D I L U V I T E™ Nanotech Composites www.DILUVITE.com

The Nanotech supplier of ultimate vibrational control materials.

D I L U V I T E NANOCAST-MMC™	Super-stiff & high damping Metal Matrix Composite, superb thermal properties. Resonance-free from 0,01hz-100khz. Very good fluidity and castability for the manufacturing of complex designs.
D I L U V I T E NANOCAST-LMMC™	Very stiff & very high damping Lightweight Metal Matrix Composite. Good cast ability for complex designs. Further improved thermal properties.
D I L U V I T E NANOCAST-PMC™	Stiff & ultra-damping (casted/forged) Polymer Matrix Composite, an ultra-lightweight Nano enhanced thermoplastic, also suitable for thin wall designs.
D I L U V I T E NANOGOLD-SMC™	Stiff & hyper-damping Structured Matrix Composite. Anti-vibrational plate material with IR shielding to enhance damping of stiff structures to improve damping. Can be thermoformed for curved surfaces.
D I L U V I T E NANOGOLD-SMC+™	Very stiff & hyper-damping Structured Matrix Composite material. Excellent IR shielding. Cannot be thermoformed (or limited curved).
D I L U V I T E NANOCARB-HMC™	Super-stiff & ultra-damping curable composite for 3D structures and inserts. Two-component Hybrid Matrix infused with hyper-stiff Nano-carbon that can be altered for stiffness, damping, weight and more.
D I L U V I T E NANOCARB-ULLC™	Ultra-stiff & super-damping Nano-carbon based Ultra-lightweight Laminate Composite for thin membranes with fair drapability allowing 3D surface designs and various ultra-light structures.
D I L U V I T E NANOCARB-HDLC™	Hyper-stiff & super-damping lightweight Nano-carbon based Heavy Duty Laminate Composite for (curved) wall structures and monocoques.
D I L U V I T E NANOCOAT-VANTAC™	Ultra-black(matt) dissipation Nano surface coating.

Categories in D I L U V I T E™ ability to store dynamic energy and prohibit unwanted resonance:

Stiff	Very stiff	Super-stiff		Ultra-stiff	Hyper-stiff
Polymer Matrix		Metal Matrix	Metal or Hybrid Matrix	Carbon/Graphite laminate	

Categories in D I L U V I T E™ ability to dissipate dynamic energy and prohibit unwanted resonance:

High damping	Very high damping	Super-damping	Ultra-damping	Hyper-damping
Metal Matrix		Carbon/ Graphite laminate	Polymer Matrix	Hybrid composite of Carbon/Metal/Polymer

About Nanotech Composites

Since the arrival of nanotechnology in the 1980's, large leaps in composite performance have been made possible by applying mechanical science on the scale of nanometres and micrometres. In fields such as surface science, chemistry, biology, energy and medicine and in applications of micro fabrication or molecular engineering, a lot of breakthroughs have been reported on what's possible with organic (carbon) and ceramic based nanocomposites. The more famous ones are certainly Carbon Nano Tubes (CNT), and graphene: the building sheet itself used for CNT's but now as a single layer in form of a hexagonal bonded lattice of carbon atoms.

Some of these materials and ingredients have become less expensive and have found their way in industrial engineering, and even appeared in some consumer products. Furthermore, scalable and affordable Nanotubes, spheres, and other structures of carbon (and/or of different molecules or materials than carbon) have been discovered, along with many new possibilities for designers and potential manufacturing improvements. Basically, it means that extreme properties previously not possible by classic engineering on a macro scale, are now made possible by rearranging the same basic atoms and molecules on a Nano scale in order to get better practical macro-level results.

Promising properties on paper do not always result in good performance. Many applications of CNT's are disappointing in performance, especially when considering performance value vs. cost. Most problems are linked to difficult and lacking production processes and dispersion problems. Using commercially available CNT's in a matrix composite, even if properly made and dispersed, the addition of these carbon nano tubes in the composite trades in gained stiffness against degraded damping properties, regardless of it being made with single walled (SWCNT), double walled (DWCNT) or multi-walled tubes (MWCNT), or the specific length of the tubes implemented.

