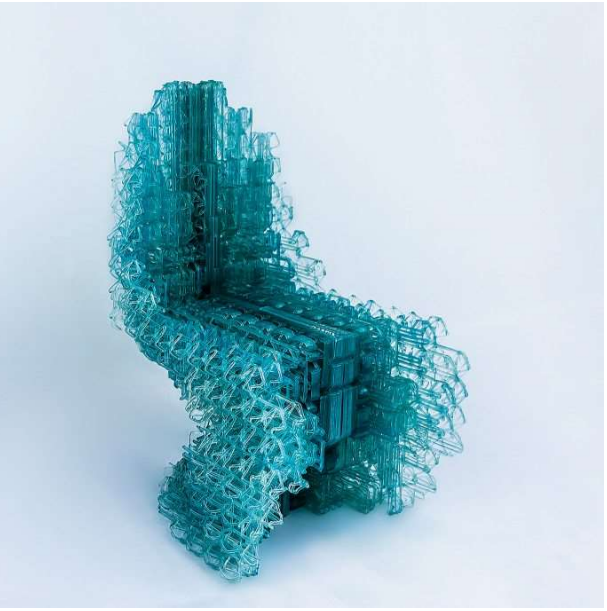
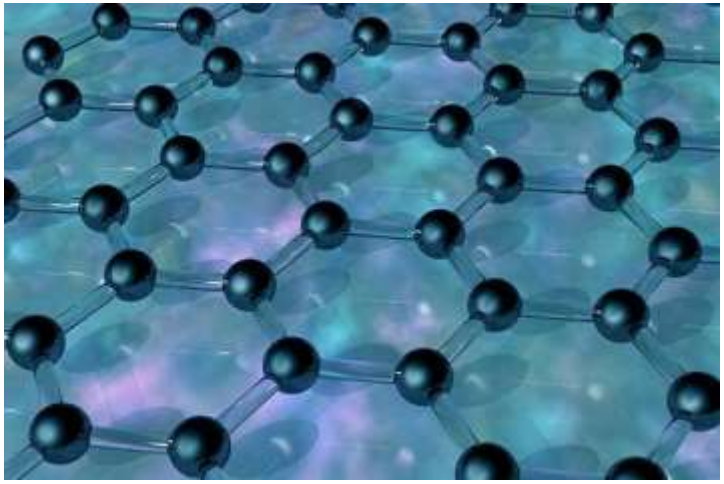
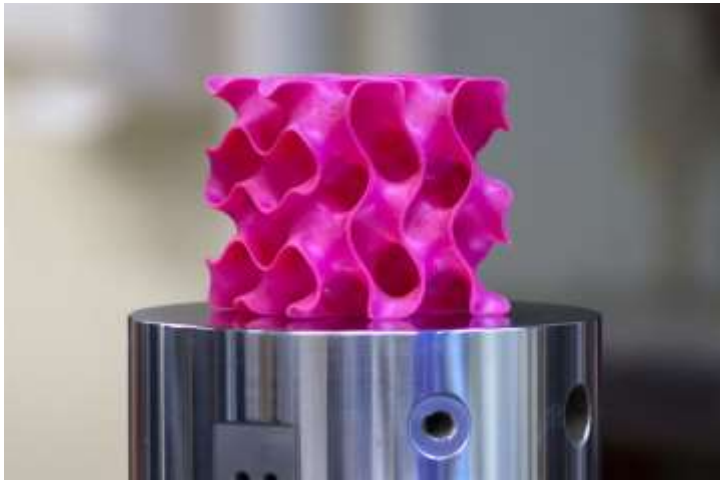
AMAZING NEW MATERIALS





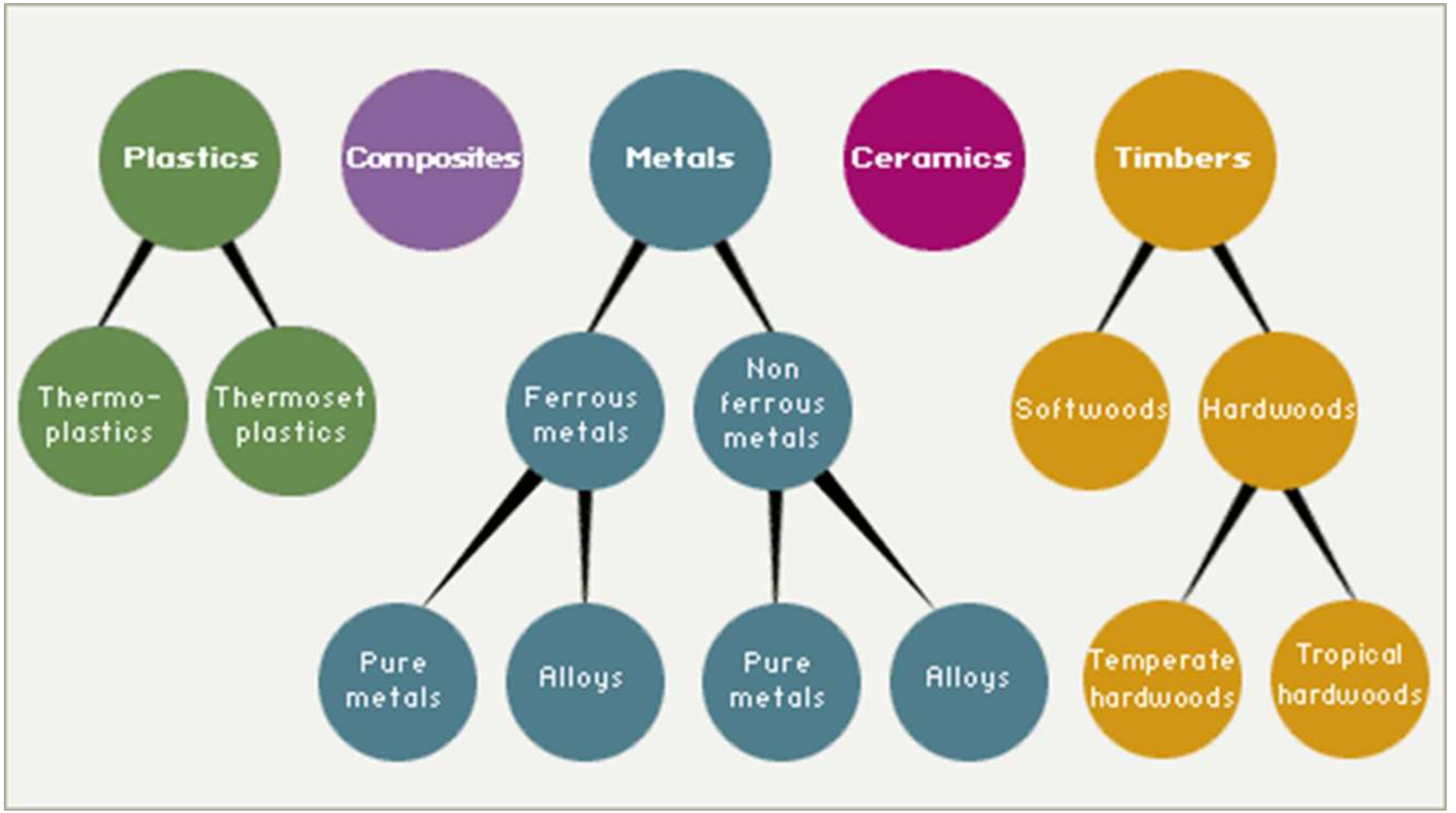


COMPILED BY HOWIE BAUM

Classification of Materials

- **Materials used in the design and manufacture of products**

- Plastics
- Wood
- Composites
- Ceramics
- Metals
- Fabrics


Plastics
Composites
Metals
Ceramics
Timbers
Thermo-plastics
Thermoset plastics
Ferrous metals
Non ferrous metals
Softwoods
Hardwoods
Pure metals
Alloys
Pure metals
Alloys
Temperate hardwoods
Tropical hardwoods


THE ELEMENTS
He
Ne
Ar
Kr
Xe

How are Elements Classified?

Four Regions: metals, nonmetals, metalloids, & inert gases.

75% or more of all of the elements are metals !!!

https://www.ptable.com/


Aluminium
Brass
Cast Iron
Bronze
Steel
Metal Sludge
Copper

Classification of Materials (Metals)

- Metals can be further classified as Ferrous (with iron) & Non-Ferrous (without iron) (shown first)

Ferrous	Non-Ferrous
Steels	Aluminium
Stainless Steels	Copper
High Speed Steels	Brass (Copper & Zinc)
Cast Irons	Titanium

Stainless Steel

Steel alloyed with chromium (18%), nickel (8%) (which is why sometimes, it is called 18-8 stainless), and magnesium (8%).

It won't rust because of the outer layer of Chromium !

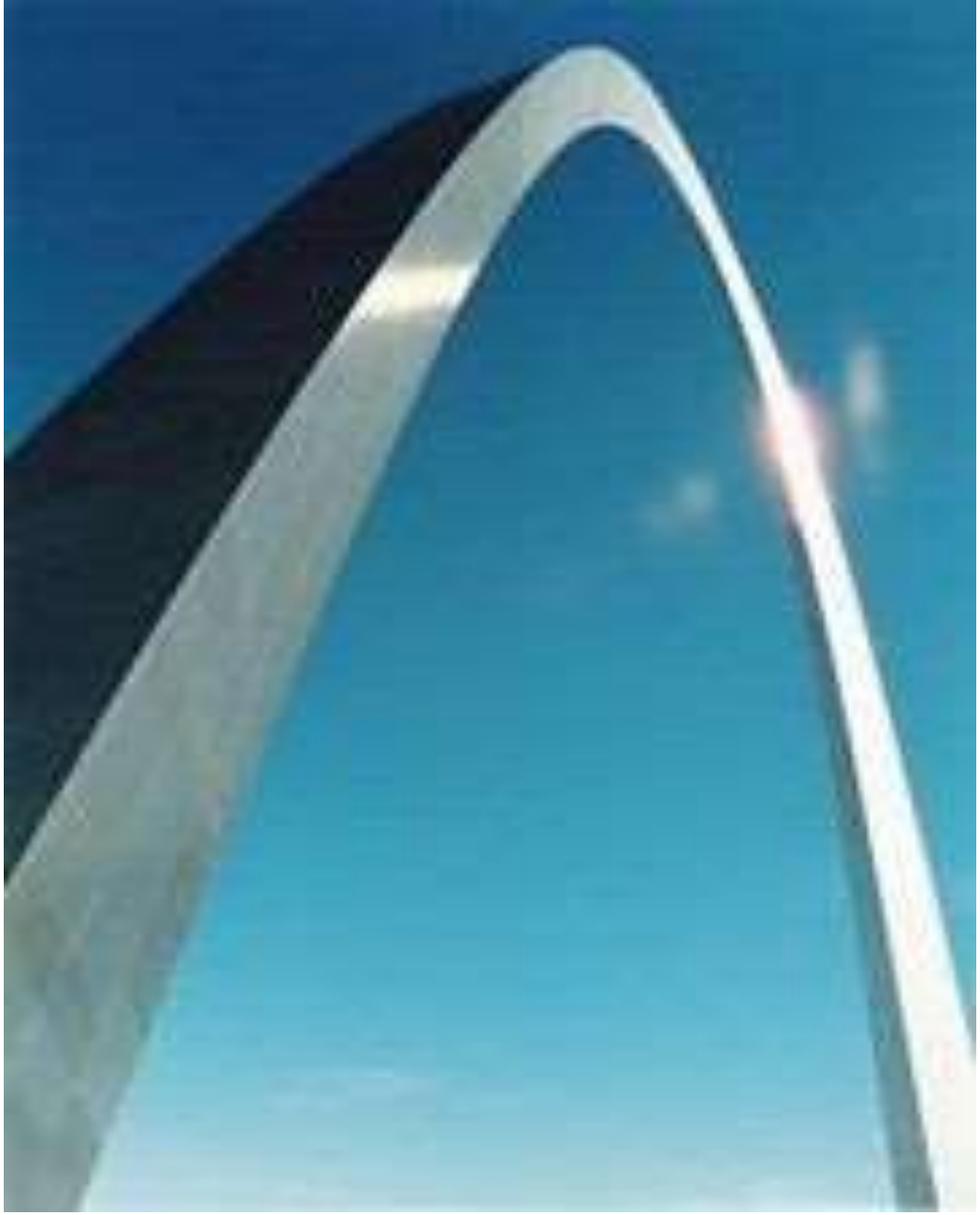
Hard and tough

Corrosion resistant

Comes in different grades

Sinks, cooking utensils, surgical instruments

The most popular form is Type 304 stainless steel.



The 630-foot (192 m) high, stainless-clad (type 304) Gateway Arch defines St. Louis's skyline.

“CLOUD GATE” aka THE BEAN, IN CHICAGO

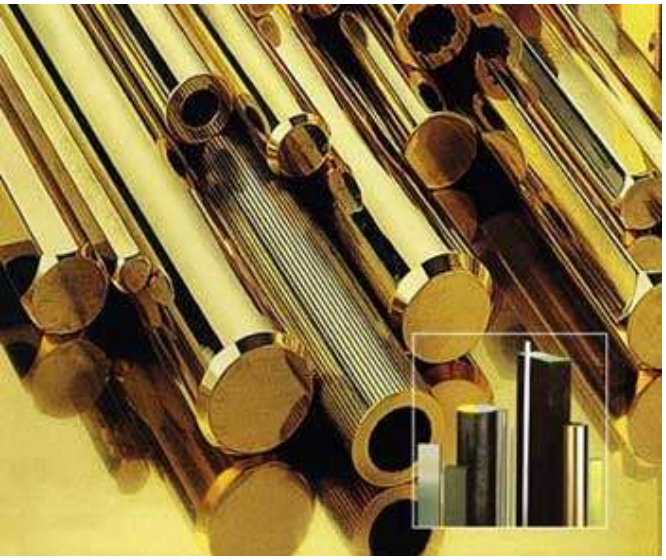
It is made up of 168 stainless steel plates (Type 304) welded together and its highly polished exterior has no visible seams.

