Revolutionary Materials
WHY, HOW, Possibilities

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WHY Revolutionary Materials

- Brilliant [incl. AI] and Multifunctional on steroids without the usual increased costs, weight, maintenance and performance reductions
- The “usual”, 10X improvements in weight, cost, performance
- Room-Temperature Superconducting
- Ever smaller, cheaper, lower energy utilization computing, sensors, IT, Storage
- DIY on steroids, make everything, anything at home
- Protection from corrosion, hydrogen, radiation, etc.…

WHY - Continued

- Energy / Storage [>70% efficient Photo Voltaics, Storage in structures/ skins, Li/air & solid state batteries, hydrogen storage, ….]
- Health management including autonomous detection and repair
- SUSTAINABILITY, Green, including processing, reusability/ reprocessing/ recyclable
- Alternatives to Rare Earths
- Decoherence Control for Quantum Technology
- IT protection from EMP
- IT/Electro-optics/sensing/energy harvesting as an integral part of Everything
- Brilliant, multifunctional, lightweight inflatables, membranes for everything aerospace, including aircraft wings

HOW – Tools and Approaches

- HPC/ Quantum Computing for ab-initio material design at the Atomistic/ quantum scale, Including AI "Optimization"
- "Printing", down to Molecular Scales, enables unique efficient fabrication capabilities, superb microstructure
- Mod-Sim, Computation for faster Material R&D – to - Certification
- Meta-Materials writ large
- LENR Transmutations, including to create Rare Earths, convert "Pollutants"
- Nano Science/ Technology Writ Large

HOW - Continued

- SBER [Structural/ Strain Bond Energy Release], shear/ compression to collapse Band Gaps, E^3 faster and cold chemistry
- Sensors/ Instruments down to the atomistic level [~100 T Networked Sensors in ~ a decade]
- Systems of systems material design, materials as unique engineered piece-parts
- Syn.Bio – Bio materials, Bio production and functionalism
- Tailorable cellular substructures, e.g., tetrahedrons, foams
- Molecular Machines
- Biomimetics, including from quantum bio
- Nano Plasmas in solids
- Active control of material properties, programmable matter

LENR [Low Energy Nuclear Reactions]

- Originally in late 80's termed Cold Fusion, which it is not….
- Now, some 30 years of world wide research producing heat and **transmutations** , far in excess of "chemical"
- Causative, enabling physics not yet proven, agreed to, needed to scale, engineer, make safe
- "Best Bet" Physics is the weak force, collective effects, enabled by energy concentration at nano surface morphology sites
- This theory indicates E^3 to E^5 times Chemical and internal IR triggering after initiation

Revolutionary Materials Possibilities – AKA “Materials Dreams”

- Superb Microstructure via Nano or better printing, reduced dislocation/ grain boundary issues, 5X thus far, at high temperatures, potential up to O[20x], Massive Potential Commercial/ Technology Impacts
- Composites at some 11X Aluminium

Materials Processing

- Alters the shape and/or the composition/properties of a material or an object, “transformation of input materials into a product”
- In the current/ conventional case produces inclusions, dislocations, micro cracks which degrades strength by a factor of up to 20.
- Is shifting in real time from “cutting” to Accretion
- Is far more of an empirical art than a scientific technology [e.g., physics/ chemistry of nano tube formation still unknown]

The Usual Materials Processing Approaches

- Thermal, incl. via lasers
- Chemical
- Pressure
- Impact
- Microwave
- Ion Beam
- Mechanical “Cutting”/Shear
- Ultrasound
- Microgravity
- Explosive Forming/ Shock Waves
- ‘Flow” Processes
- Electric Fields

Revolutionary Materials Processing Approaches

- Controlling material properties at the NANO Scale……By assembling at the Nano scale
- ‘Printing” writ large, any way or how, “additive manufacturing” [on the way to atom-by-atom Molecular Manufacturing]
- Production of “Nano Tubes”, other Nano Materials, e.g., Graphene etc.
- Others - Ionizing Radiation, High Strength Magnetics, Plasma, Bio processes, LENR
- Quantum State Modifications

The usual, current approach to materials processing is to utilize one or perhaps two of the techniques. There were no extant cases discovered wherein many multiple [up to the some 17 methods currently available] were applied either sequentially or simultaneously.

