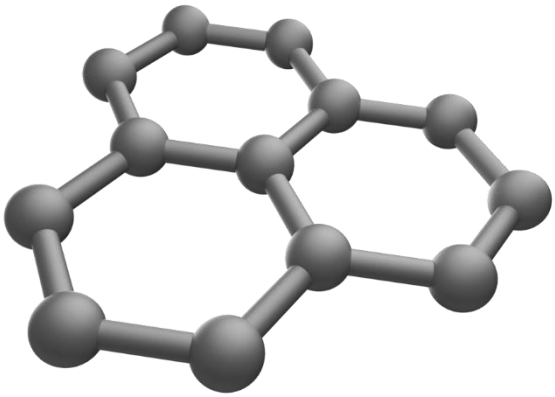
# SEAS Graphene Magnesium Technology White Paper

The latest technologies have been applied at SEAS and we have developed a new Graphene Nano-material in cooperation with a leading research institute in Europe. This is added to the coating, which ensures better audio performance as well as better corrosion protection.

The development of the new Excel Graphene solution has been ongoing for more than 2 years, required investment in test equipment beyond 100.000 USD, and the solution has been in-situ tested in various places of the world with high humidity, like in places from Singapore to Spain.

Graphene was initially discovered in the 1960s, then re-discovered around 2004 when characterized as a wonder-material, due to its spectacular properties on a Nano-scale. To benefit from these properties in our macro-scale world, Graphene must be "enabled" to facilitate the application. To put it in layman's terms, you cannot just sprinkle some Graphene over your loudspeaker and expect an improvement.



Graphene must be dispersed evenly and not clog together, because then it loses its properties and instead retains the properties of Graphite (nick named fake Graphene).

The corrosion protection of Graphene seems controversial, because Graphene is indeed electrically conductive and should instead add to a faster transport of electrons and oxidization. The corrosion protection is a result of the insulation between the Nano-particles of Graphene, and in particular a double-insulation gives outstanding corrosion protection (Source: Feng Yu, DTU https://www.nanotech.dtu.dk/Research-mega/PhD-projects/Feng-Yu).

Finally, to bring Graphene from the laboratory into industrial application, reasonably high quantity production is needed, without compromising quality. https://www.nature.com/articles/d41586-018-06939-4

SEAS developed the first commercial loudspeaker unit using a cone made from cast and machined magnesium, launched in 1993. As far as we know, we are still the only ones doing it this way today.

The SEAS Magnesium cones are famous worldwide for their audiophile qualities. Behind this technology is a unique manufacturing process, which ensures high damping as well as the stiffness of a metal cone.

First of all, the SEAS Magnesium cones are cast, not just a flat sheet that is punched into a certain shape. The casting ensures that we achieve much higher damping in our magnesium cones than other magnesium products in the loudspeaker industry. The key is that the cast magnesium is an alloy with other constituents, whereas a flat sheet of magnesium suitable for punching must be relatively pure magnesium and therefore will have low damping.

Furthermore, the casting gives us geometric freedom to vary the thickness of the cones, such that they are made thicker near the center and thinner towards the outer edge. Although the cone might look like a straight conical shape to the eye, it's mechanical vibration behavior is not purely conical, but much better behaved, due to the thickness change.

After casting, the cones are machined to reduce the overall thickness and the weight of each cone is measured, to ensure the tightest possible tolerances, which can only be accomplished by machining.

| Classical “Stone” grey SEAS Magnesium cone | Raw cone, after machining (not cleaned) | New SEAS Graphene coated magnesium cone |
|---|---|---|

Hereafter each cone is surface coated to protect it from corroding, and it also looks much better.

High damping magnesium is the best material for woofer cones because of its damping properties, light weight, combined with the good sound speed which stems from the stiffness-to-weight ratio. For woofer cones, the damping is of highest priority, even if it compromises stiffness a bit, because the woofer cones have their early break-up modes inside the audible frequency range. Therefore, nothing beats a high-damping magnesium cone.

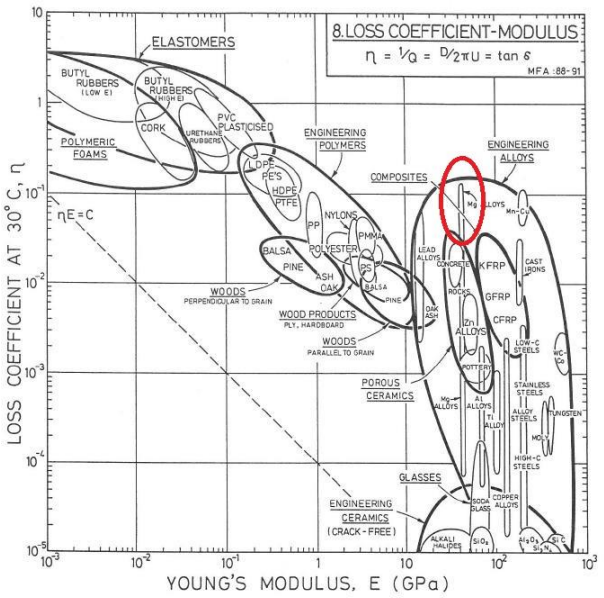
At SEAS we have spent more than 5 years and more than a thousand engineering hours to identify a better material than magnesium, maybe a composite could be the solution? but we return empty handed.

Therefore, we decided to improve on the Magnesium Technology.

Magnesium can be both low- and high-damping, depending on the alloy. See graph on the right side:

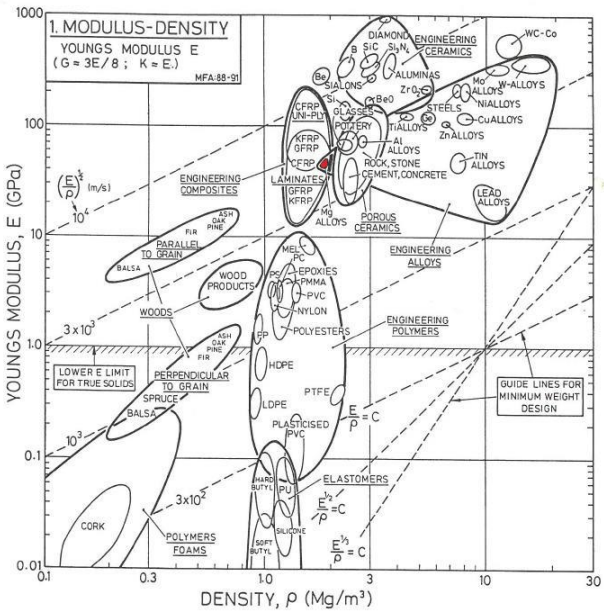
Where high purity magnesium suitable for punching also has low damping, the SEAS cast Magnesium cones has a high content of alloys and this gives it the desirable high damping property.

High damping magnesium (red circle) is the best of all materials, when benchmarked against stiffness, on par with Cast Iron, but significantly lighter!




A classical benchmark for loudspeaker cone materials is the stiffness-to-weight ratio, which gives you the speed of sound in the material. Higher is better. See graph on the right side, magnesium is marked as a red dot:

Magnesium is a soft material compared to other metals but also the lightest of all metals, and when benchmarking sound speed it is on-par with other materials, like aluminium, steel and titanium. Ceramic materials, incl. diamond, and beryllium, are located higher on the graph.




Source of graphs: M.F. Ashby – Materials Selection in Mechanical Design.

This latest technology with the Graphene coating provides the ultimate in sound performance from some of the lightest and best damped materials available in the loudspeaker industry.

SEAS Graphene, 2019-02-01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