It measures 33 by 66 by 42 feet (10 by 20 by 13 meters) and weighs 110 tons !!

The outside skin of the DeLorean car (Back to the Future model shown) was also made of Type 304 stainless steel !!

The operating flux capacitor from the DeLorean used in the movies “Back to the Future” !!

NON-FERROUS METALS



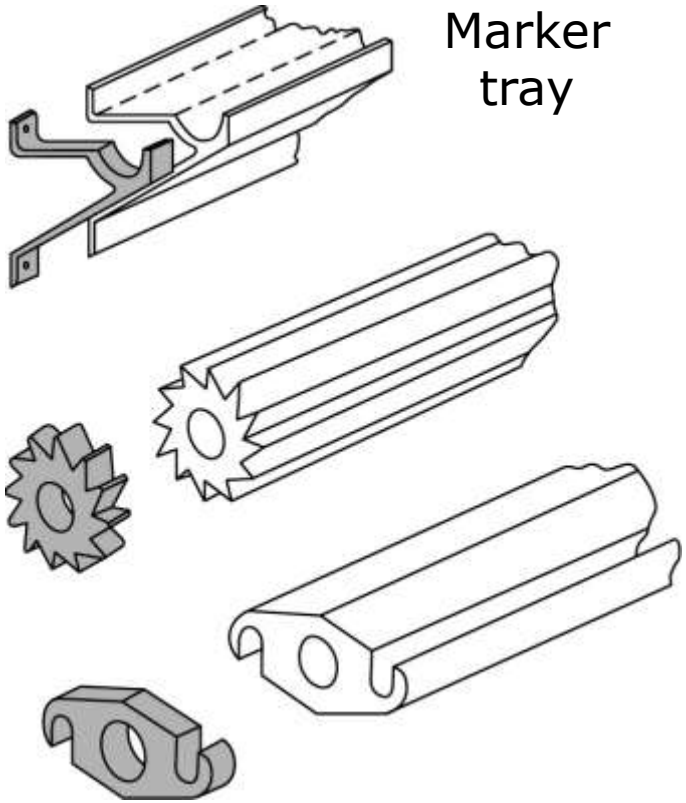
MOST METAL ZIPPERS ARE MADE OF ALUMINUM !!

EXTRUSION OF ALUMINUM AND OTHER METALS

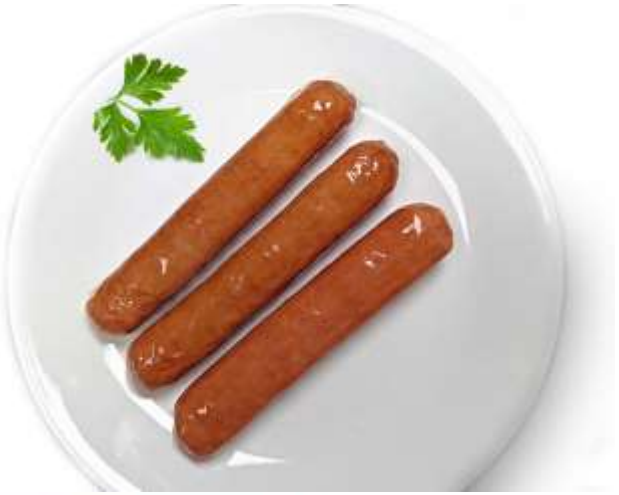
Extrusion is a manufacturing process where a material, often in the form of a billet, is heated to about 900 degrees F and then it's pushed and/or drawn through a die to create long objects of a fixed cross-section.

What kind of foods are extruded?

Chalk or Marker tray



Extrusion has found a great application in Food Processing. Various products like pastas, breakfast cereals, hot dogs, ready to eat snacks, cookies like Fig Newtons, etc. are now manufactured by extrusion.

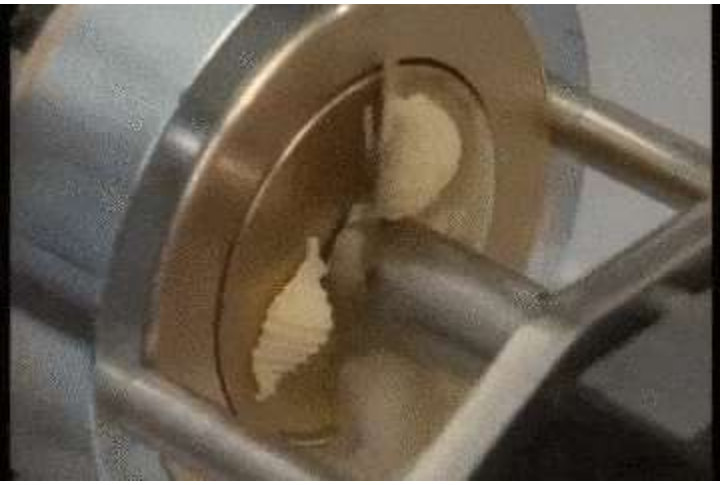


Spaghetti

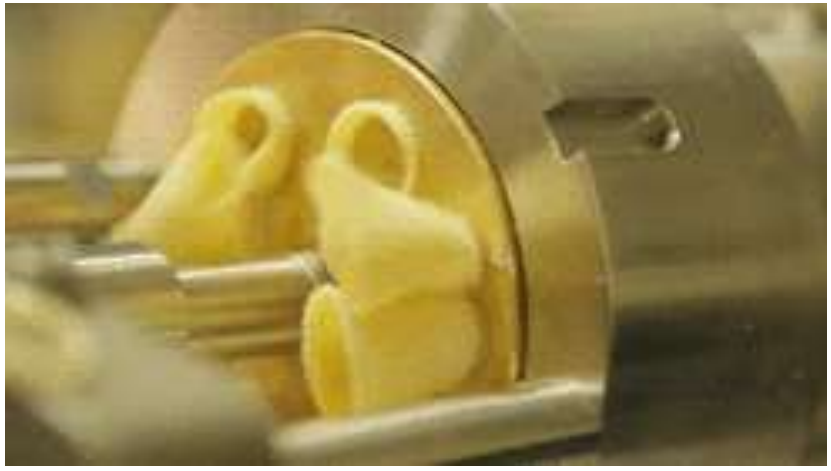
Macaroni

Lasagne

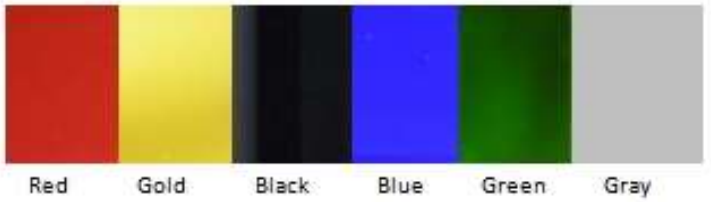
Spiral

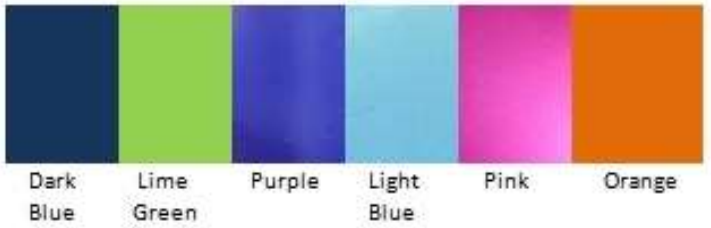


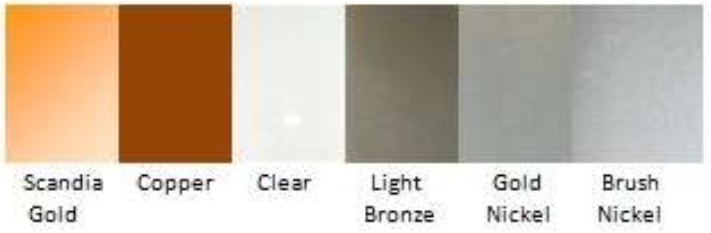
Pasta Extrusion Methods



TYPICAL ALUMINUM ANODIZING COLORS:







LIKE ALUMINUM, TITANIUM CAN ALSO BE ANODIZED WITH A WIDE VARIETY OF COLORS

CHANGES IN THE COPPER METAL COLOR OF THE STATUE OF LIBERTY, OVER THE YEARS, AS IT OXIDIZED

LITHIUM CARBONATE FOR BIPOLAR DISORDER

LITHIUM BATTERIES, AND GREASE

Classification of Materials (Plastics)

- Plastics can be further classified as;
- Thermoplastic (melt when heated)
- Thermoset (don't melt)
- Elastomers

Thermoplastics	**Thermosets**	**Elastomers**
Acrylics	Epoxy resins	Rubbers
Nylons	Phenolic	Silicones
Poly Vinyl Chloride	Polyesters	Polyurethanes
Polyethylene		

PLASTICS

Polymeric Materials in Everyday Life










Classification of Materials (Wood)

- Wood can be further categorized as;
- Hardwood
- Softwood
- Manufactured board

Hardwood	**Softwood**	**Manufactured Board**
Oak	Pine	Plywood
Ash	Cedar	Blockboard
Beech	Fir	Medium Density Fiberboard
Sycamore	Spruce	Melamine board

Classification of Materials (Composites)

- A composite is a combination of two or more chemically distinct materials **(usually a fibrous material and a liquid resin)** whose physical characteristics are superior to its constituents acting independently.

- Because of their high strength/stiffness to weight ratio they are widely used in the:

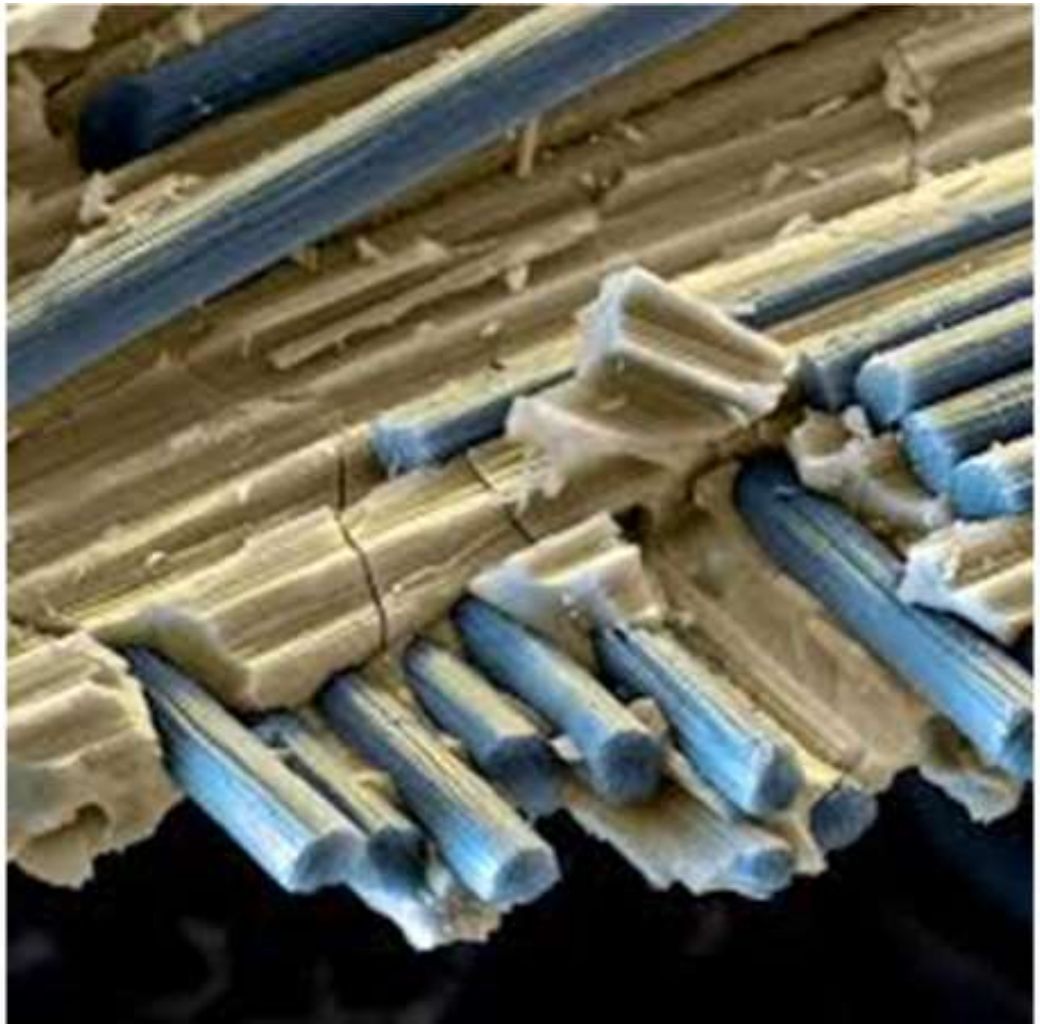
- Aerospace industry
- Offshore structures
- Boats
- Sporting goods

