MATERION

ADVANTAGES OF USING BERYLLIUM DIAPHRAGM COMPRESSION DRIVERS

A MATERION PRODUCT BRIEF
Delivering Smart Solutions

Summary

The audio industry has used titanium and aluminum for the diaphragms of compression drivers for years. Using these traditional one-piece dome+surround assemblies leads to a hardening of the surround area over time since it has to flex to allow the dome to move up and down. The work-hardening causes a reduction in acoustic quality and ultimately mechanical failure. By using Materion Electrofusion's rolled beryllium material and "BeX" diaphragm assembly for audio equipment, manufacturers will be able to create products with high-quality sound as well as lasting reliability.

When setting up a venue for live performances such as concerts or theaters, it is important to have equipment that will amplify the sound being produced on stage. When searching for audio equipment, audio professionals want a product that will not only reproduce live sounds and recordings in the highest fidelity, but they also want products that are durable and require little maintenance or repair.

Traditionally, aluminum and titanium have been the most popular materials used in manufacturing diaphragms for compression drivers. But both materials have been found to degrade over time, causing audio distortion and faulty frequency response. Through our research, we have found that when used as a manufacturing material for compression driver diaphragms, beryllium can reproduce sounds accurately with little to no degradation in its sound production over time.

MANUFACTURING PROCESS

Beryllium is an inherently hard metal and has a reputation for being brittle in thin structures. However, manufacturing processes have been developed by Materion to favorably alter the ductility of beryllium, enabling the manufacture of beryllium acoustic components.

PVD BERYLLIUM

Physical vapor deposition (PVD) is used to deposit thin films of beryllium onto a surface that can then be molded into the diaphragm. The grains produced in this process are coarse and are oriented perpendicular to the plane of the deposited layer. This process places physical limits on the thickness of the finished diaphragm and is not used by Materion.

ROLLED BERYLLIUM FOIL

A precisely controlled rolling process produces a highly uniform grain structure while also minimizing residual strains in the finished product. Historically, the price of rolled beryllium has kept it from being used in all but very high-end audio products, but Materion

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Electrofusion has recently developed a much more cost-effective rolling process.

COMPARISON

The difference in grain structure between the two processes results in rolled beryllium having significant functional improvements over PVD beryllium. When a moderate normal force is applied to PVD beryllium, the material shatters into multiple pieces of various sizes. Applying the same force to rolled beryllium, however, displays comparable ductility to that of titanium and aluminum. When it reaches its failure point, rolled beryllium tears or splits instead of shattering, and there's a better chance that the cohesive material will continue to function.

Currently, rolled beryllium is used in audio equipment such as field studio monitors, consumer and professional compression drivers, and radiating tweeters for both home and studio applications.

VIBRATION MODELS AND MEASUREMENTS

FINITE ELEMENT MODELING

We constructed a finite element model using the geometry of a Truextent® brand 4-inch diaphragm assembly. We ignored acoustic loads from the compression driver itself to essentially model the dome in a vacuum. We fed each material's properties into the model without changing the geometry and recorded the first six bending modes.