Unfortunately, some issues also apply to graphene. On paper it may have the single highest stiffness value however, when applied as a coating or an add-on it rarely has real impact on the stiffness performance of structures and membranes: such a thin layer (0,334 nanometre, or 0.00034 micro meter; 200 times less than the thickness of an average human hair) is usually insignificant for the component's performance. Also, the boosted high paper-value applies for the in-plane direction of the platelet only. This fuels the desire of structuring it as a three-dimensional nanotube (CNT) in order to achieve some actual macro-level improvements when used as an ingredient for a material or component. Thicker, multiplied layers of graphene will fail to help in practice, as these hexagonal layers do not bond and can freely slide over each other. This explains why graphene or Graphene Nano Platelets of fewer layers are more expensive and only fewer than 10 layers are considered actual graphene (transparent): above that it is called exfoliated graphite (grey coloured).

D I L U V I T E™ Nanotech Composites are perhaps today's best and most versatile example of what *can* be made possible and put in actual and real delivered performance, when searching specifically for solutions that are usually compromised in anti-vibrational performance by the opposing stiffness and damping properties. These nanocomposites do solve the issues encountered when applying or evaluating purely macro-engineered materials or the actual measured performance of commonly applied Nano materials. Furthermore, the presented product portfolio provides for excellent thermal solutions and is offered against best performance/cost value in the Nanotech industry. Our services comprehend design and material application to meet the specific demands of any project, tailored to the most important properties of the developed component or structure, and the production method of the finalized design.

More on the big battle: Stiffness versus Damping

These two properties are desired when fighting off unwanted vibrations that cause side effects, such as distorted (audio) signals and unwanted panel vibrations. Material resonance is perhaps the most overlooked and hard to overcome factor of mechanical dynamics. It causes wear and failure of components, such as seen in the practical tool life in metalworking industries. It will also make the difference between winning a race in motorsports or losing it. Even engines that do not fail during any race could have probably be made faster using materials that keep things non-resonant, as these engines were probably tuned to a more conservative engine configuration to specifically prohibit such failures during the race. Better materials can make things both faster as well as more reliable. That fully counts for industrial production applications as well. In all these applications, structural stiffness must be applied to take on force without bending or deforming (Young's modulus or storage modulus). And just as important is damping as it helps to expel stored energy by dissipation, turning it into heat (loss factor tangent). Improving stiffness almost always means simultaneously lowering damping, and vice versa; and that is precisely the 'big battle'.

A sheet of rubber -which has very high damping- will not ring like a bell when colliding with a force applying motion to it, but at the same time it takes very little force to deform it. At the other end of the spectrum is your family porcelain: it does give a lot of structural stiffness, but it will probably make some harsh resonant noise when stapling them back in the cupboard. Acoustic materials based on plastics and paper pulp composites, provide some kind of middle-compromise.

Some metal alloys such as steel, titanium as well as beryllium-based alloys (beryllium is a very lightweight and stiff metal that is both expensive and toxic) can excel in stiffness, but perform poorly in damping. Aluminium alloys with a density between beryllium and titanium can offer some stiffness but still lack damping. Lightweight magnesium as a pure metal offers fair damping, but it will probably lose those properties when alloyed to make it usable and strong enough for manufacturing: even small amounts of common alloying ingredients, especially those needed for grain refinement of the brittle magnesium, remove all the elevated damping capacity. For the implementation in special damping alloys some very stiff and dense metals like Tungsten have showed real potential but, alloys containing Tungsten in effective amounts in order to provide sufficient increase of stiffness and damping, are very heavy (and quite expensive). This severely limits practical usability. When applied in resin composites, these Tungsten particles are very hard to hold homogeneously dispersed: the heavy particles will sink down during the curing or casting process when mixing is not possible. Often, the result for many aspects is less than poor, and the performance doesn't justify the costs.