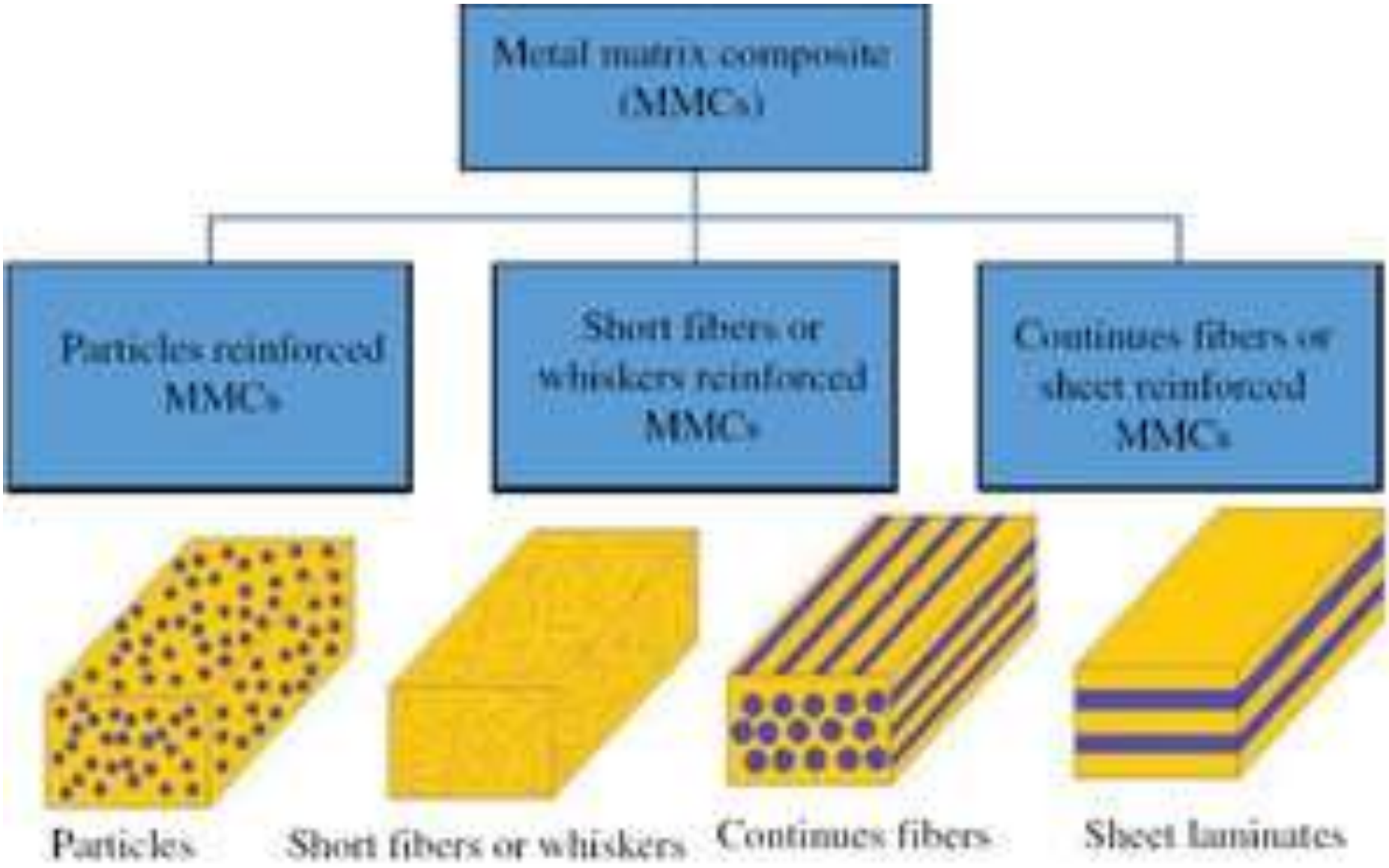
Classification of Materials (Composites)

3 Types of composites include:

- Reinforced Plastics
- Ceramic-matrix
- Metal-Matrix
- Laminates

FIBER + MATRIX = COMPOSITE




Metal matrix composite (MMCs)
Particles reinforced MMCs
Short fibers or whiskers reinforced MMCs
Continues fibers or sheet reinforced MMCs
Particles
Short fibers or whiskers
Continues fibers
Sheet laminates

METAL MATRIX COMPOSITES

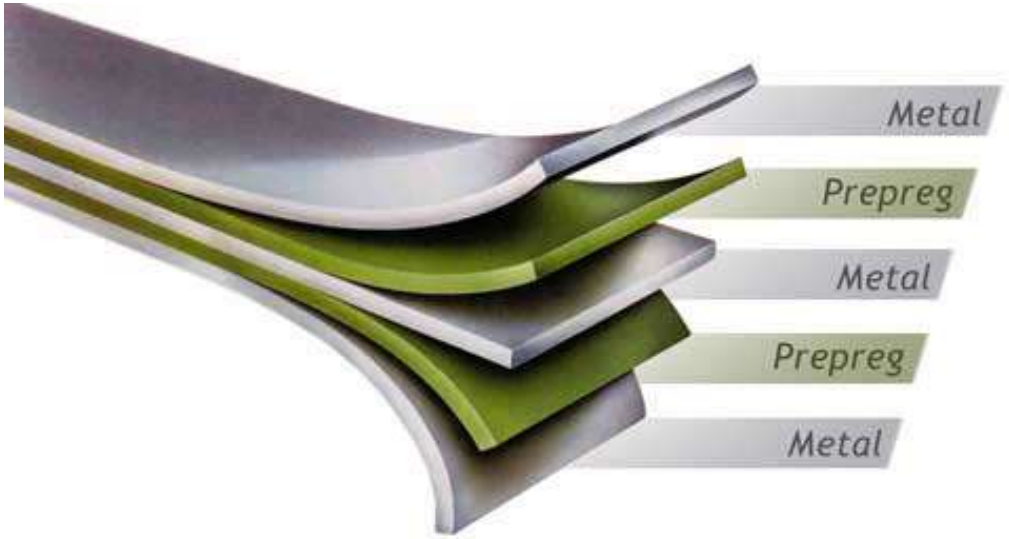
High temperature fibers dispersed in metal materials

FIBER METAL LAMINATES

-**GLARE: "GLAss-REinforced" Fiber Metal Laminate** (FML), composed of several very thin layers of metal (usually aluminum) interspersed with layers of glass-fiber "pre-impregnated with resin, bonded together with a matrix such as epoxy.

-**ARALL**: Abbreviation for **Aramid (Kevlar) aluminum laminate**. Composite produced by adhesively bonding sheets of isotropic high-strength aluminum and tough aramid fibers.

The aluminum provides higher strength isotropic properties and metal-forming qualities to the composite laminate while the aramid (Kevlar) fiber supplies fatigue and fracture resistance.



USE OF GLARE

CERAMIC COMPOSITES:

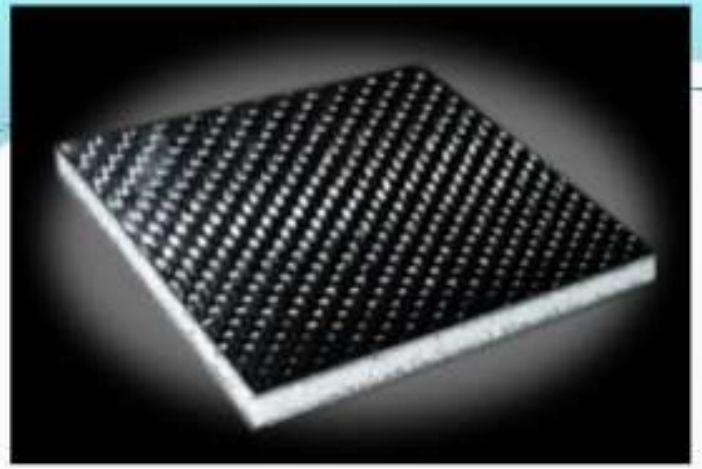
A brake disc (or *rotor* in U.S. English), usually made of cast iron or **ceramic composites (including carbon, kevlar and silica),** is connected to the wheel and/or the axle.

Silicon Carbide Whisker-Reinforced Ceramic Composites

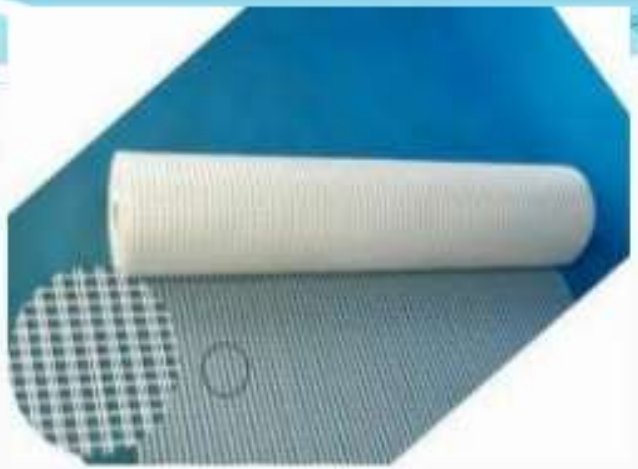
EVEN BATMAN USES A CERAMIC RESIN COMPOSITE TO PROTECT HIMSELF FROM BULLETS.