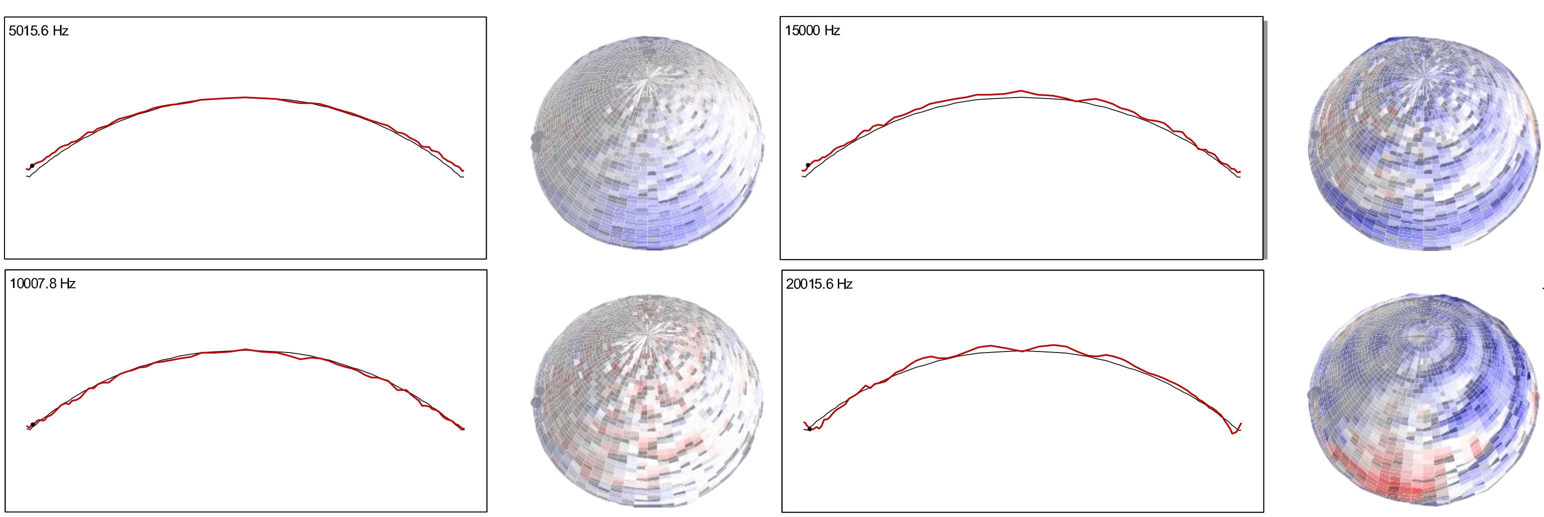
What we found after measuring the six bending modes is that beryllium's bending modes occur at frequencies approximately 2.5x higher than those of aluminum and titanium.

LASER VIBROMETRY METHODS

Using the Klippel SCN laser scanner, we were able to gather 2D and 3D measurements of the geometric and vibration scans of each of the three compression driver domes we tested (one for each of the materials: aluminum, titanium, and rolled beryllium).

These scans were made on an open compression driver (JBL® 2446 with back cover removed) using a custom fixture that ensures repeatable position of the Device Under Test. To minimize the effects of different suspension methods, these scans were limited to a 51 mm radius,

Beryllium Dome Total Vibration at 5kHz, 10kHz, 15kHz, and 20kHz.



1 mm outside the nominal voice coil radius. This restricts the measurements to the metallic part of each assembly.

The 2D and 3D measurements of each dome's vibration was recorded at four frequencies: 5, 10, 15, and 20 kHz. From these snapshots, we saw that the beryllium dome is more stable at high frequencies than either the aluminum or titanium ones. More importantly, the aluminum and titanium domes show large areas of anti-phase motion even near 10 kHz, which destructively interferes with in-phase motion. The product of this anti-phase motion is sharp peaks and dips in acoustic performance.

ACOUSTIC PERFORMANCE TESTING

We performed the following tests that included a two-inch terminated plane wave tube (Buck) using a Bruel & Kjaer 1/4-inch microphone, a Bruel & Kjaer 2619 preamplifier, 2801 power supply, and an Audiomatica CLIO 10 QC Firewire PC Windows XP® measurement system using a 192 kHz sampling rate. System calibration was performed using a Bruel & Kjaer 4231 Calibrator. The nominal 16 Ohm drivers were driven with four volts RMS for 1 watt power level.

FREQUENCY RESPONSE & HARMONIC DISTORTION RESULTS

We included both a non-ribbed and a ribbed titanium diaphragm variant as the ribbing adds stiffness to the titanium, which extends its high-frequency response while creating higher Q resonances over 10 kHz.

When compared to the three other diaphragms we tested, the beryllium diaphragm exhibited substantially more output in the two octaves from 3–12 kHz than all of the standard materials. Though the ribbed titanium diaphragm had additional energy over beryllium at the highest octave, the measured vibration was rougher.

WAVELET ANALYSIS OF TIME DOMAIN BEHAVIOR

To address sound quality issues noted by some audio professionals, we looked closer at the time domain behavior of each of our tested diaphragms. Because we know that peaky frequency response is correlated to a longer decay time, we believed we could gain insight into the relative performance of the diaphragms in professional audio applications.

We used a CLIO 10 QC to do a wavelet analysis on the impulse response of the transducer. We compared each tested wavelet to a perfect wavelet.

What we found was that the ribbed titanium diaphragm had the worst ringing of the four tested, with long decays at both the upper two octaves and at 1 kHz. The titanium diaphragm with no ribs was the second worst performer, ringing at the top octave and 1 kHz. Though the aluminum diaphragm had favorable decay characteristics, the beryllium diaphragm had the best top octave decay characteristics of the materials tested.

