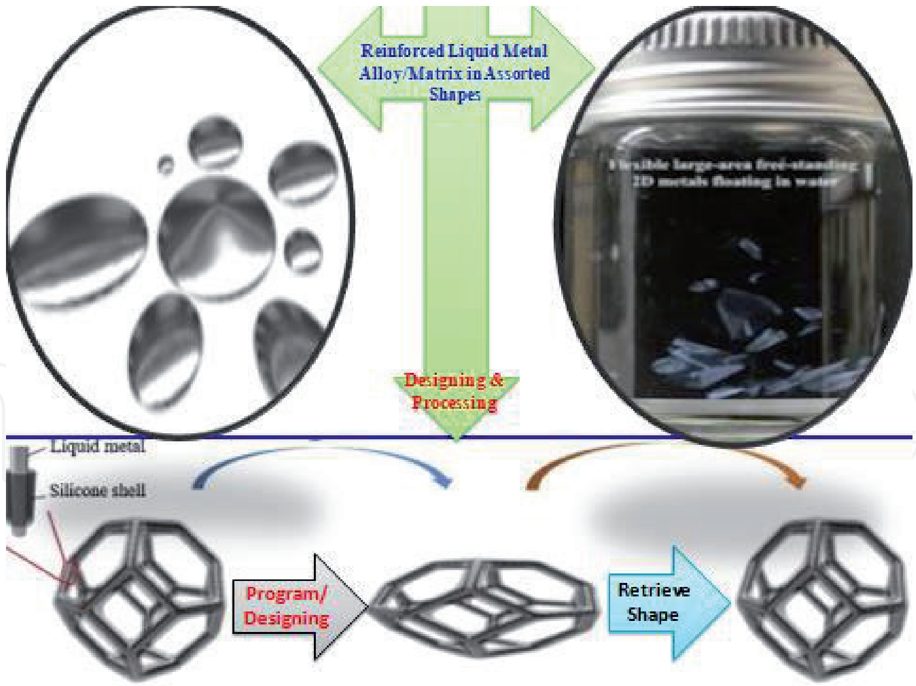

Figure 4.
Multifunctional liquid metal matrixes yield through hybrid design/built-up.

meta-material, 3D printing, flexible electronic and coolant for nuclear reactor [13]. Many multifunctional liquid metal matrixes/alloys we obtained via hybrid design/built-up method as shown in **Figure 4**.

7. Specially reconfigured 2D metals

2D matrix owes single-layer pattern of crystalline materials owing distinct physical and chemical features leading to assorted applications like photovoltaic, semiconductor, electrode, water-oil separation/purification, marker, bio-sensor, etc. [14]. Amid 2D matrixes self-supporting metallic matrix is very hard to obtain due to involvement of characteristics 3D structural bonding. Top-down/bottom-up synthetic approach produces self-supported single-layer 2D metal matrixes owing surface controlled properties and stability <2 nm cross-section, but giant films size and range are limited. Wet-chemical paths yield bulk 2D metal matrix, while few atomic layer reinforcements are obtained via mechanical exfoliation (metal's tiny plane size is lesser than few micrometer). Indeed it is very tricky task to create bulky 2D metallic frameworks as large as and as chemically complex as 3D matrix. Facile reinforcements are obtained through advance nanotechnology are best employed in mechanical devices. Vapor deposition technique has re-configured coating of thin metallic layers at the apex of hydro-gel substrates yielding swallow/deform exfoliated films. In-plane dimension/chemical composition method has reconfigured much precious freestanding 2D nanomembrane without physical margin viz.; Ti-metallic films, more entropy alloy FeCoNiCrNb and metal-glass ZrCuAlNi, non-layered ceramics, semiconductors, polymers, composites [15]. These reinforced 2D matrixes owe 3D chemically complexity and pave a path to unknown remarkable world of low-dimensional matrixes lead to novel usages including soft robotic, flexible electronic, filtration, bio-composite and bio-engineering. Certain low dimensional self-supportive metallic/non-metallic membranes are reinforced for restricted plane size <10 μm, but polymer exfoliated folding yields apt geometry/morphology as chemically complex as 3D matrixes owing surface induced physic-chemical characteristics as shown in **Table 1**. Such freestanding material matrixes gained terrific interests due to distinct nano-skeleton and shrink dimensionality, special physico-chemical features and indent modern applications. Reconfigured 2D metal system hold inherently bonding akin to 3D scale, thus emerged as thermodynamically stable atypical single layer (cross-size <2 nm) matrixes. Tiny 2D metal matrixes are tricky for practical applications, while steady high surface-volume reinforcement augment innate thickness from 0.8 nm to 50 nm and lateral dimension from 20 nm to 8000 nm with aspect ratio from 10 to 1000, thus defeats thermodynamic stability barrier. Despite geometry/morphology restraints reconfigured 2D metal matrix showed unusual features like eminent electrical/heat conductance, great flexibility and proactive surface which is best for flexible electronics and clean energy production. Reinforced 2D Au/Ag-Bi metal matrixes shows profound surface plasmon resonance being best for LSPR-sensors applications.