http://www.youtube.com/watch?v=DIT7UILed1o#t=0m18s

FIBER MATERIALS USED FOR REINFORCEMENT IN PLASTIC COMPOSITES



CARBON FIBRE COMPOSITE



GLASS FIBRE

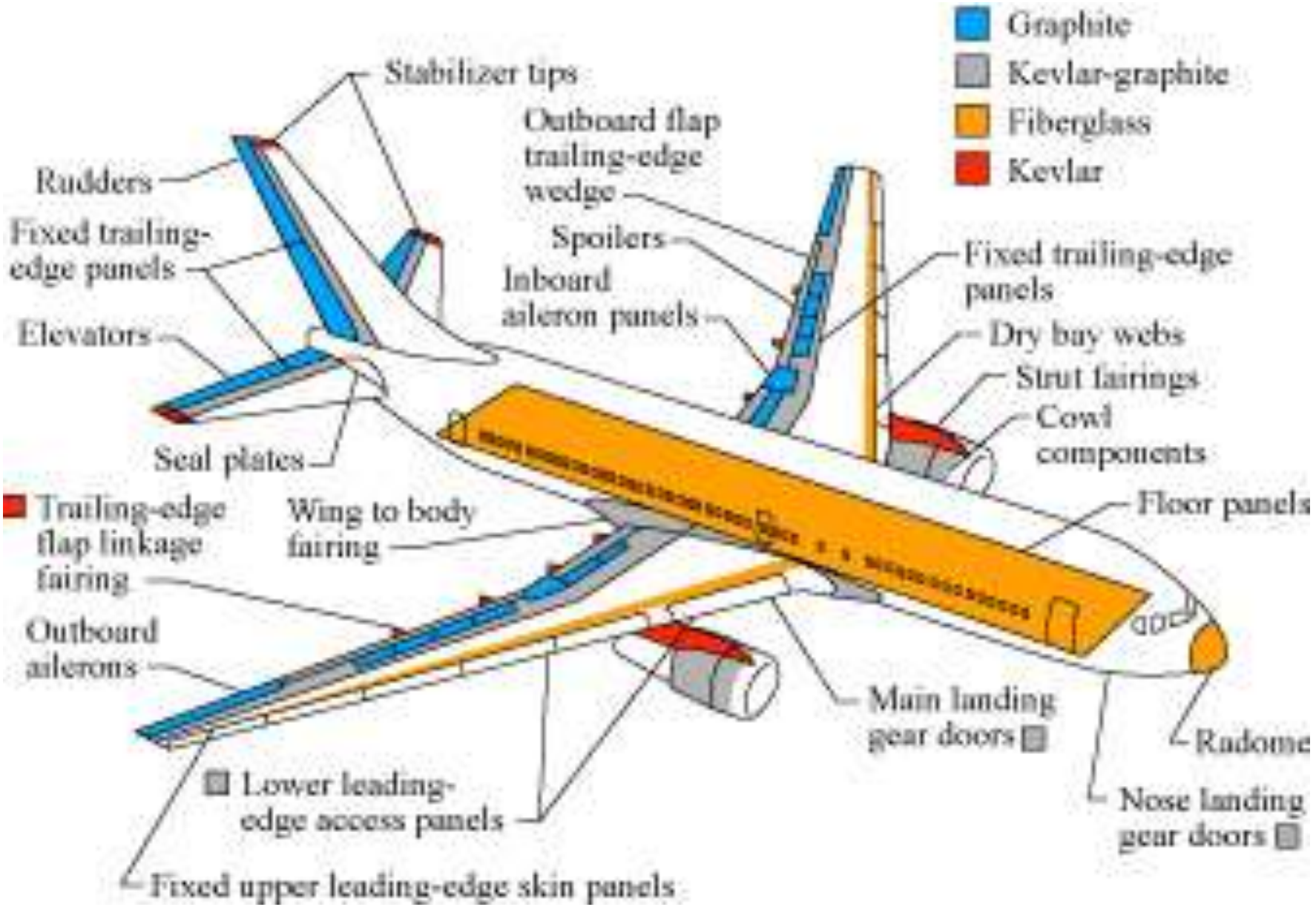
ARAMID FIBRE COMPOSITE

WOVEN FABRIC

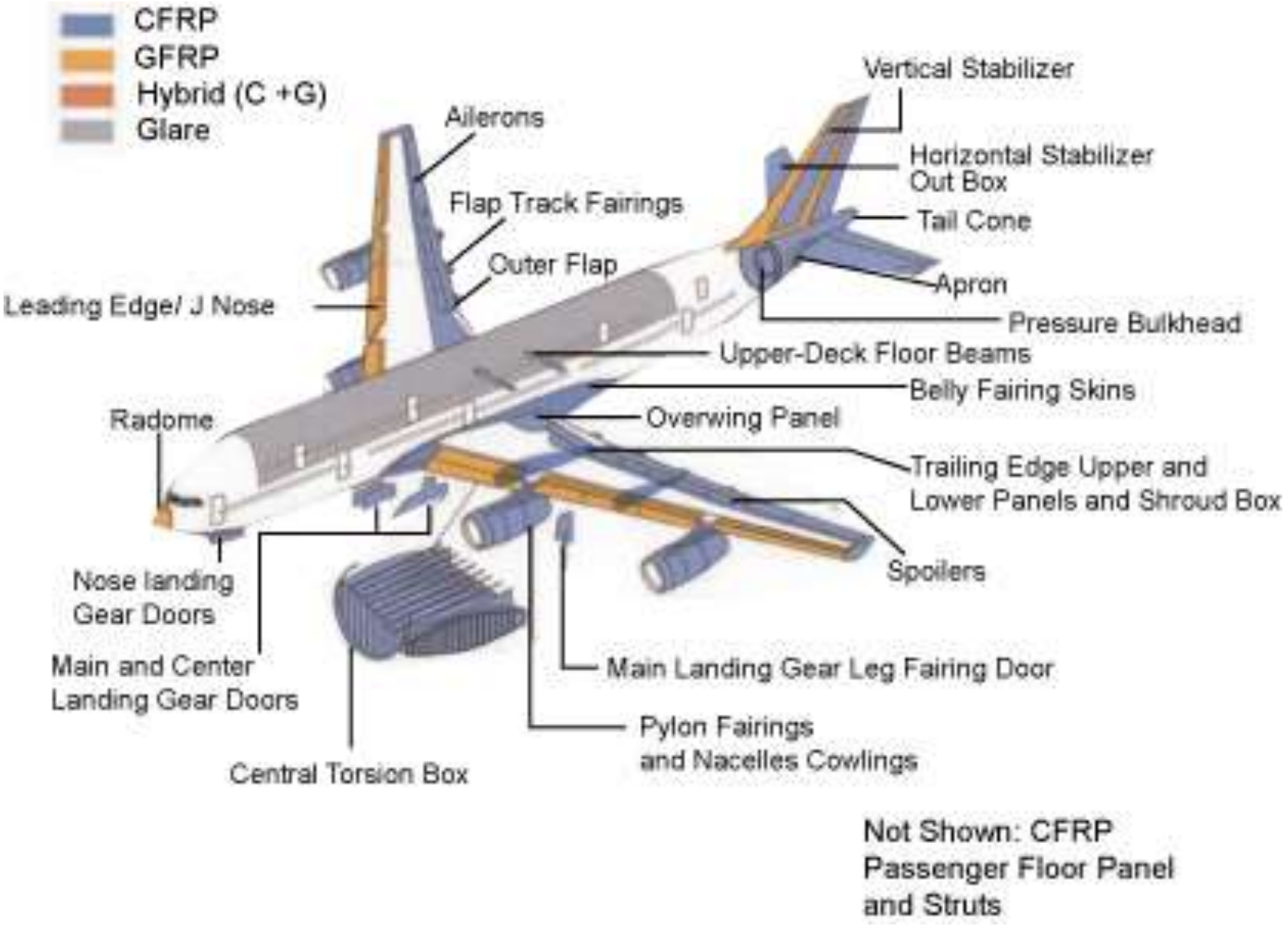
A CARBON FIBER CELLO !!

http://www.youtube.com/watch?v=J_gI3chGtww&feature=related

Boeing 767

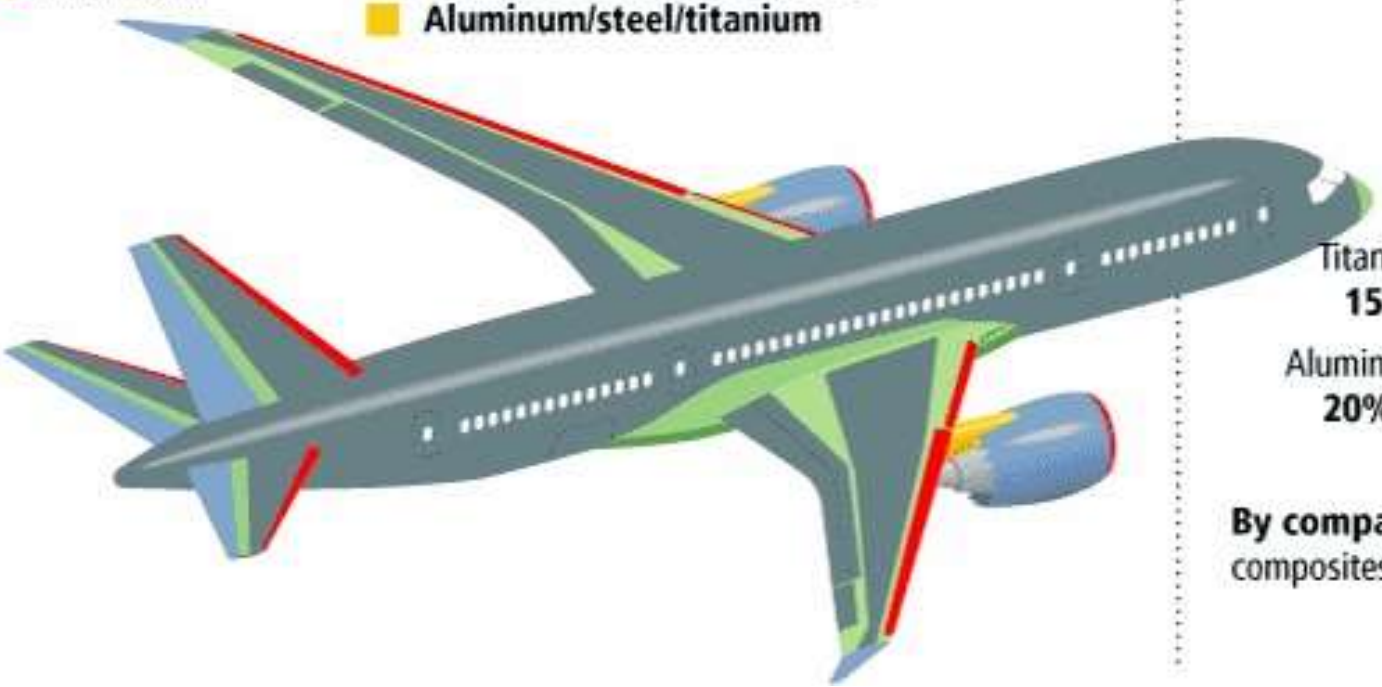

Graphite
Kevlar-graphite
Fiberglass
Kevlar
Stabilizer tips
Outboard flap trailing-edge wedge
Rudders
Fixed trailing-edge panels
Spoilers
Inboard aileron panels
Fixed trailing-edge panels
Elevators
Dry bay webs
Strut fairings
Cowl components
Seal plates
Trailing-edge flap linkage fairing
Wing to body fairing
Floor panels
Outboard ailerons
Main landing gear doors
Radome
Lower leading-edge access panels
Nose landing gear doors
Fixed upper leading-edge skin panels

Airbus A380


CFRP
GFRP
Hybrid (C +G)
Glare
Vertical Stabilizer
Ailerons
Horizontal Stabilizer
Out Box
Flap Track Fairings
Tail Cone
Outer Flap
Apron
Leading Edge/ J Nose
Pressure Bulkhead
Upper-Deck Floor Beams
Belly Fairing Skins
Radome
Overwing Panel
Trailing Edge Upper and
Lower Panels and Shroud Box
Spoilers
Nose landing
Gear Doors
Main and Center
Landing Gear Doors
Main Landing Gear Leg Fairing Door
Pylon Fairings
and Nacelles Cowlings
Central Torsion Box
Not Shown: CFRP
Passenger Floor Panel
and Struts

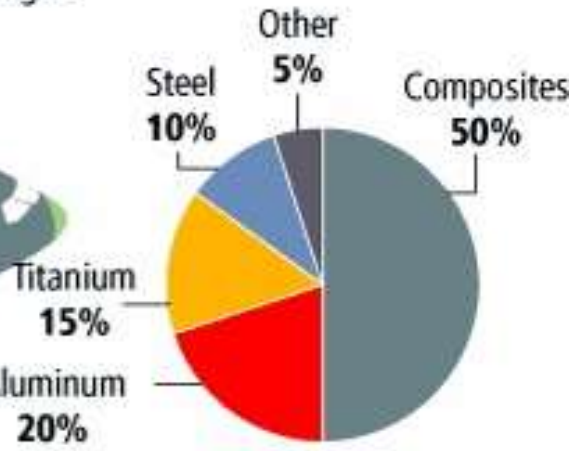
Materials used in 787 body

- Fiberglass
- Aluminum
- Carbon laminate composite
- Carbon sandwich composite
- Aluminum/steel/titanium

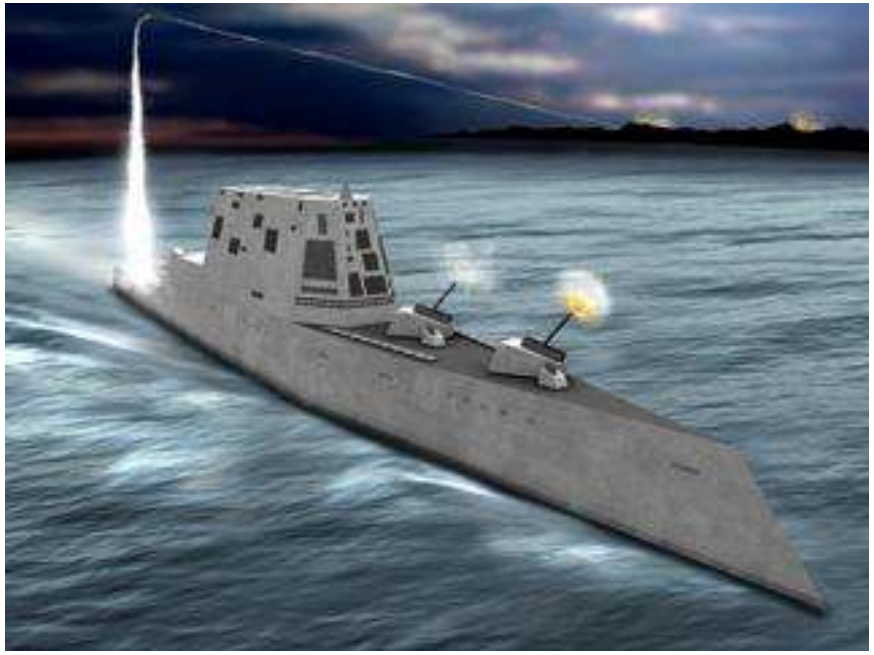


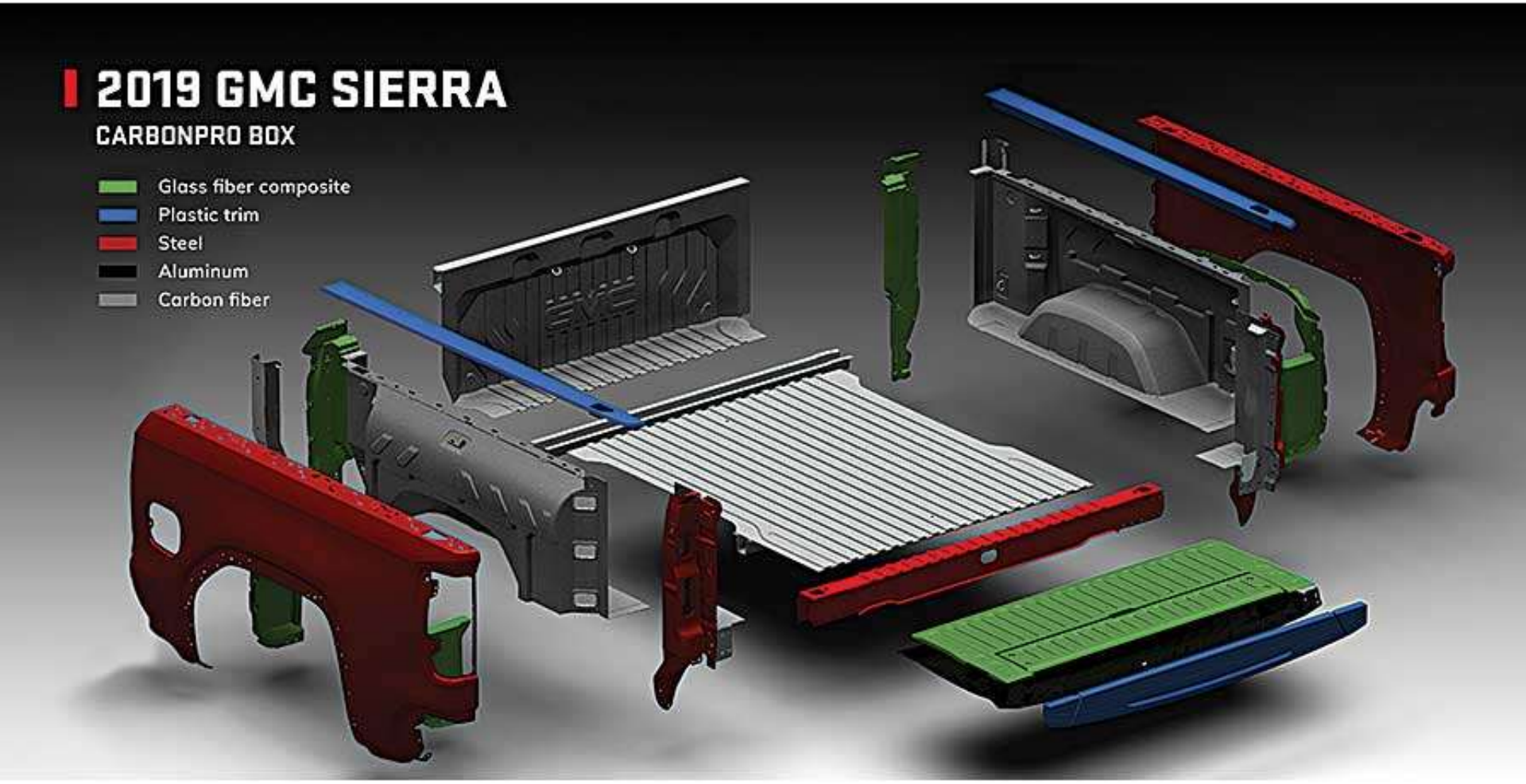
Total materials used

By weight



By comparison, the 777 uses 12 percent composites and 50 percent aluminum.