Extremely stiff carbon ply epoxy laminates and some engineered ceramics can even provide double or triple the stiffness of steel at much lesser density, but fail in the dissipation of energy when put into resonance for having damping properties comparable to metals, whilst its laminating procedure limits design freedom and increases labour costs. Diamond may lead in stiffness, but again: <u>very</u> poor damping. Combined with high costs, practical application of structures applying diamond films (by Chemical Vapour Deposition) are severely limited and usually only chosen to achieve certain abrasive hardness or elevated conductivity figures. Even in 'cost-no-object' applications such as high end speaker membranes, both synthetic diamond and beryllium are starting to disappoint in delivering on the promise of being better or best driver membrane materials. The idea behind increased application of beryllium tweeters, is to enable unflexed 'pistonic' movement with main resonant break ups pushed above the audible frequency spectrum. Yet, every resonance has harmonic artefacts beyond frequency bandwidth making for a costly compromise of stiffness over damping and unrealistic spark over musical realism. Furthermore, super-stiff solutions mostly based on resin with carbon ply or ceramic fillers, offer very poor thermal properties.

D I L U V I T E™ offers custom solutions for virtual any application in need of both stiffness *and* damping, using assemblies of stiff and high damping Nano compounds and materials. Perhaps even more exceptional: a standalone casted matrix composite were high stiffness goes already hand in hand with high damping and high conductivity, made possible by special metals enhanced with carefully selected Nanotech ingredients into crystalline structures that are ideal for enhancing internal friction at all frequencies, thus cancelling out unwanted resonances.

Those who are seeking the best anti-vibrational and thermal performance versus cost, can choose for the casted NANOCAST-MMC™ or the lightweight NANOCAST-LMMC™. Or cast and form with the even lighter thermoplastic composite NANOCAST-PMC™ that is also applicable for thin-walls. In either way, they will take a leap in engineered performance that allows getting a big step ahead in their playing field. Designers applying D I L U V I T E NANOCAST™ will ultimately not only win the battle between stiffness over damping, but also prevail upon the competition.

For even more advanced anti-vibrational structures, D I L U V I T E™ offers bendable plates with extreme damping: NANOGOLD-SMC™ or the stiffer but less flexible version NANOGOLD-SMC+™. Furthermore, with the two-component powder/liquid NANOCARB-HMC™, virtually any three-dimensional product can be made that should be a leap forward in its anti-vibrational performance. There is even more possible with the NANOCARB-ULLC™ and NANOCARB-HDLC™ laminates. These are at the pinnacle of the D I L U V I TE portfolio, pushing far beyond any assumption of maximum anti-vibrational properties, and set a new paradigm in synergy of *stiffness and damping.*

D I L U V I T E NANOCAST-MMC™

In the last century, many metal alloys were specifically created to help fight resonance issues. Most of the alloys with high damping capacity were based on copper (Cu) and manganese (Mn), marketed under names as 'Sonoston' and 'Incramute', best known for their implementation in ship screws. In the 1980's, both practice and research exposed that these (costly) materials lost most of their damping power over time. Even at low temperatures, these alloys will self-anneal (restructure their crystalline arrangement), meaning that tension/stress between the copper and manganese is lost, whilst this proved to be the essential property for increased dissipation of vibrational energy to start with.

In the 1990's, improved Cu-Mn alloys appeared -such as the M2025 from Japan- with the addition of iron and nickel. Still, these were low in thermal conductivity. Also, stiffness and damping varies with frequency, temperature and application. In the last decades metal matrix composites became more popular. More recently there was the addition of Carbon Nano Tubes and graphene. Despite the high scores in some particular aspects, these expensive Nano-composites offer mixed results, especially when considering the costs. Although there have been big advances in all kinds of properties in all the mentioned materials, the most important challenge of stiffness vs. damping remained largely unsolved: the stiffest ones would lack damping and vice versa. Also, combined performance would vary heavily with the frequency of the vibrations and resulting resonance.

In search of the best possible material structures most inert to unwanted resonance under the most demanding circumstances, D I L U V I T E™ Nanotech Composites developed a specially structured crystalloid metal matrix, enforced by the latest developments in Nano materials (such as graphene and nanotubes), implemented in new and unique ways at far better value proposition. These composites set new standards of high stiffness in combination with high damping at any vibrational frequency. One of the most important and best applicable among the products in the portfolio is this castable Metal Matrix Composite (MMC). It provides better damping loss capacity than any commercially available alloy, even surpassing that of lead whilst also being much stiffer than e.g. aluminium alloys.