Bottom-up mechanical compression, nanolithography, top-down solution-base chemical methods are used in reinforcement of 2D metal alloy and glass in bulk amounts. Assorted synthetic reinforcements are used to direct geometry of 2D metal matrixes as nano-sheets, membranes and films. Masking agent also controls film deposition and results desired shape 2D surfaces like Ag-C matrix, ultra-thin nano-TiO_2 sheet, silicon nano-sheet, high entropy alloy, ZrCuAlNi, and SiC ceramic.

PolySlide Company yields reinforced composite-tubes and optional metallic feedstock to be used in making of pneumatic and hydraulic cylinders. PolySlide tubes are blend of filament-glass fiber with resins due for unusual aspects like dynamic component, non-conductive, good dimensional stability, non-corrosive and impingement resistance beside sustainability at extreme conditions viz.; high/low temperature, oil/grease, grit, salt and acid/base chemicals. Such reinforced cylinder owes size range from 0.25-in. inner diameter till industrial grade 24-in. diameter. PolySlide tubing found to prevent galling which let sealing slide over applied surface contour and reduces knit friction. Some reinforcements are derived through frameworks like wound glass-fiber, resin and polytetrafluoroethylene in many matrixes viz.; composite tubing, bearing and pneumatic cylinder. Such matrixes are preferred over metals due to unique features like huge load-bearing capacity, little friction, non-corrosive, resistant, self-lubricant and no-greasing. Reinforced matrixes reinstate metal usages for making special things like building equipment, mining/farming wheels, compact track loader, excavator, back-hoes implement, applicator, cart and spreaders [15].

Reconfigured methods	**Metal used**	**Thickness (nm)**	**Lateral size (nm)**	**Aspect ratio**
Confine growth method using organic ligands	Palladium	0.8	100–200	100–200
	Silver	2	500	250
	Copper	2	20	~10
2D milieu-confined growth	Gold	2.4	200–500	80–200
Hydrothermal	Rhodium	0.4	500–600	1000–1500
Nano-particle assembly	Platinum	10	50–100	5–10
Mechanical compression	Aluminum	2	7300	~3500
Exfoliation	Antimony	4	1000	250
PSBEE based 2D process	Titanium dope high alloy/glass, FeCoNiCrNb	10–50	10^4 to 10^7	10^2 to 10^6

Table 1.
Relative analysis of thickness and in-plane dimension of 2D metal matrixes yield via different methods [13, 14].

8. Reincarnated quantum states in 3D materials

Several 3D superconducting quantum materials are reincarnated as electronic "energy stacks" being active at 2D topological surfaces [13]. Every recreated energy stack own special states viable for 2D quantum Hall effect viable for mesoscopic transportation in quasi-1D matrix through maintained parity and time-reversal symmetries (controlled by energy gain and loss). Quantum movement in reincarnated matrix is analyzed by non-Hermitian system only in unbroken phases (not for broken phases) in the energy band using exceptional points. As broken phase allowed spontaneous symmetry states wherein cross-stitch matrix is separated into two identical single lattices equivalent to degenerate eigen states. In quantum phases of matter, intrinsic interfaces exist amongst electrons as quite complex than classical atomic and molecular interactions [16].