Though titanium diaphragms do not produce a sound

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quality on par with aluminum ones, they are utilized in the industry due to their reliability. With beryllium diaphragms, we at Materion Electrofusion believe that we have produced a material that has better audio performance than aluminum while also carrying the reliability of titanium.

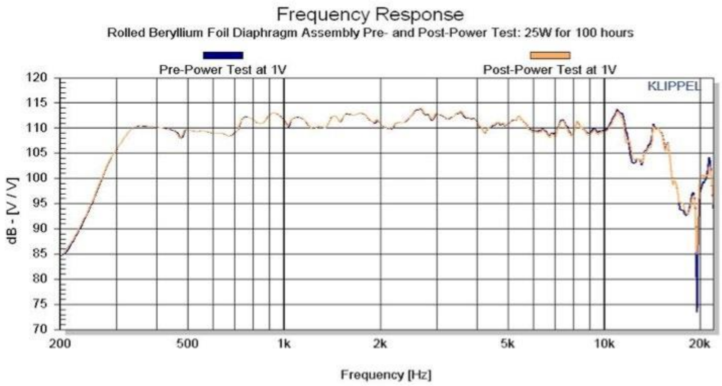
All in all, rolled beryllium foil has clear performance and durability advantages over presently used diaphragm materials.

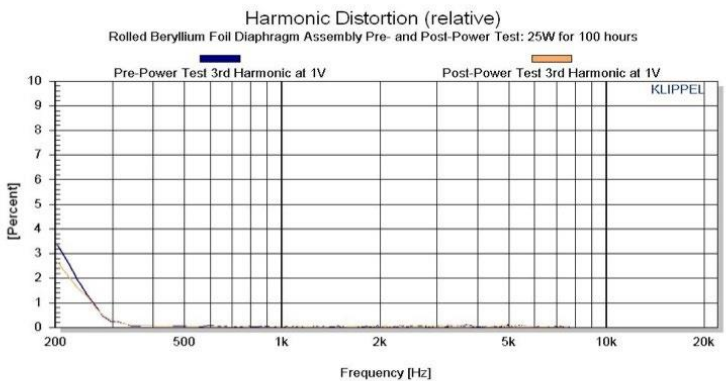
equipment, manufacturers will be able to push the boundaries of what consumers think their speakers and headphones can do.

Call Materion Electrofusion today to speak with an audio engineer on how beryllium diaphragms can enhance your equipment's audio performance.

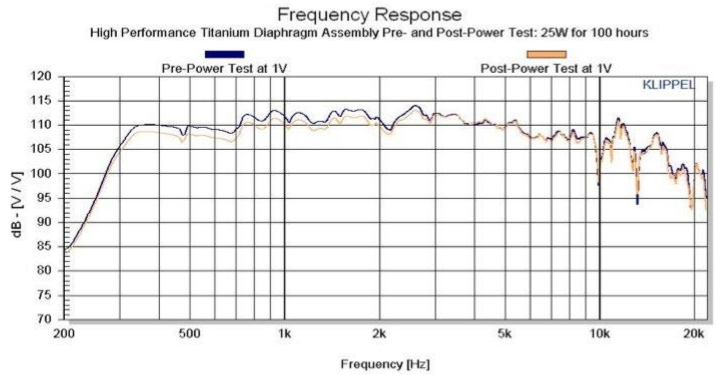
Call +1 510.623.1500 or email us at Truextent@Materion.com

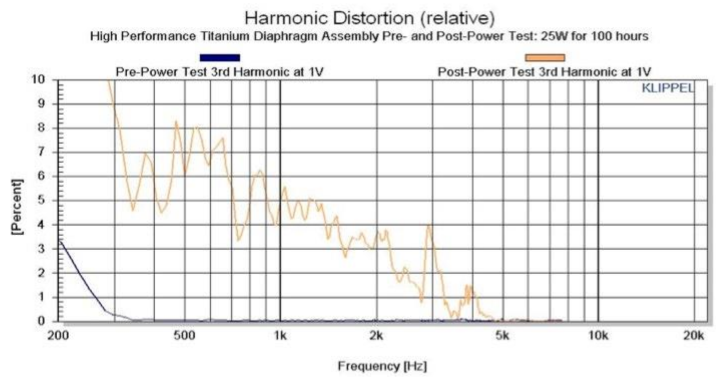
Truextent Beryllium Foil Diaphragm





Titanium Diaphragm





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