2019 GMC SIERRA
CARBONPRO BOX
Glass fiber composite
Plastic trim
Steel
Aluminum
Carbon fiber

Classification of Materials (Ceramics)

- Ceramics are compounds of non-metallic elements, examples include;

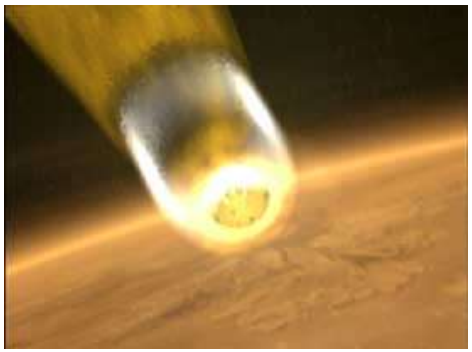
- **Oxides** (alumina – insulation and abrasives zirconia – dies for metal extrusion and abrasives, sandpaper

- **Carbides** (tungsten-carbide tools)

- **Nitrides** (cubic boron nitride, 2nd in hardness to diamond)

PROPERTIES

- high hardness
- high strength (tensile & compressive)
- high chemical resistance
- high temperature resistance
- good insulation
- high wear resistance
- brittle



Engine Products

Kyocera engine products include cam rollers, turbocharger rotors, glow plugs, cylinder liners, seals, pistons, piston pins, valve and valve guides, fuel injection parts and various custom made components made from a wide selection of advanced ceramic materials.

Ceramic Piston Head and Rings

Ceramic Seal Assembly

Ceramic Cam Roller

Ceramic Turbocharger Rotor

SILICON NITRIDE BALL AND OTHER TYPES OF BEARINGS

CERAMIC COATINGS

TIN-NITRIDE

CHROMIUM NITRIDE

TITANIUM ALUMINIDE

CERAMIC KNIVES

KYOCERA KITCHEN KNIFE

http://www.youtube.com/watch?v=JFnT5INymiY

Neurostimulation: Feed-thrus

Morgan Advanced Ceramics' Alberox Products assists in the feed-thru design for neurostimulators that pulse various nerves to treat medical conditions, including epilepsy, depression, migraines and obesity.

Cochlear Implants: Feed-thrus

Requiring stringent quality controls and consistent repeatability in order to survive within the body's harsh environment, Morgan Advanced Ceramics' Alberox Products feed-thrus facilitate in amplifying and improving the quality of sound.

Hip Joints: HIP Vitox®

Morgan Advanced Ceramics' HIP Vitox® ceramic-on-ceramic hip joints eliminate polyethylene wear debris and metal ion release concerns in combination with exceptionally low wear rates.

Pacemakers & Defibrillators: Feed-thrus

Morgan Advanced Ceramics' Alberox Products feed-thrus allow electricity to pass in and out of the implanted device to administer an electrical charge.

Implantable Joints: Diamond-like Carbon (DLC) coatings

Morgan Advanced Ceramics' Diamonex Products Diamond-like Carbon coatings provide a biocompatible, sterilization-compatible, non-leaching and wear-resistant surface for key pivot points and wear surfaces.

FIBER REINFORCED CONCRETE CHAIR AND TABLE DESIGN

Classification of Materials (Fabrics)

•Fabrics can be further classified as natural and synthetic

Natural	Synthetic
Cotton	Nylon
Canvas	Polyester

Materials used in space suits include aluminized Mylar, neoprene coated nylon, dacron, urethane coated nylon, tricot and spandex. The outer layer is a blend of Gortex, Kevlar and Nomex

Corn fiber

Made from corn sugar

Cargill produces “Ingeo”

Insect resistant

Performs like polyester

Breathable

Hypoallergenic properties

Superior softness

Biodegradable

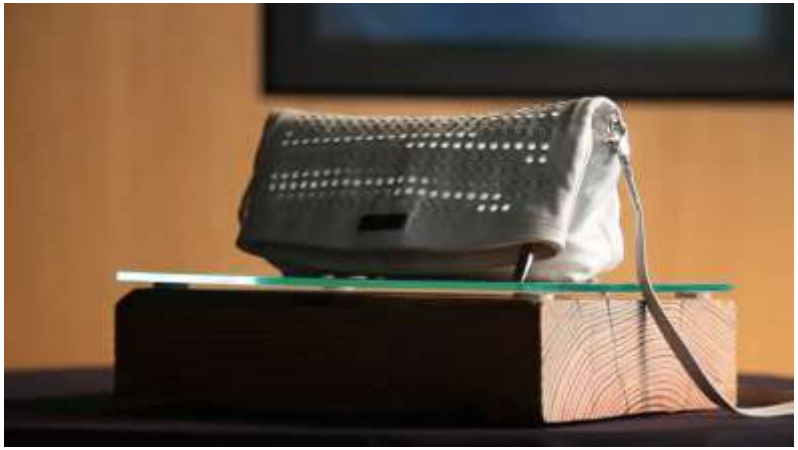
HEMP CLOTHING ITEMS

BAMBOO FIBER AND FABRICS

BioSteel is a trademark name for a high-strength fiber-based material made of spider web "silk" protein extracted from the milk of transgenic goats.

It is reportedly 7-10 times as strong as steel if compared for the same weight, and can stretch up to 20 times its unaltered size without losing its strength properties.

THE LATEST TECHNOLOGIES IN THE WORLD OF FASHION



Smart textiles can be broken into two different categories: aesthetic and performance enhancing.

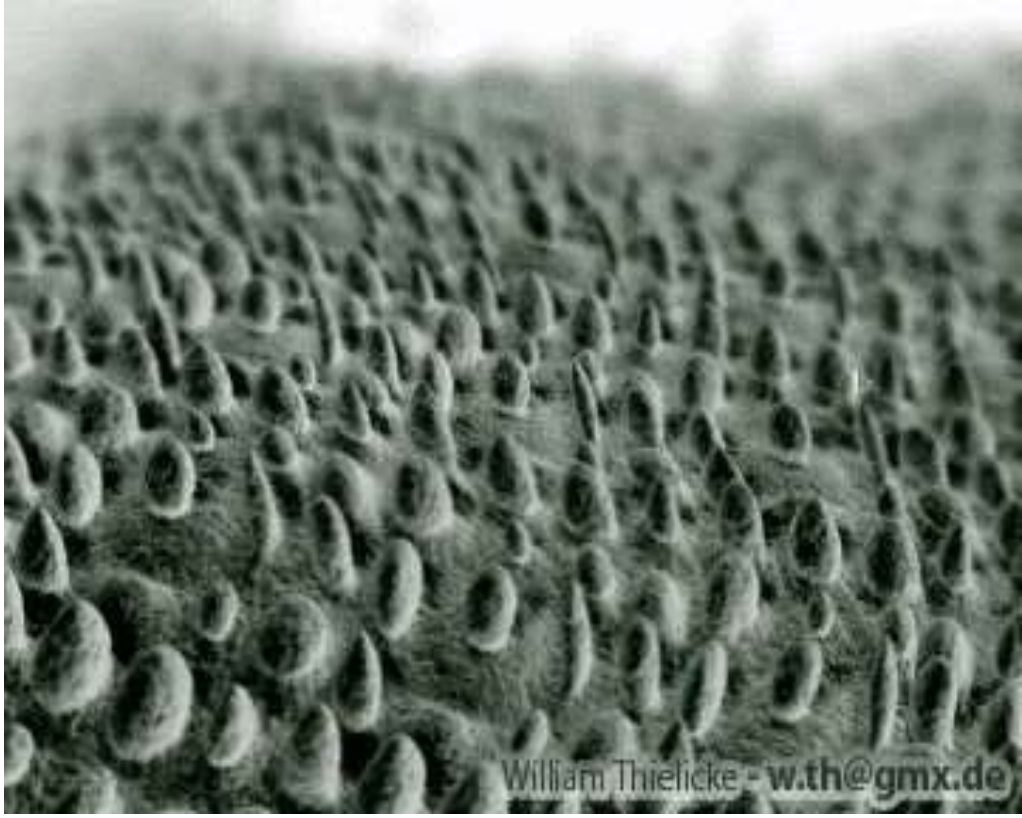
- Aesthetic examples include fabrics that light up and/or change color or shape

- Gather energy from the environment by harnessing vibrations, sound or heat, and reacting to these inputs.

- Embedding the fabric with electronics that can power it for light effects, changing shape, entertainment – games, smart phones, etc.

PERFORMANCE ENHANCING

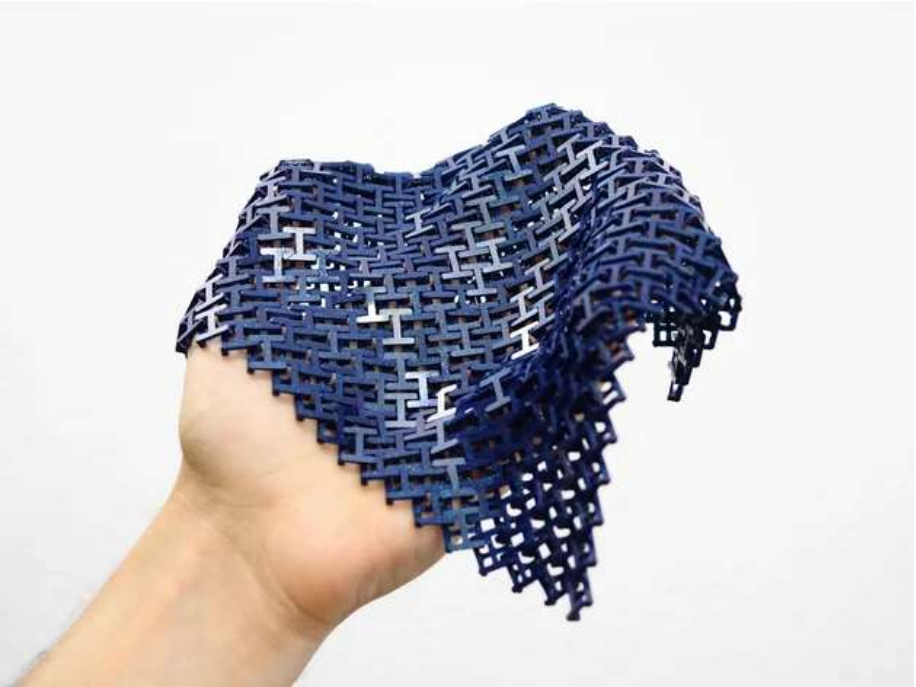
- Athletic, extreme sports and military applications.
- Regulate body temperature, reduce wind resistance, and control muscle vibration
- Protective clothing, to guard against extreme environmental hazards – coatings for **waterproofing,** Ultra-Violet light protection, etc.
- Drug-releasing medical textiles, or fabrics with moisturizers, perfume, and anti-aging properties.

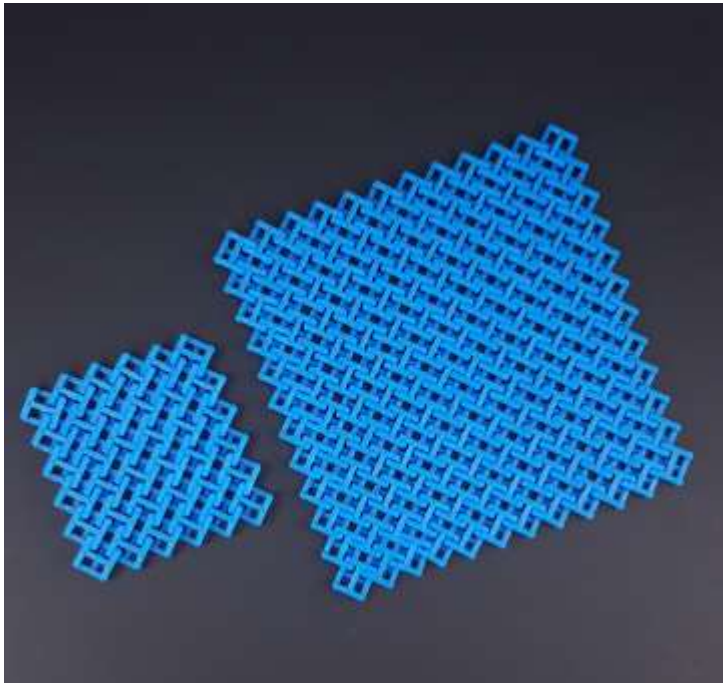


Black Panther took home the 2019 Academy Award for Best Costume Design for outfits that included an intricate collar and crown created using 3D printing using the Selective Laser Sintering (SLS) process.

Among the elaborate costumes worn in the movie were a crown and huge shoulder mantle donned by Queen Ramonda, played by American actress Angela Bassett.

3-D PRINTED CHAINMAIL FABRIC MATERIALS





The articulated 3D printed links in the previous picture were used to make this beautiful dress.

It is called the Kinematics dress and was designed by the Nervous System Company.

3D-scanning technology allows the design to be custom-fit to the wearer's body by manipulating the tessellated mesh file before printing.

Because of the openness in some areas, under garments are worn with it.


OSCARS
THE

DISCO DOG !

3D printed and regular Fashions designed by Iris Von Harpen

Classification of Materials (Smart Materials)

- A smart material can be described as a material that has a useful response (movement, etc.) to external influences or stimuli (force, light, etc.)