Michael Faraday study of light and matter interaction onto thin gold leaf showed faint ruby color fluid production was the first ever reported quantum states, too supported its validity [13–16]. Today quantum physics and computing have certified such quantum things a bit more irony, as formerly noted as unbelievable. Superconductivity is observed in many such reincarnated quantum matrixes such as quark-gluon, simple plasma, degenerate matter, Bose-Einstein condensate and quantum-spin liquid. However, quantum spin liquids are surprising due to never aligned but continuously oscillating electron spins even at the lowest absolute zero (as normal matter's spin get frozen). This quantum spin liquid is valuable and practical reincarnated electronic matter at quantum scale due to superior electronic applications and quantum mechanical impacts. Modern S&T have reconfigured many 1/2/3D materials like ballistic $LaAlO_3/SrTiO_3$ conductors, quantum hall phased graphene-$SrTiO_3$ matrix and magnon stretch graphene being gifted with unique features like planned quantum state, regimented magnetic stimulations and unique electrical conductance [17]. Advanced nanotechnology generates magnon spread viable for quantum Hall effect or ferromagnetism across the bulk path all over graphene reinforced magnetic phases due to survival of 2D excited electron waves at low temperature. Scientists has reinforced prolong spin-wave guides in-out of quantum hall edge channel via electro-magnetically regimented quantum states across insulated anti-ferromagnetic phases of 2D graphene.

In twenty-first century, many properties of quantum nature of matter were either ignored or unknown earlier are ever explored due to endowed applications in many quantum fields including computing, sensing, teleportation, and communication [1, 13–17]. Reincarnated quantum states offer electric potential with fine-tuned state marking transition to topological order along with paternal quantum entanglement as viable for quantum Hall effect through such reconfigured 2D/3D matrixes. Scientists have reincarnated remarkable quantum Hall effect in topological superconductors to be used in futuristic fault-tolerant quantum computers. Reincarnated stable state matrixes own quantum entangled storage and process information which aids creation of quantum computing. Physicists had discovered 2D/3D phased topological materials for quantum hall effect and then reincarnated "energy stacks" of 2D electronic states in 3D superconductors for designing of quantum computing.

9. Reconfigured matrixes for spintronic

Spintronics is a gist of spin transport electronic which engaged in study of electron spin-fields allied magnetic moments as cogitated in semiconductor based electronic transistors and metal derived solid-state devices, since from 1990 (multiferroics akin in insulator) [18]. Spintronic vitally differs from usual electronics, since spin and charge are used as extra degree of freedom for data storage and transfer. Spintronic effect is mainly comprehended in thin magnetic semiconductors and certain magnetic alloys (2:1:1 copper, manganese and tin). Certain opticomagnetic matrixes are reinforced for spintronic including Heusler-alloy like Co_2Mn-Si and more band-gap doped semiconductors like ZnO, TiO_2 to be used in quantum and neuromorphic computing [5]. Spintronic matrixes reconfigured solid-state devices perform electron transportation through spin-fields and charges at quite speedy and inexpensive way due to less energy usages in spin transformations than current production. Manganese-gallium and arsenic non-oxide alloy has designed for unique interfacial resistance and tunnel barrier induce ferromagnetism utilized in quantum and neuromorphic computing. Dzyaloshinskii-Moriya interactive spin orbit torques results robust interfacial magnetic skyrmion through many reinforced polycrystalline/amorphous matrixes like Pt/CoFe/MgO, Pt/Co/AlOx CoFeB and Ta/CoFe/TaOx with chirality govern vertical anisotropic superior ferromagnetism. Novel antiferromagnetic matrix controls skyrmion Hall dynamics and aids certain designing criteria like low damping, great thermal stability, larger voltage ruled magnetic anisotropy, writability at low cost, readability and data storage/transfer being vital in making racetrack memory based skyrmionic devices [19]. Such reinforced matrixes offer lots of incentives in getting high density memory based advanced devices through designed big spin Hall angle and electric field exchange MRAM phenomenon.