Furthermore, its unique crystal structure makes for an excellent damping loss of virtually the same high value at any frequency from <1Hz to >100kHz, something normally never seen in alloys or polymers that suffer from resonance problems at certain frequencies. The composite is stable up to temperatures beyond 300 degrees Celsius and its excellent thermal conductivity is comparable to that of aluminium alloys. This means it can be used as a heat dissipation material (heat sinks) in advanced audio cabinets and chassis, as well as industrial equipment such as precision machine parts, tool holders, measuring and lab equipment, and various other high-end applications.

The material's wideband-frequency energy dissipation is maximized whilst its density remains significantly lower than that of steel. Additionally, it is free of typical toxic materials such as lead, mercury or beryllium. Much opposed to cast iron, the material is naturally corrosion resistant. Other properties such as thermal radiation (infrared heat dissipation) can be further enhanced by coating the structure of component with NANOCOAT-VANTAC™ surface treatment.

D I L U V I T E NANOCAST-LMMC™

For many casted parts the weight is of crucial importance. Therefore, lightweight metal alloys are often chosen, even in spite of being less fit with regards to other properties. When adding vibrational behaviour to those properties, it can in fact be very problematic to find a suitable solution at all: light weight alloys can be especially easy to put into resonance (ringing like a bell) and suffer from poor damping (continued ringing after initial excitement). In contrast, the lightest structural and castable metal of all: magnesium, has pretty fair damping when casted as a pure metal. Unfortunately most of this damping capacity is lost when alloyed to make it stronger and more suitable structures and even more so when hot/cold-formed. Also of importance is that magnesium alloys are around 40% less stiff than aluminium and usually very combustible, considered to be a hazard for many companies.

Beryllium made name for its use in satellites, as it is very light and extremely stiff, but also expensive, toxic and just like most stiff materials it comes with very poor damping loss. What about titanium then? Most titanium alloys can't be really considered a lightweight choice, as titanium is 80% heavier than aluminium, therefore often replaced by carbon composites these days. Considering all the above, it is no wonder that aluminium alloys are still by far the most common choice for many products, parts and components, and are often even considered a standard. Unfortunately, comparable to titanium, all these aluminium alloys suffer from poor damping. The damping loss is not much better than that of steel, at only one third of the stiffness of steel. Therefore, at smaller wall thicknesses, steel still competes with aluminium on performance vs. weight ratio.

By implementing similar technology as found in D I L U V I T E NANOCAST-MMC™, whilst optimizing the density for lightweight implementations, a new metal matrix composite was developed. The resulting NANOCAST-LMMC™ has excellent damping properties and performs very close to the performance of the heavier MMC version. It is in fact lighter and stiffer than aluminium. The composite's damping increases at higher frequencies, much opposed to aluminium and most other metals, especially lightweight alloys. It is also strong, versatile and very conductive. Furthermore, the smart composition of (Nano) materials responsible for its enhanced properties keep costs relatively low compared to other lightweight Nano-MMC's, yet it is unmatched in its damping properties. It is also easy and safe to tool, great for complicated cast designs and it avoids the use of toxic beryllium. Much like the heavier MMC material, it is naturally corrosive resistant, but can be finished with many coating options, or further optimized for heat dissipation with ultra-black NANOCOAT-VANTAC™.

D I L U V I T E NANOCAST PMC™

Suitable as ultra-high damping material add-on for stiff structures, but especially developed for thin, lightweight standalone structures such as smaller engineered parts and membranes, this Polymer Matrix Composite (PMC) sets new standards in the combination of super low mass combined with ultra-high damping, whilst providing unparalleled stiffness amongst polymers.

Its attractive price proposition within the D I L U V I T E™ portfolio make it an excellent choice for its use as damping-inserts into designated cavities and as an add-on at larger production volumes of products in need of optimum damping capacity. It's especially suitable to further improve structures made from NANOCAST™ metal matrix composites (NANOCAST-MMC™ and -LMMC™).