There are many examples of smart materials in everyday use that are not modern developments. They include;

- Metal springs

- Light bulbs self regulate because as the filament temperature increases, their resistance rises

- Ancient civilizations have long used porous ceramics for self cooling

Classification of Materials (Smart Materials)

- Other more modern examples of smart materials include;
- Shape memory polymers and alloys
- Smart or Memory Wire
- Smart Link Silicone
- Smart Fluids
- Piezoelectric Materials
- Chameleon Colours

Classification of Materials (Smart Materials)

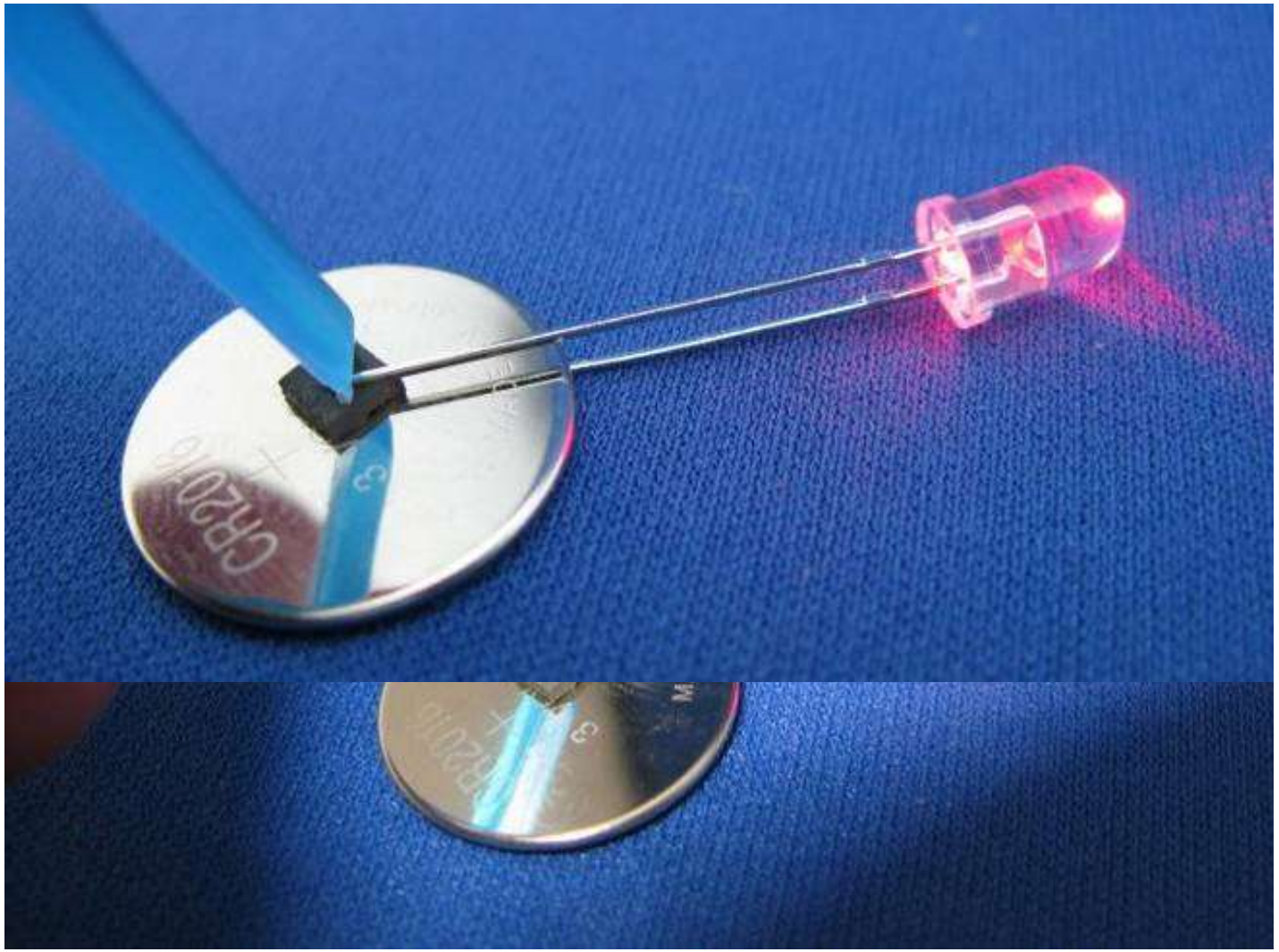
- Thermocolor Sheet

This is a self-adhesive sheet whose color changes according to the temperature. Used for thermometers, heat warning patches and novelty advertising of products

Classification of Materials (Smart Materials)

- Quantum Tunnelling Composite (QTC)

- A QTC in its normal state is a perfect insulator
- When compressed it becomes a perfect conductor
- If only lightly compressed its conductivity is proportional to the pressure applied



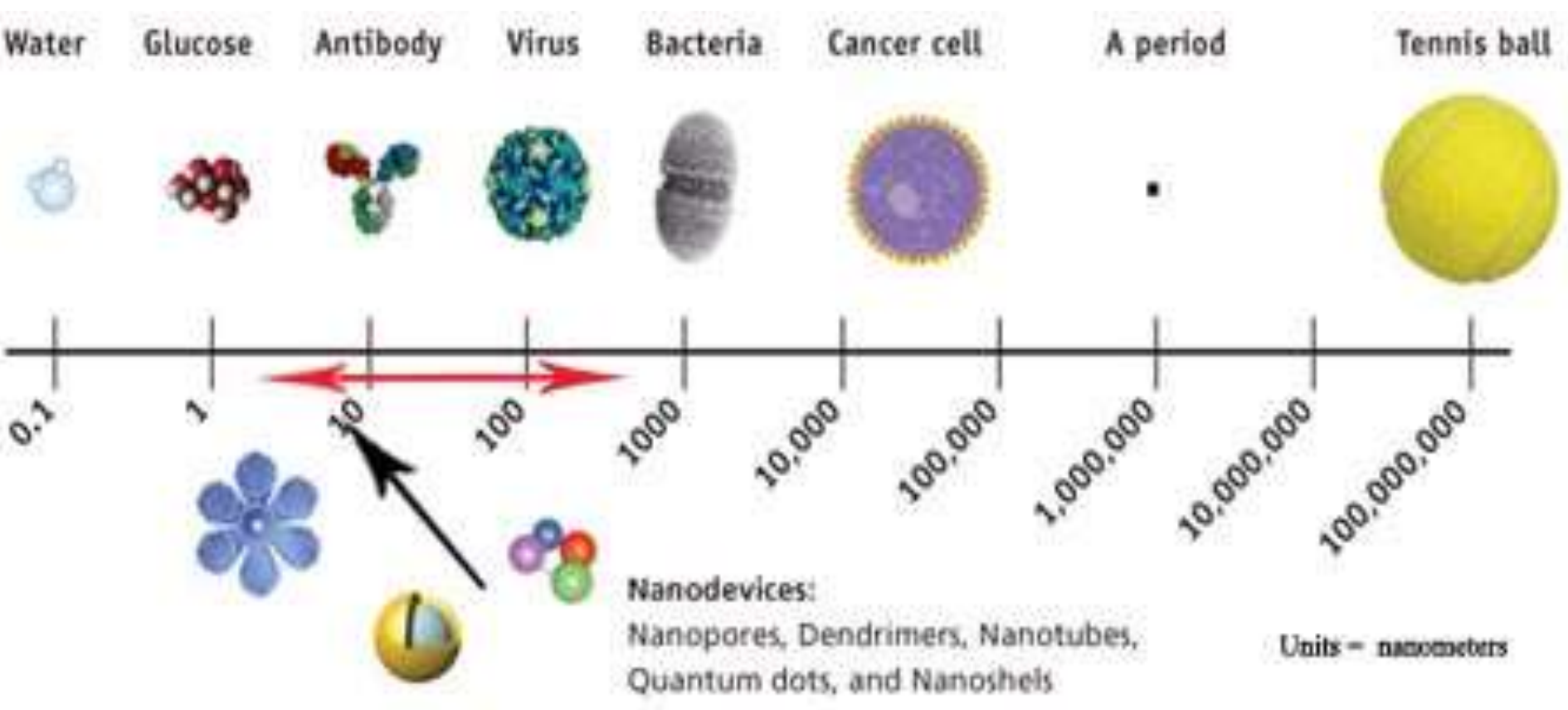
Before pressure is applied

Light Pressure being applied

Nanotechnology refers to materials, applications and processes designed to work on extremely tiny scales, usually for things between 1 and 100 nanometers long.

A nanometer is one-billionth of a meter. A sheet of paper is about 100,000 nanometers thick, while a single gold atom is about one-third of a nanometer in diameter.

Many unique properties and uses can be derived from structures built at the nanoscale, giving nanotechnology enormous potential for future development.

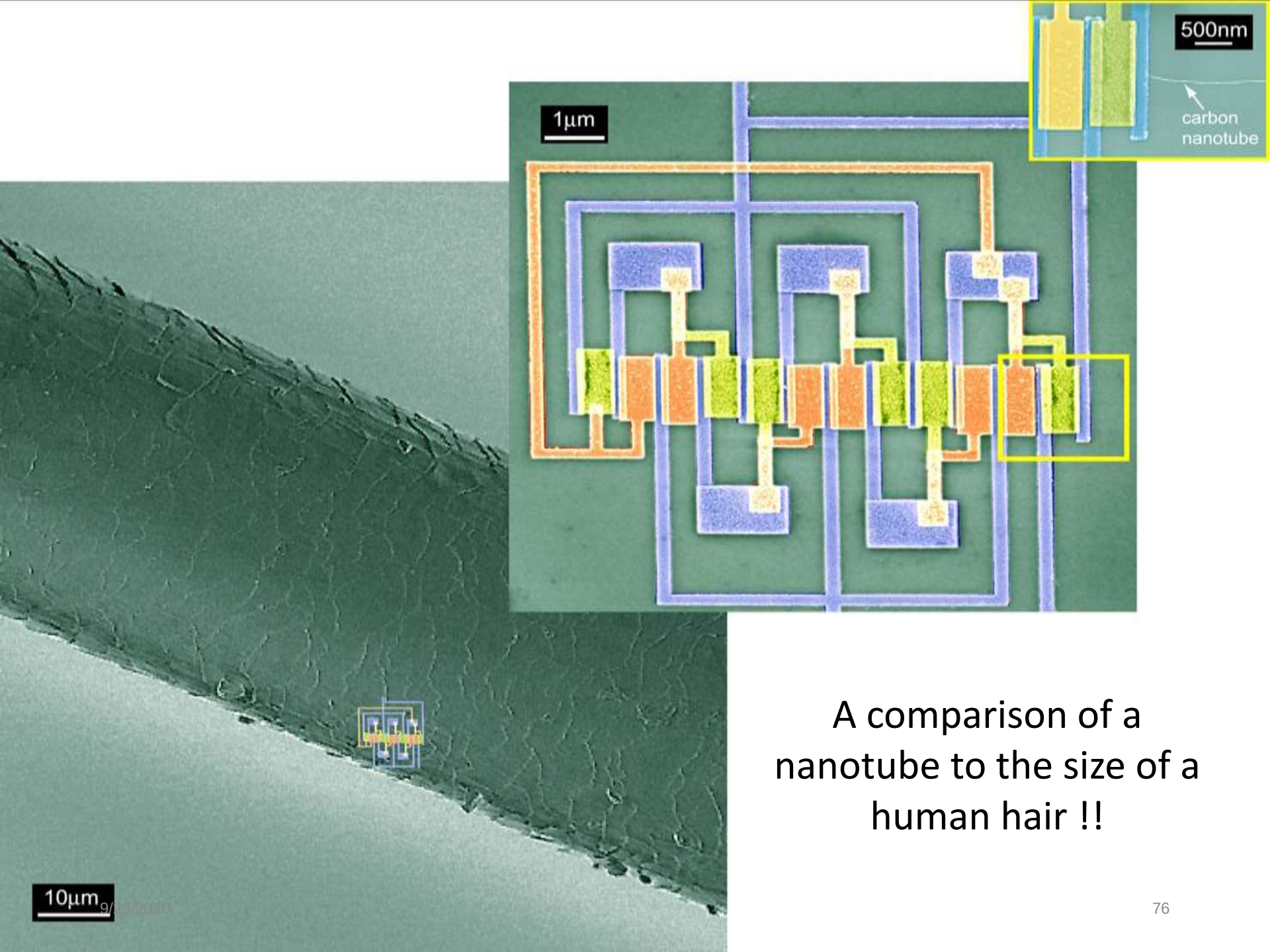


Units in nanometers (µm) a billionth of a meter !

How small is Nano ?

https://www.youtube.com/watch?v=5AAR7bNSM_s

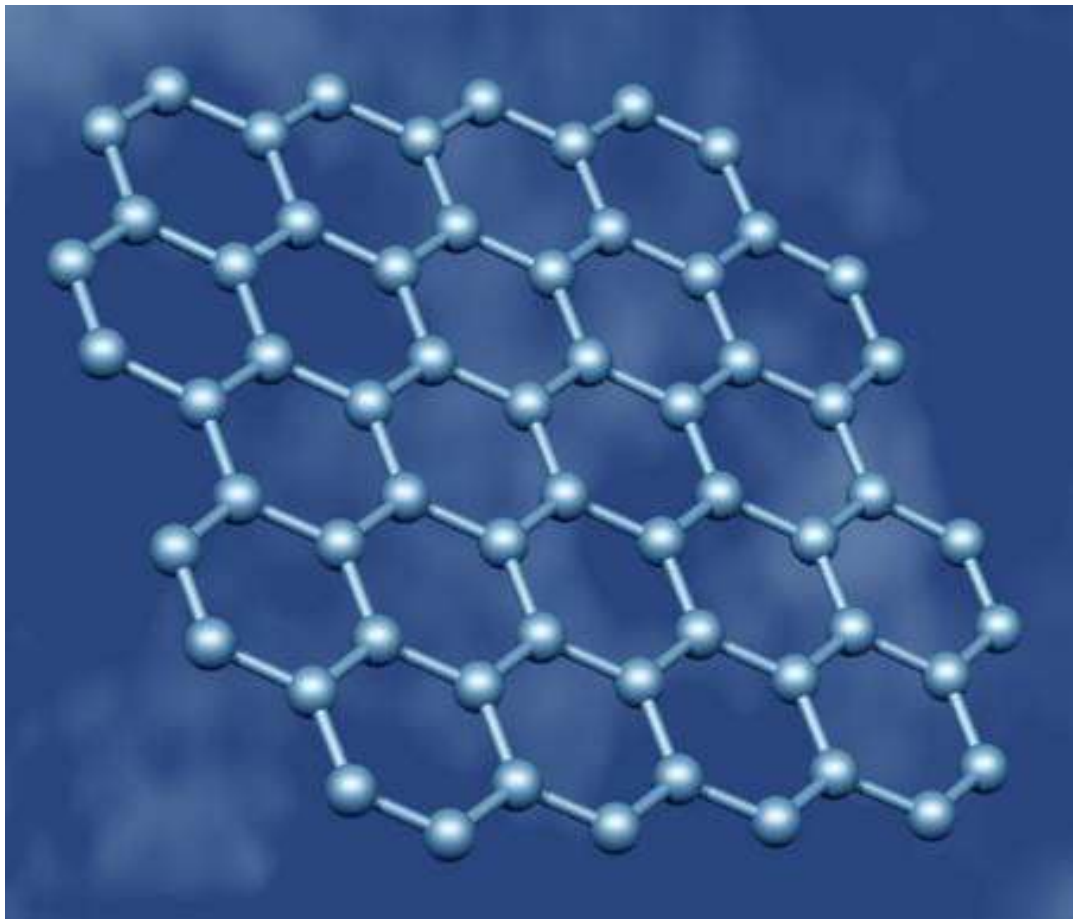
go to 55 sec



A comparison of a nanotube to the size of a human hair !!