10. Graphene for spintronic devices

Graphene offers huge platform for designing spintronic based devices due to native augmented spin-dependent electron transportation with control spin-current effect [20]. Spintronic device own spin-field channels obtained via atomic interactions of randomize electrons thus cart spin signals over transistor-scale. Reconfigured matrixes like Si-Ga-As and graphene generates such field-channels to cart signals with balance energy split amongst up and down spins [19]. But graphene offers remarkable features including big spin-time, strong spin-orbit precession, controlling spin-field swap, suitable spin relaxation path (sinking spin signal integrity) and compel equilibrium being vital in designing wise spintronic circuits/devices. Graphene reinforced cobalt matrix yield electrodes offer good contact and enhance nonlocal spin valve and superior spin transportation without any variation in spin-signals in micro-scale devices [20]. Due to cobalt scattering such graphene derived electrode own unique qualities like collateral interactions, reduce diffusion path and spin-relax alterations which aids carting of spin-signals upto 5 mm distance amongst all tested materials. Graphene-boron nitride reinforced matrix bids superb mechanical, optical, thermal, electric and magnetic properties like huge specific surface area, elevated Young's modulus, duel contact over an air-gap and reduce substrate interactions via self-supported layers being useful for lots of advancements in many fields including photo-electricity, catalysis and transistors. Rise of graphene has modernized technology and structural designs in spintronic/spin-current base devices/circuits including micro-electro-mechanical system (MEMS), energy-harvesting systems, sensors, actuators, ink-jet printers and flexible electronic as scalable silicon alternative. Such graphene reinforced matrixes have also replaced carbon-based nano-electronics and spin-based devices besides ferromagnetic and atomic switches. 2D graphene gave many advanced and novel dimensions to the material matrixes including nano-ribbon and nano-sheets wherein layers shrinks width < 10 nm owing band gap suitable in fabrication of transistor circuits. Assorted technological reinforcements endowed large surface active properties and non-zero band gaps thus makes graphene more beneficial than CNTs in MEMS/new electronic-device in last decade. Graphene derived all-spin logic-single micro/nano-electronics create whole spectrum of spintronic devices (low energy usage) beyond existing technologies. Reinforced graphene matrixes grow many novel applied technologies striking new market and applicability like spintronic and magneto-resistant hard disks are game changers in electronics and optoelectronics by.

10.1 Reconfigurable 2D/3D conjugated polymers

Conjugated polymers enter a new aspect in 2D material matrixes due to unique applicability in flexible electronics and soft robotics. Certain structurally reconfigured 2D conjugated polymers pave innovative growth in material science by virtue of superior electronic parameters [19, 20]. These conjugated polymeric reinforcement yields altered lattice symmetries and structural properties leads to progressive utilities of functional materials beyond graphene. Expertise domains of sciences like organic chemistry, condensed matter physics and nano-materials have teamed up so as to get special designed reconfigured 2D/3D material matrixes offering grand features as guessed hypothetically until now. Polyaniline (PANI) polymer reinforced 3D matrixes are developed for energy storage and induced rate electricity transport in especial gadgets like mobile, electric vehicles and power-grid [21]. PANI reinforced conductive electrodes and supercapacitors stores charge by exchanging electrons with ion through dopant material thus results in large energy storage through "pseudocapacitance" effect. Nano-carbontube is reinforced into PANI matrix to owe capable high energy densities designed for super-capacitor to be used in power storages. Futuristic global energy exploits such reconfigured matrix leading technologies for intermittent storage and high-power delivery devices for effective and broad potential applications.

10.2 Graphene's cousins abet dream to reality

Carbide, nitride, silicene, germanene, stanene, black phosphorus and Zintl phase materials are few known 2D reconfigured matrixes called graphenes cousins offer gifted properties seek for spintronic and quantum computing [19–23].