The product's thermoplastic polymer matrix is enhanced by state-of-the-art implementation of very innovative Nano material assemblies, specifically designed to overcome unwanted resonance by rising the composite's stiffness above levels typically found in polymers, whilst optimizing it's damping at the same time. This Nano-polymer also overcomes dispersion problems in the matrix, as are often encountered in CNT (Carbon Nano Tubes) infused polymer/resin composites. The composite can be vacuum or pressure casted or semisolid-forged by hot-compacting. It is seven times lighter than NANOCAST-MMC™ and up to two times lighter than carbon fibre applications.

The material's damping properties are far better than any of the CNT polymer/resin solutions that have recently become available. Both stiffness and damping are much higher than that of advanced epoxy resins. Additionally, comparable with NANOCAST-MMC™, this polymer version provides for a standalone solution without the need of laminating (different from e.g. carbon ply). This makes complex forged/moulded designs possible, even at much thinner wall requirements than those applicable at metal casting or regular thin ply laminating.

The embodiment of all these highly desired properties together, position this high-tech Nano composite as the ideal choice for advanced structures, such as high-end loudspeaker (midrange) membranes and lightweight aerospace applications that should remain free of unwanted resonance.

D I L U V I T E NANOGOLD™

To open possibilities for ultimate high damping in designs using the D I L U V I T E™ Nanotech Composites portfolio, this advanced compound is especially structured to be applied as a hyper-damping, energy-dissipating sheet solution. It is designed to be an add-on to NANOCAST-MMC™, NANOCAST-LMMC™, NANOCARB-HDLC™, or any other flat or even curved surface material chosen for its extreme stiffness, but (therefore) lacking of damping loss. The most effective version of the compound sheet is a ~4mm thick matrix holding titanium nitrite coated tungsten carbide solids: NANOGOLD-SMC™

Chosen for their ultimate stiffness -over three times higher than that of advanced steels- combined with a density of more than five times that of granite rock, the tungsten carbide particles have been carefully cut to a 3D-sloped prism shape. They are positioned in the matrix to dissipate any vibrational force regardless of its direction. This results in the uttermost effective prevention and elimination of resonances in applications such as anti-vibrational platforms or top tier loudspeaker cabinets.

The clear viscoelastic polymer matrix infused with Nano-technology is a thermoset/thermoplastic hybrid that gives an interesting view into the composite's matrix, revealing the dissipation-improving triangles/prisms. The clear resin is specifically capable to allow a straight passage of infrared radiation (IR) to be reflected by the triangles. Their golden titanium nitrate coating does not only enhance mechanical properties: gold is actually the material-colour that is most effective for IR heat shielding.

D I L U V I T E NANOGOLD-SMC+™: Depending on the desired bending radius or thermoplastic properties of the sheet panels, the amount of prisms per surface inside the matrix can be increased to further increase stiffness with little loss of damping. The measurements in the illustration and table are made based on a minimum amount of prisms per square meter. NANOGOLD-SMC+™ contains a higher amount of prisms and achieves much higher loss modulus as well as higher infrared-shielding, but this is accompanied by increased weight and less suitability for tight bending. Compared to the less dense filled SMC, it is especially limited in its drapability into three-dimensional curves by thermoforming.

D I L U V I T E NANOCURE-HMC™

This absolute cutting-edge hybrid matrix composite system meets the need of a versatile and tuneable two-component resin/powder composite that can be made by curing comparable to e.g. epoxy based products. Like NANOCAST™ products, it can be implemented without the need of laminating, but also without the absolute necessity of casting moulds and heating processes.

The composites key ingredient to optimize stiffness is a variable amount of non-directional dispersed hyper-stiff NANOCARB™ solid rods. In every rod's individual direction, an extreme stiffness of 900 GPa is achieved which is comparable to diamond or the theoretical in-plane figures of graphene. This is higher than the actual measured stiffness of CNT's on macro scale, and also the hardest ceramics such as tungsten carbide and boron nitride. The filler can be applied without unwanted side effects, much unlike (hollow) CNT. The high surface area of CNT's often cause air inclusion in the resin or dispersion problems. The high molecular forces between the particles cause hard to overcome clustering. Furthermore, by aligning of the graphite/graphene plates in the highly dense and solid rods vertically, it increases thermal conductivity to more than double the conductivity of aluminium, far above the maximum conductivity of copper and again surpassing most measurements on the actual cross plane conductivity of both graphene and Carbon Nano Tubes.