There are some 17! Possible combinatorials.

Such combinations could/ should produce materials with quite different and possibly interesting properties, worth exploring this terra incognita, both experimentally **and computationally**…….

As an example of what combinational processing approaches can produce, the combination of shear and compression has [from both theory and experiment] collapsed electronic band gaps and produced materials with several orders of magnitude faster , and cold, chemistry, a superb spark plug.This field of energetics is termed Structural or Strain Bond Energy Release [SBER]. Also, such combinations produce, for cracks, E-M emissions suitable for NDE evaluation, used on assembly lines in parts of Asia, also to detect earthquakes, sub detection, Overall – Bandgap Engineering

Some Potential Materials Processing Serious Desirements/ Revolutionary Outcomes

- Structural Nano tubes, contiguous tube assemblages that exhibit the strength of the individual tubes, order[s] of magnitude above that of usual materials.
- “Ageless Materials”, Resultant materials which lack the usual collection of dislocations, nano cracks, inclusions etc. that degrade the properties of conventional materials.
- Trabecular Bird Bone , other biomimetic derived structural approaches

Potential Ways Forward for Structural Nano Tubes

- Determine the physics, chemistry etc of the nano tube formative processes and investigate such for potential alterations which could produce far better materials than the current nano tube composites
- Combinational Materials Processing approaches, Which/ What TBD
- “Zipper Mechanism”, Stone-Wales bond rearrangements [rotations], merging of smaller tubes into larger ones
- Applying Electron Beams at elevated Temperature, Frenkel pair defects/ covalent links
- Interstitial B atoms, acting as “atomic Welders”…..
- Combined external stimuli/ tuned molecular designs
- Carbon-Carbon Bonds

In the process of conducting such Revolutionary Materials Processing research, which is on the frontiers of the current SOA, we should discover, stumble over, unearth, produce materials with very different and possibly extremely useful properties, characteristics. [Ala Goodyear and his discovery of the vulcanization of rubber]. Need to, for each new combinational result, determine the characteristics of the resultant materials.

Of Interest….

- DARPA ‘Atoms to Product” Project, Creating Manufacturing, Materials processing approaches between Nano and current industrial practice[E-9 to E-3 meters].
- The Livermore and MIT work / others, creating/ Printing assemblages of ever smaller discrete structural elements [ordered micro-structure]
- Materials “design” [and fabrication?] at the Quantum level - Via machine learning technologies/ “Big Data”

Application of AI to Mod-Sim creation of Revolutionary Materials

- The hard problem here is the requisite training data [errors, lack of resolution, disparate sensors detecting disparate quantities, Incompleteness]
- Small changes in initial, B.Cs in the data sets could in highly non-linear situations , hypersensitive processes, change much, therefore need superb knowledge of initial, boundary conditions for the data sets. [Poster child is tens of Molecules changing surface chemistry wrt fibers in composites/ debonding]

Some Additional Opportunities wrt Materials Design/ Processing - 1

- Syn Bio/ Bio extraction, processing, fabrication/ products
- NASA ARC has excellent efforts on all aspects of this putative “New Age” in materials.
- If utilize for Mars ISRU can adopt the Russian Design approach of clunky, add thickness/ weight where needed as do not have to haul the stuff from Earth.

Some Additional Opportunities wrt Materials Design/ Processing - 2

- Produce multifunctional materials that , instead of degrading, IMPROVES the material performance/ cost/weight/maintenance, as add structural strength/ endurance, sensing, actuation, computing, energy storage [chemicals, electrical]
- Graphene writ large – “strength” [MIT, 10x], Electronics, Holey for Lithium/air Batteries, Rm/ Temp. S-C, ETC….
- Reusable TPS – Bi-Metallic Strips backed by water, which oozes out as needed, could not discolor.....
- Metastable Materials, Layered Materials
- Graphene Aerogels - Huge weight Reduction

We have Barely Emerged From The Medieval , Electron Based/Blacksmith Days

- We can increasingly design and Fab Materials Atomistically
- Incorporate, sans decrements, the Multi-functionality of living entities material systems
- The universes of Quantum Technologies and new/ many multiple processing approaches lie before us
- We can/ will empower individuals as materials inventors, designers, fabricators [DIY on steroids]