GRAPHENE – HEXAGON-SHAPED PLANE OF CARBON ATOMS IN SHEET FORM

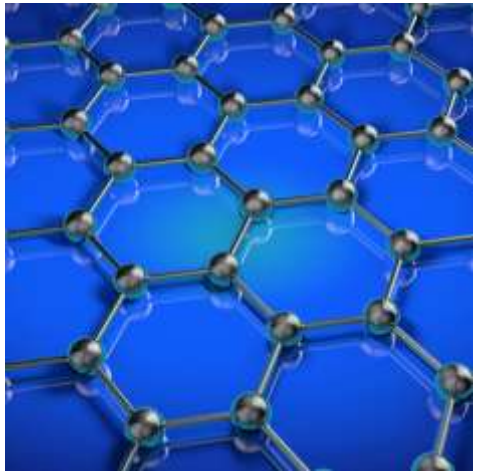
Graphene, the basic structure for all graphitic materials, is a two-dimensional (2D) sheet of carbon atoms arranged in a honeycomb lattice structure.



The outstanding properties of graphene are:

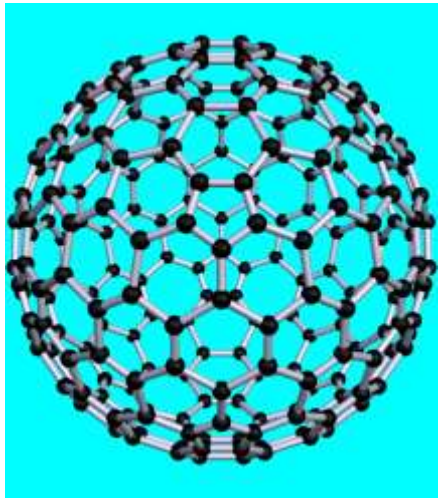
- Very high mechanical strength
- High electrical and heat conductivity

Graphene is a flat sheet of carbon atoms arranged in hexagons.

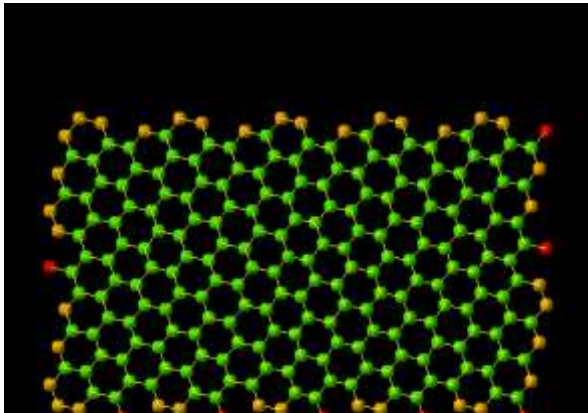


Fullerenes are molecules of carbon in the shape of spheres, ellipses and tubes.

The sphere shape is known as buckminsterfullerene, or a buckyball



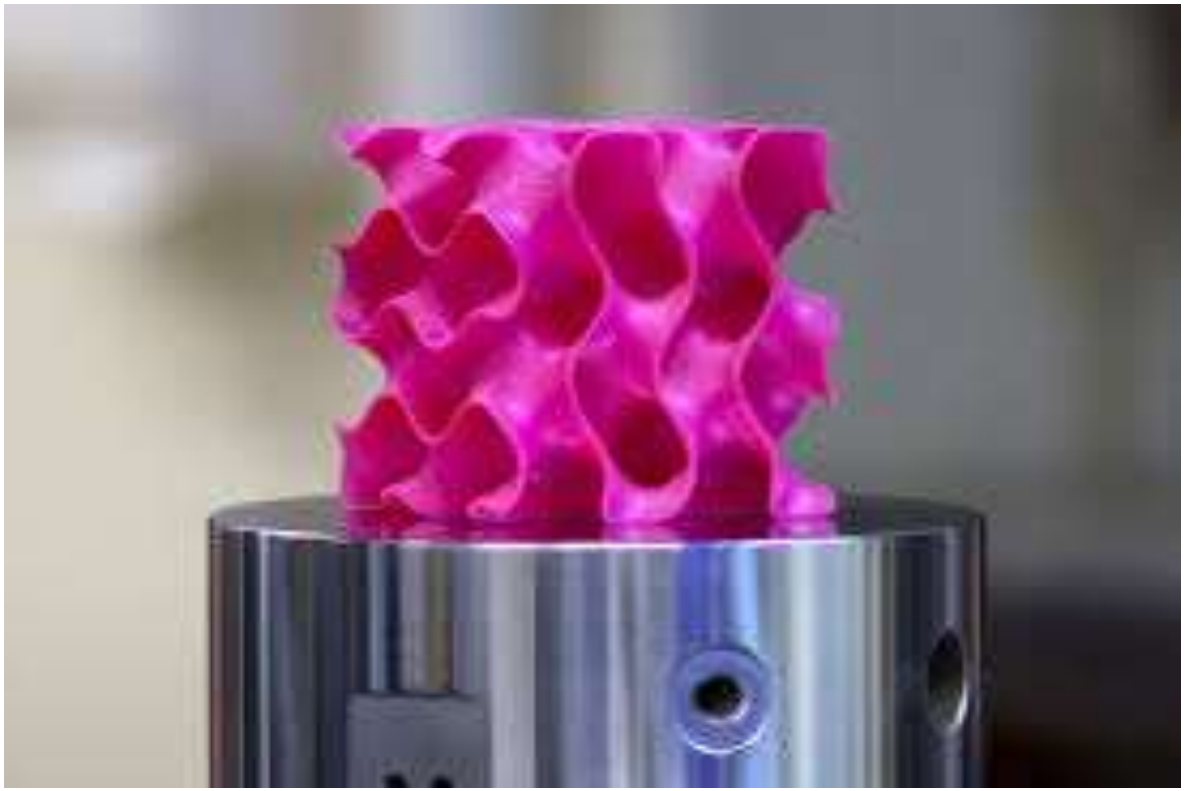
Carbon nanotubes, also known as buckytubes, are fullerenes in the shape of a tube with the outside carbon atom structure made of Graphene.



Porous, 3-D forms of graphene developed at MIT can be 10 times as strong as steel but much lighter

The new super-material is made up of flecks of graphene and the part is almost completely hollow.

Its superior properties are due to how the graphene planes are aligned.



https://www.youtube.com/watch?v=sVZjlvOYdLk

Graphene-based Sensors in Health Monitoring

Invasive Applications

Nervous System

- ECoG
- Nerual stimulation

Cardiovascular System

- ECG
- Blood glucose

Digestive System

- Gastrointestinal diagnosis

Locomotor System

- EMG
- Muscle stimulation

Non-invasive Applications

Biophysical

Electrophysiological

- EEG
- EOG
- ECG
- EMG

Kinematic

- Pulse/heart rates
- Respiration
- Phonation
- Facial expressions
- Blood pressure
- Joints movements
- Gesture
- Muscle movements