Designing engineers are set free to choose the density of the composite from being lighter than aluminium to as heavy as steel, by a variable mix between NANOCARB™-filler and high density (15.6kg/litre) Tungsten carbide Nano-powder. This all without very little loss of stiffness but with further increased conductivity thanks to the dispersion of the Nano-sized particles throughout the matrix. These characteristics make it the hybrid composite of choice in carefully weighted applications. So again, by going to Nano scale, a very practical macro-level problem could be solved: the carefully selected particle size is no longer suffering from the sink-out behaviour as normally encountered with tungsten or tungsten carbide powders and granulates. Stiffness and conductivity can also be further enhanced by increasing the Nanoparticle vs. polymer ratio by vacuum infusion, hot compacting or pressure curing/forging.

Being supplied with these enhancing components pre-mixed in the powder/resin system, according to desired stiffness, weight, strength, damping, heat resistance and curing time makes NANOCURE-HMC**™** the ideal product for many advanced high-tech applications. It is suitable to replace complete -or parts of- components with a certain balance and weight, such as found in championship golf drivers and other top level sports equipment, including nautical applications and racing parts.

D I L U V I T E NANOCARB-ULLC™

At the fundaments of all D I L I V I T E**™** compounds lies the concept of zooming in to Nano scale and then change how stiffness and damping interact on a molecular level in order to overcome their role as opponents, but instead work together to achieve maximum anti-vibrational behaviour on the macro-scale. For the development of a novelty laminated-NANOCARB™ composite, this concept was taken not only as a starting point but rather as an end point. In our labs it soon pushed physics in exciting directions.

The NANOCARB™ laminates are not just infused with the concept, or made including this concept as just an ingredient: they are built by it. At the first measurements of the usable and actual "macro-level" composite, something very special happened: when the stiffness increased, the damping also increased. The physics that worked on Nano scale to improve macro-scale composites and make the D I LU V I T E™ portfolio possible, were now actually doing something many scientists considered impossible: to make composites that are amongst the stiffest structural materials of the modern world, whilst not also introducing poor damping (such as normally encountered when infusing them with Nano ingredients such as CNT's). This is the material that does it. And it pushes the number one indicator of anti-vibrational performance, stiffness times damping, totally out of the scale and beyond what was presumed possible by many scholars in materiel science publishing on novelty composites that have been researched in order to achieve maximum loss modulus.

For NANOCARB-ULLC™ the developed NANOCARB™ fibre-based tow was put to use as a flexible continuous fibre, is extremely thin and light yet still extremely stiff, whilst also remaining a very high tensile strength (as commonly known for carbon composites to far surpass that of metals). This fibre was woven and infused with the ultimate damping-enhancing topology of D I L U V I T E™ and layered into a usable constructional surface. Increased flexibility ensures drapability into the shape of three-dimensional designed membranes.

During the product's development along this novelty scientific paradigm, it soon became clear that when stiffness of the fibres and resulting laminate was pushed up, simultaneously damping went up too, up to a certain and very high point of maximum damping was reached. The resulting laminate can be made so extremely thin (NANOCARB-ULLC™ specifically), so that it weighs only 81 grams per square meter. It remains extremely stiff to prohibit inner-layer vibrations and it is highly capable of dissipating unwanted resonances. It not only lives up to all much appreciated features such as strength-properties known of aerospace carbon fibre composites, it is also more conductive, especially impenetrable by gasses and fluids, and features an improved resistant of rupture by a blunt object's impact (for performance comparison see also the purple dot/line in diagram below).

The NANOCARB-ULLC™ material is ideal for impermeable membranes and lightweight designs or enclosures that should be clean of resonance. It is expected to change the landscape of many industries seeking the ultimate anti-vibrational solution in lightweight moving parts and high end appliances. It could very well be the game changer in many cost-no-object goals and pushing anti-vibrational limits in all those fields far from horizons met today.