11. Reinforced polymer/dendrimer matrixes: current and future developments

Reinforced polymer based matrix are futuristic smart materials discovered for the prospective advancement in S&T. Nano-metal doped polymeric matrixes are best to be used as fillers due to designed parameters such as shear stress, shape, size, control-rate, concentration and time dependent non-Newtonian mechanics, shear-thinning and visco-plastic flow controls. Metal reinforced nano-materials own significant tuneable features including rheology as suitable for deriving advanced utilities in photo-voltaic, catalysis, optics, drug career, smart adsorbents and energy-storage devices. Bottom-up, self-directed assembly of polymer block is powerful mean for robust reconfiguration and well manipulation of desired matrixes. Nano-material based polymeric matrixes display amazing characters due to inbuilt atom-by-atom reinforcements being absent in usual bulk counterparts. Assorted dendrimer designing are achieved through click chemistry and nanotechnology, currently discovered promising reinforced polymeric matrixes for progressive S&T. Novel nano-periodic systems acquired for dendrimeric reinforcements through material templates in the form of nano-devices, nano-materials, and nano-medicines. Many commercial products are architecture with designed characteristics via advances dendrimeric reinforcements. Such dendrimer reinforcements transmit ideal nano-structure obtain during repetitive branched monomer iterative protection and de-protection. Rationally reconfigured dendritic matrixes are employed in drug delivery, electro-catalysis and light emitting materials [1, 2]. This novel dendrimer bid base for organic-inorganic hybrid pass on diversified utilities. Hyper-branch dendrimer forms 3D globular, viscous and highly soluble matrixes owing superior features like low-viscosity, high solubility and multi-functionality over linear-branched counterparts. Such reinforced dendritics are beneficial due to innate parameters like elastic, light weight, high resistance, processable, robust, chemical inert and thermal stable. Hyperbranched dendrimeric matrixes hold linear segments with spherical end being adaptable in fabrication of nano-composites like polyamidoamine dope-nanogold, nanocarbon-sols and heterogeneous nanostructures [3]. Click chemistry carried reinforcement aids stimulus detachment in porous dendrimeric links and yields various matrixes including layer-by-layer films, nano-particles, nano-sheets, nano-wires, and nano-tubes and optoelectronic nano-devices [2–4]. Reinforced dendritic matrixes showed peculiar characters like linear/cross-link/chain branching, open functionality; classified topology, co-hybridization and terminal grafting. Flexible dendritic matrixes offered innovative chemical and biology applications in many industries. Dendrimeric polymer owns quite handy size/shape and compartmental zones made-up through hyper-branch and tree-reconfigure templates capable of surface functionalization, mono-dispersions with immense stability make it smart carrier for drugs. Dendrimer derived nano-device have latent value in cancer chemotherapy without stimulated immune side-effects since targeted drug therapy through designed tectodendrimer matrixes (dendrimer unit exhibit assorted role in targeting, disease diagnosis, drug career and imaging) [2]. Boron EGF-reinforced PAMAM matrix own drug targeted cells preferably in intra-tumoral injection. CED-doxorubicin-2,2 bis (hydroxymethyl) propanoic acid reinforced dendrimers dipect in vitro less toxicity in colon carcinoma cells [1–3]. Cationic dendrimers owe more cytotoxicity, cell membrane instability and cell-lysis over anionic dendrimeric-PAMAM matrixes [1–4].

12. Concluding remarks and futuristic developments

2D graphene reinforced many pioneer matrixes have established practical developments in modernization of S&T beside thrusts novel domain of many 2D materials including layered double hydroxides, LAPONITE-clay, boron nitride, black phosphorous, graphitic carbon, carbide, nitride, heavy metal-halide/oxide, perovskite-oxide and polymer [1–4]. Reconfigured matrixes gift unique features like; flexible skeleton, mechanically strong, facile electronic /thermal transportation, zero band-gap, semimetal nature and highly mobile electron driven conductance. Numerous matrixes feed basic need of S&T besides promoting researchers to widen a plethora of 2D/3D materials. Fascinatingly, broad domains of assorted 2D/3D materials are developing everyday and more than 150 remarkable matrixes are reconfigured till date [1, 23]. These matrixes endowed surprising technologies, and innovative findings in many domains including sensor, photo-detector, LED, laser, FET, physics, catalysis, biomedicine, environmental, aerospace and construction. Patented superior outputs at nano-scales and low energy consumption are the key encouragements in electronics hunt for device architectures through such reconfigured 2D/3D materials [1].

Since graphene discovery, scientists have found a series of 2D/3D layered matrixes through reinforced physical and chemical features and thus tackled functional restrictions of 2D materials. Graphene reinforcements aid to replace half of its carbon with other extrinsic atoms and able to derive diverse stacking in 2D/3D matrix/hetero-structure/hybrid owing new/designed properties [2, 23]. Many reconfigured hetero-structures own special features as missing in graphene/other materials and best heir to most popular silicon in electronic devices like solar panels. Scientists are devising optional matrixes to cater skilful demands in energy storage to fix silicon with competent materials. Assorted bulk 2D/3D matrixes of the counter materials are being explored for innate beneficial optoelectronic features due to practical applications at economic scale beside substitutes for outdated technology [1–4].

This introductory chapter is an overview of assorted 2D/3D material matrixes which appeared as alternatives for soft-hard composites and modernize many fields including bio-electronic, optics, drug-therapy, medical product, tissue engineering, battery, super-capacitor, electro-catalyst, adsorbent and aerospace component manufacturing. Intrinsically reinforced matrixes yield through diverse materials found superior than their counterparts by virtue of designed features like better load reassignments, tailored interfaces, strong, heat protection, and impactful solidity viable at low cost with end-use components. Reconfigured material matrixes are promising due to notably attenuated performance utilities and persuade novel advancements in futuristic S&T.

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