Thermometer

- Body temperature

Environmental

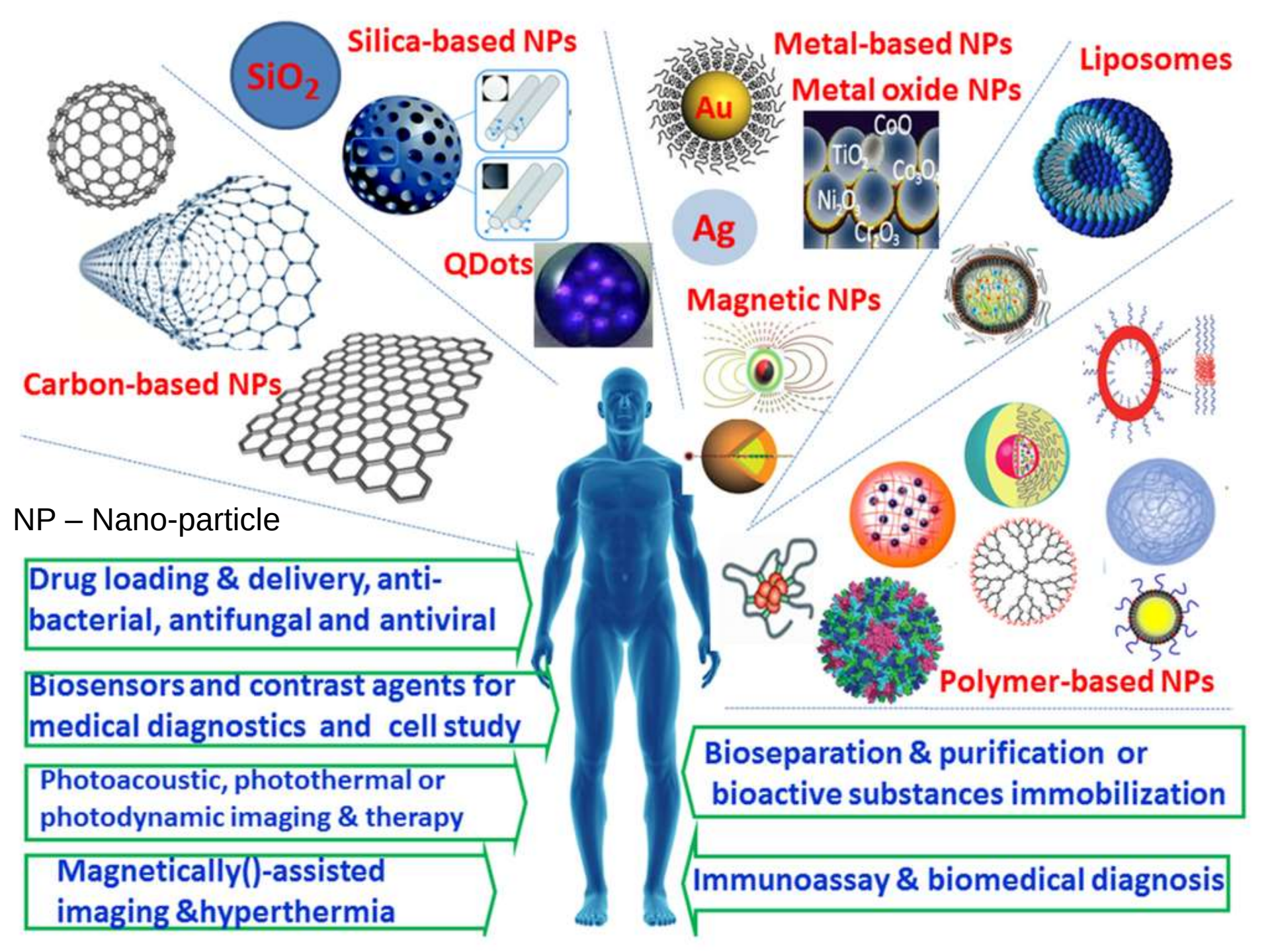
- Light
- Gases
- Heavy Metal

Bio-chemical

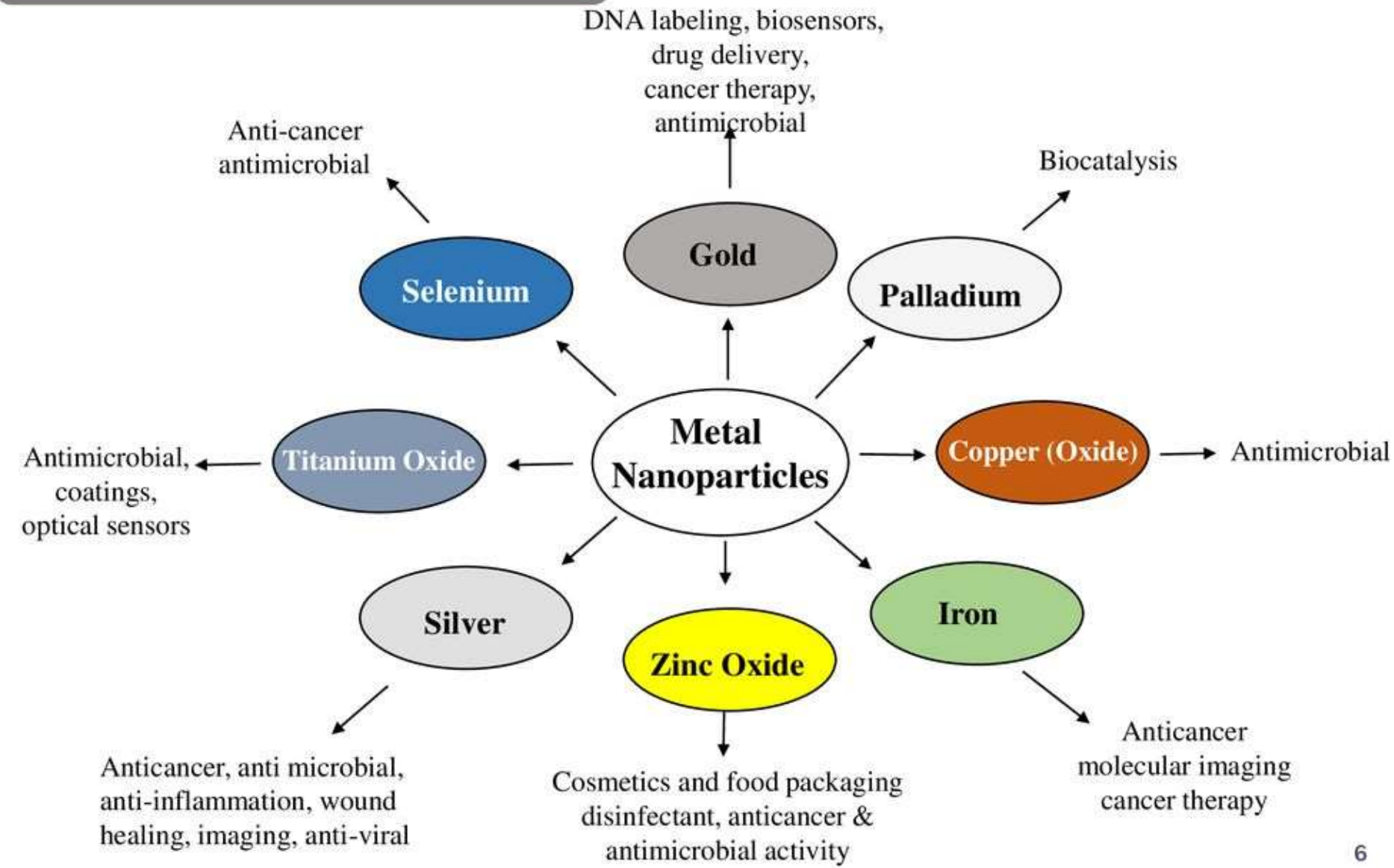
- Volatile gases
- Electrolyte
- Metabolite
- Bacteria
- Drug
- Dopamine
- Tumor markers
- Others

Nanomaterials in Consumer Products

The Future is Now


Silica-based NPs
SiO_2
Metal-based NPs
Metal oxide NPs
Au
Ag
CoO
TiO_2
Co_3O_4
Ni_2O_3
Cr_2O_3
Liposomes
QDots
Magnetic NPs
Carbon-based NPs
Polymer-based NPs
NP – Nano-particle
Drug loading & delivery, anti-bacterial, antifungal and antiviral
Biosensors and contrast agents for medical diagnostics and cell study
Photoacoustic, photothermal or photodynamic imaging & therapy
Magnetically()-assisted imaging &hyperthermia
Bioseparation & purification or bioactive substances immobilization
Immunoassay & biomedical diagnosis

Types of Metal Nanoparticles



Infrormation obtained from MLi, Xiangqian, et al. "Biosynthesis of nanoparticles by microorganisms and their applications." *Journal of Nanomaterials* 2011 (2011): 8.

LAB-ON-SKIN

Stretchable and flexible electronic devices as biosensors for measuring (clockwise from top right)

skin modulus stiffness)

Electro-cardiology

Hydration

Blood oxygen

Wound-healing rate

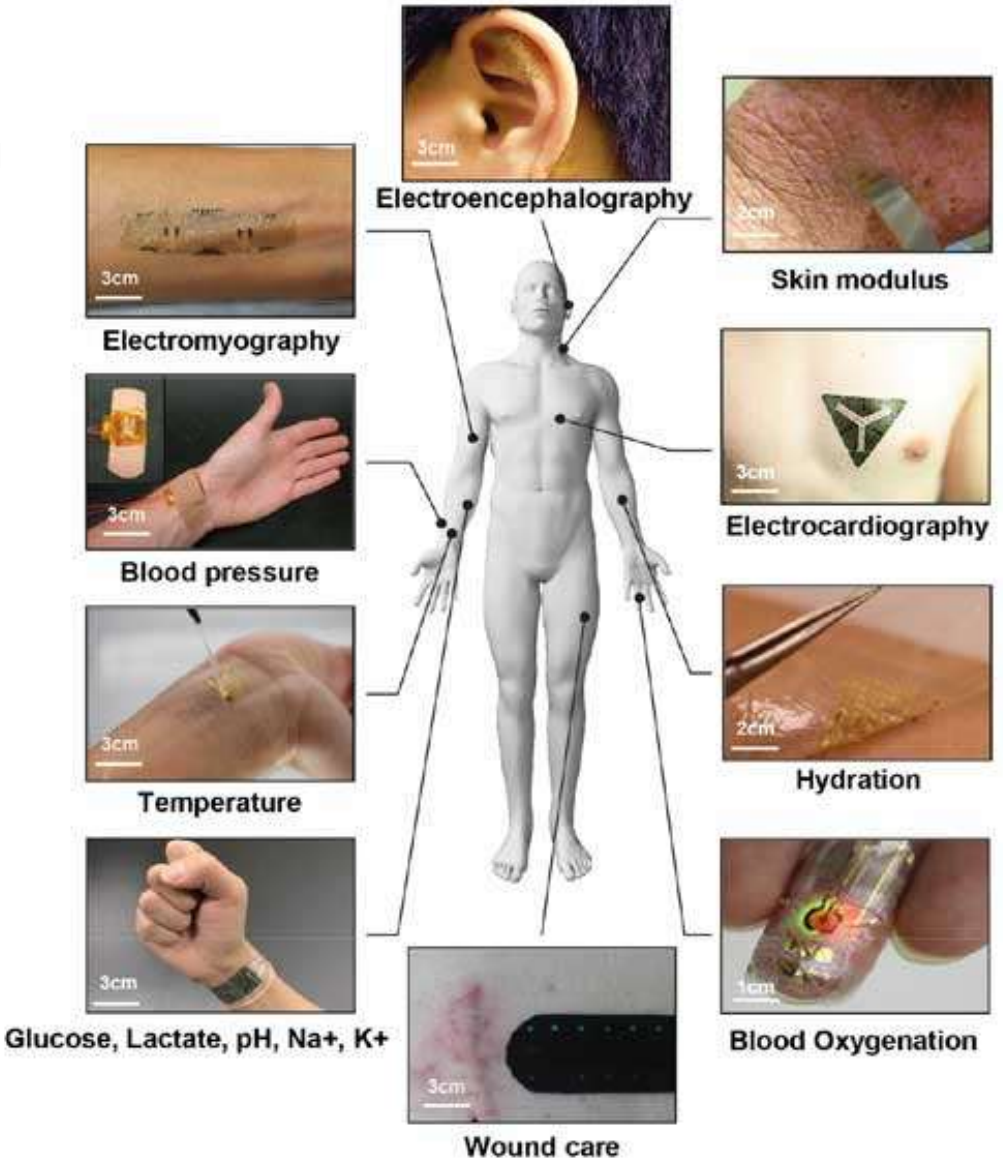
Sweat content

Skin surface temperature

Blood pressure,

Electromyography

Electroencephalography



Nanotechnology materials are going to open new realms of possibility for flexible and stretchable monitoring gadgets that are wearable directly on the skin

WHAT IF OUR PACKAGED FOODS CAME IN EDIBLE WRAPPERS, JUST LIKE FRUITS AND VEGETABLES DO?

Wikicells are edible food packaging invented by a Harvard professor for making a very thin biodegradable shell surrounding a more robust edible shell, inside of which would sit the food or beverage.

The thin shell could be removed and composted, then the thicker shell could be eaten along with the food inside or composted as well – and just like that, plastic food packaging could become obsolete.

3D-PRINTED SUSHI NUTRITIONALLY CUSTOMIZED BASED ON DINER'S BIO-DATA

From the Japanese company **Open Meals**, which debuted its complex 3D-printed sushi in Austin, Texas last year, comes a new range of high tech food that's tailored specifically to the nutritional needs of its diners.

When customers make a reservation, it'll trigger the system to automatically send them a biodata kit in the mail, which **optionally** requests body fluid samples.

The results will determine the exact creations you're ultimately served when you arrive.

Plentiful and sometimes even edible, seaweed might just become the packaging of choice for food and beverage uses, cosmetics and other applications.

It's cheap, easy to harvest and doesn't require fresh water or fertilizer to grow and can biodegrade in soil in less than six weeks.

Flexible red seaweed is used for disposable plates and cups and to make **Agar** for clear, jelly-like edible pouches.

Evoware seaweed-based packaging produced in Indonesia

SHRILK

Some bioplastics might even have a future in hospitals for tissue engineering or suturing wounds.

A material called “Shrilk” comes from the wings and outer skeletons of arthropods like crustaceans, beetles and caterpillars

It’s translucent, resilient, pliable and strong.

It could be used to create everything from garbage bags, diapers and packaging to scaffolds for tissue regeneration or growing organs for transplants in laboratories.

MYCELIUM

Mycelium is the underground portion of fungi we see growing out of the soil, and it can be used to produce a surprisingly strong material that can be grown into molds of virtually any size and shape.

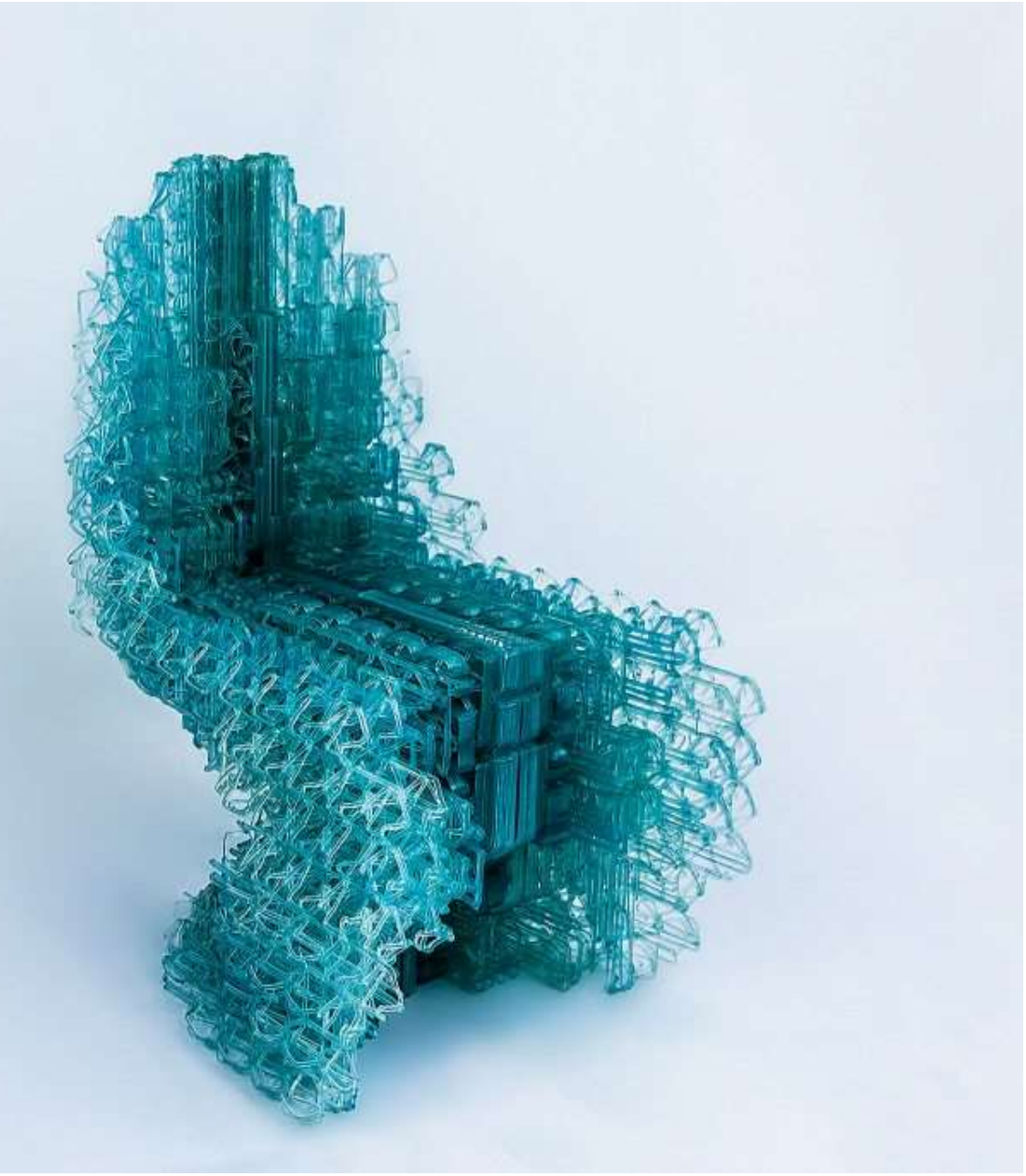
It is made with several species of fungi along with farming byproducts like leaves, mulch, seed hulls from rice and cotton gin waste to create a sort of styrofoam alternative that's actually more Ultra-Violet stable than foam and just as water-resistant.

The material breaks down within 180 days, whether in a landfill or somebody's backyard.

MYCELIUM PACKAGING BY EVOCATIVE DESIGN

CRUNCHY FOOD NEST SERIES

These Food Nests use the tomato as the main ingredient and explore the hand-size container as well as the larger group-size container for sharing.



The Voxel Chair is 3D printed using a different method than on a flat surface that moves.

It is made from transparent, biodegradable Polylactic Acid (PLA) plastic which is made from corn, with a blue tint,