D I L U V I T E NANOCARB-HDLC™

Every application based material solution is made up from a world of compromises between properties and specific performance. Even when finally overcoming the assumed rules of physics concerning stiffness vs. damping and turning it into a hard-striving duo working in complete synergy, there are still other properties to consider. As explained, the ultra-light NANOCARB-ULLC™ is a Nano-carbon laminated composite made suitable for thin membranes weighing as little as possible, whilst allowing fair drapability into three-dimensional shapes. While considering these facts and appreciating the stiffness of the diamond-like carbon rods in the NANOCURE-HMC™ composite, it became clear there was yet more to be explored, and to be achieved.

The resulting Heavy Duty laminate, using a slightly more flexible form of the super-stiff NANOCARB™ rods as a continuous filament, thicker and heavier than those used in NANOCARB-ULLC™, and exchanges further increased stiffness against drapability, however, its anti-vibration properties are probably a world record. Any engineer operating in fields from world-championship sports equipment to space appliances in need of a mechanically most fit material that is of next-level dynamical precision without resonance, could very well be enabled to explore new territories of actual next-level accomplishments, far surpassing those of their competitors.

The laminate including the hyper-stiff yet impeccable weaved NANOCARB™ can still be curved and used for all kinds of structures, in contrast to the fact that today's available ultra-high modulus carbon fibres are usually only suitable for tow and roving. As for further mechanical properties, they come without compromise: it is at least 7 times stronger than high strength steel.

Performance overview by stiffness and damping

The map below shows some common engineering materials as well as human bone, described for their stiffness (Young's Modulus E in GPa) and damping (factor tan δ) at room temperature and plotted for several frequencies. Some typical viscoelastic materials like rubbers/elastomers can vary in both stiffness and damping per frequency and are not very suitable as structural compound. Many consistently stiff materials, such as metals/alloys, suffer from severe resonance or ringing at specific frequencies where level of damping loss is greatly compromised. When looking at a wider frequency-band, bones still do better than metals, even if it's super heavy (and toxic) lead. There is also a diagonal line that represents the highest combined performance of stiffness x damping loss, as often described by scholars for all mined, alloyed, synthesized and natural materials performing left/under this threshold. The D L U V I T E ™ Nanotech Composites go far beyond that line.

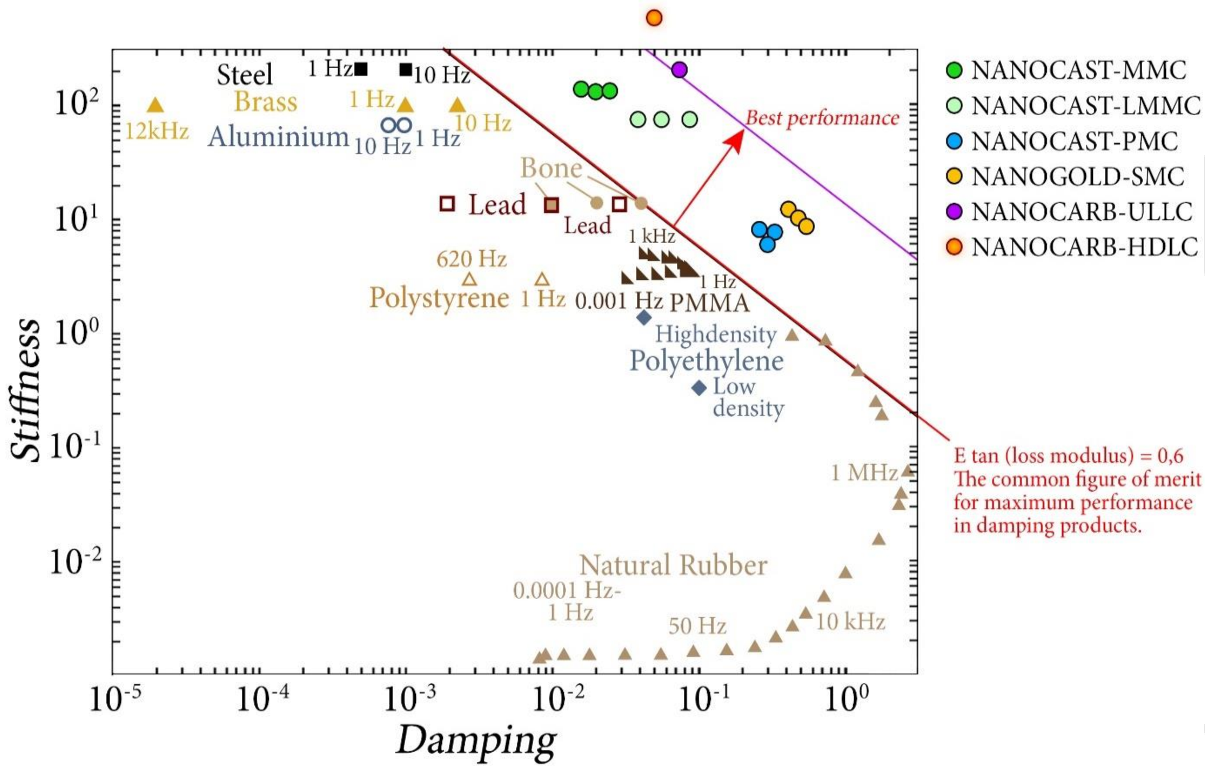

Table of (preliminary) product data amongst a variety of other materials

A comparison of materials and their application with properties listed as:

Stiffness: Storage or Young's Modulus in GPa (E, measured, averaged or range)
Damping: Loss factor (tangent)
Loss modulus: Anti vibrational performance by combination of stiffness x damping
T-Conduct.: Thermal conductivity, in watts per metre kelvin.
Cost: In 1-8* signs depending on complete applied cost relative to alternatives

Material/Application	**Stiffness**	**Damping**	**Loss modus**	**T-Conduct.**	**Cost**
Neoprene rubber	0.01	0.67	0.0067	0.05	*
PTFE (Teflon)	1.2	0.1	0.12	0.25	***
Plywood	8	0.02	0.16	0.07	*
Epoxy	3.3	0.03	0.1	0.3	**
Concrete	20	0.01	0.2	1	*
Granite	50	0.003	0.15	2.5	**
Lead	10	0.01	0.1	33	*
Aluminium alloy	69-73	0.002	0.14	150	**
Titanium Alloy 6AL-4V	114	0.001	0.1	15	***
High strength Steel	200-207	0.0008	0.16	40	**
Beryllium	287	0.0005	0.15	216	****
Tungsten	411	0.001	0.41	173	*****
Carbon ply, typical	100	0.001	0.1	0.5	****
Alu-ceramic: sapphire Al2O3	320	0.0002	0.06	35	****
SWNT measured (+theory)	542 (1200)	-	-	385 (3500)	******
MWNT measured (+theory)	400 (1600)	-	-	200 (3180)	*****
Graphene (in-plane theory)	(>1000)	-	-	500 (2000)	*****
Diamond	1050	0.00001	0.01	<2200	*******
Synth Diamond film (theory)	530 (1200)	0.0001	0.05	>800	******
M2052dampalloy(Mn20Cu5Ni2F)	47	0.03	1.41	10	****
Compressed Beech Tankwood	16	0.1	1.6	0.1	***
Tungsten Carbide	650	0.001	0.65	110	****
Aequo Audio Synth. Stone	60	0.04	2.4	0.7	***
Aequo Audio PPmix midbass	5.4	0.083	0.45	0.2	***
Aequo Audio Flexible Epoxy	1.6	0.06	0.12	0.4	**
NANOCAST-MMC™	125	0.022	2.75	135	***
NANOCAST-LMMC™	75	0.045	3.3	155	***
NANOCAST-PMC™	9	0.24	2.16	0.4	***
NANOGOLD-SMC™	>10	>0.31	>3.1	0.2	*****
NANOCARB-ULLC™ (in-plane)	~300*	0.07	13.2**	-	******
NANOCARB-HDLC™ (in plane)	~500*	0.03	15**	-	******
NANOCARB-HMC™ filler only	900	-	-	550	******
NANOCURE-HMC™	250	-	-	-	*****

*Stiffness depends on chosen thickness and layer count, resulting in numbers somewhat below or above this number.

**Although not in the same extent as graphene, these laminates are less stiff when measured off its fibre axis/direction. Therefore calculated loss modulus is based on the lower torsion stiffness of 189 GPa (UL) or 458 (HD) times damping loss.