

THE WHOLE TRUTH ABOUT BERYLLIUM DIAPHRAGMS

By Steve Mowry

Beryllium is a material with the symbol Be and its atomic number is 4 on the Periodic Table of the Elements. Beryllium is a steel grey color, strong, very lightweight, and hard alkaline metal. The element is not known to be necessary or useful for either plant or animal life. Beryllium is relatively rare element in both the Earth and the universe. Beryllium reserves are located around the world with the exception of the Middle East. The USA is currently the largest producer of beryllium products and while it does have large known reserves, particularly in Utah, there are several other important known global deposits of beryllium. Estimates are that more than 50% of the planet's beryllium deposits are located in Brazil, Uganda and Russia.

HISTORY

Although Beryllium is a strategic material used in the medical, aerospace, and defense industries, it has played a role in high performance audio transducer applications since Yamaha introduced their legendary NS-1000 and NS-2000 in 1977 and 1982 respectively. Yamaha's legendary beryllium tweeter and midrange domes and transducers are shown in **fig. 1**. These domes were formed by vapor depositing Be in vacuum on pre-shaped copper molds. These transducers were utilized in Yamaha's studio monitors and highest performance home audio loudspeakers including the GF-1.

At about the same time as Yamaha introduced the NS-1000, TAD (Pioneer Electronics) introduced a Be diaphragm professional compression driver. The process used to form their diaphragms was also vapor deposition. TAD currently offers several high performance Be diaphragm compression drivers. Additionally, TAD also manufactures an exotic Be dome / Be cone co-axial two-way transducer and utilizes this transducer in their Reference loudspeakers. This co-axial transducer is illustrated in **fig. 2**.

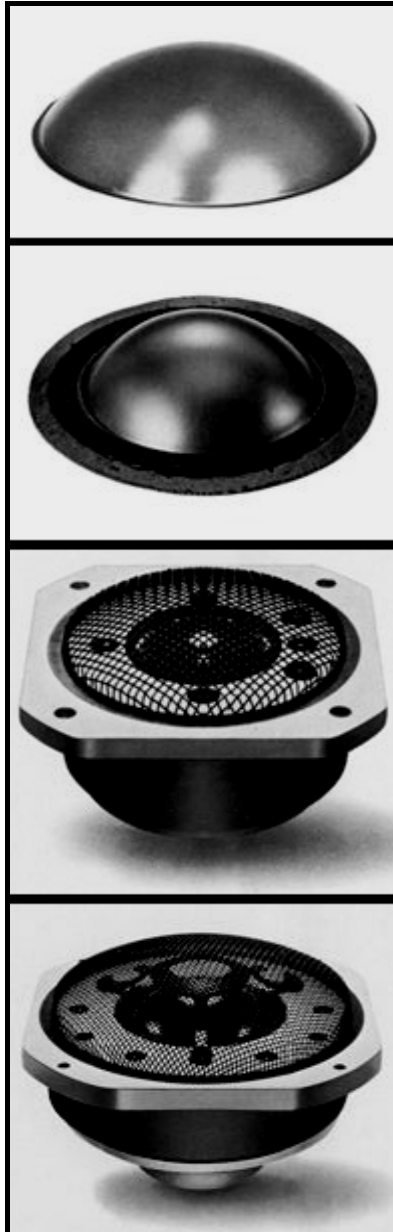


Figure 1. Yamaha's Be Domes, Tweeter, and Midrange Drivers

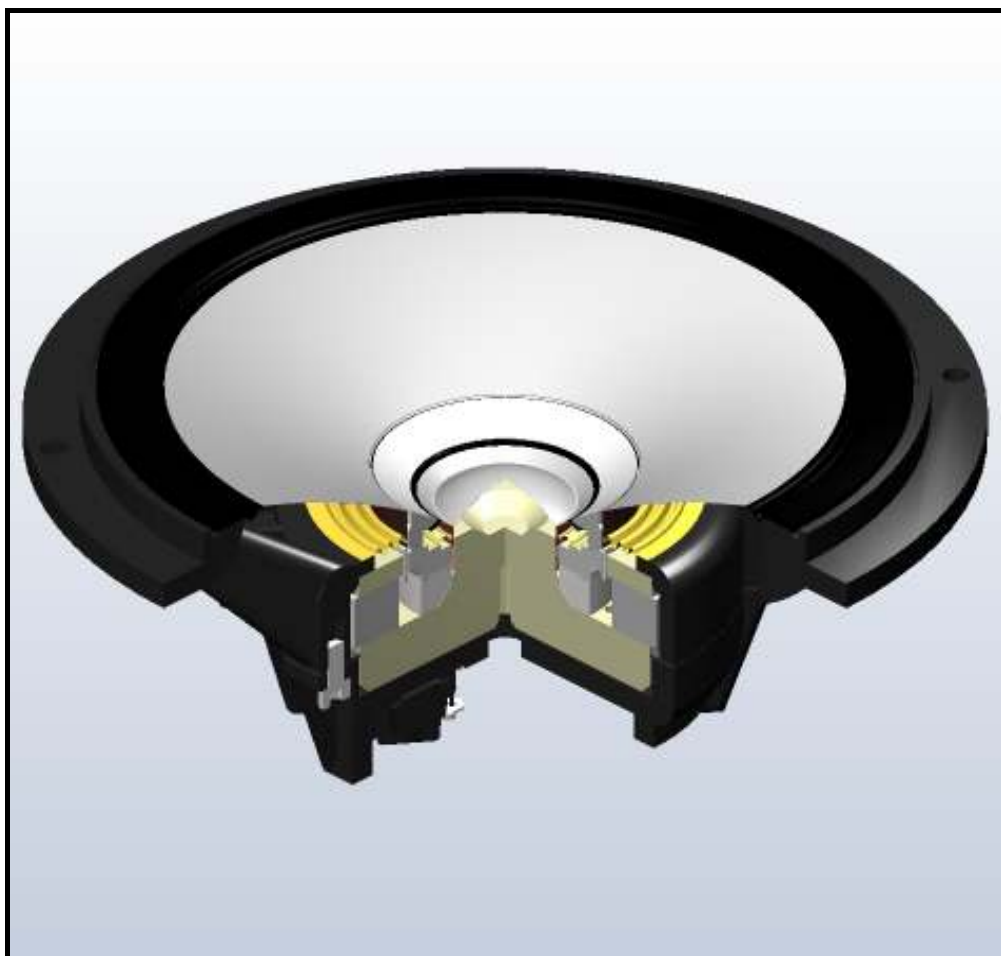


Figure 2. TAD's CST Coaxial PVD Beryllium 30mm Dome / 160mm Cone Transducer



Figure 3. A Focal 25mm Acoustic Grade Beryllium Inverted Dome Tweeter

Focal – JMLabs manufactures Be dome tweeters and utilizes these transducers in their Utopia home and professional loudspeakers. They also include Be tweeters in after-market car audio kits. I would have to guess that Focal manufactures more Be dome audio transducers than any other company. **Fig. 3** shows Focal's Utopia Be inverted dome tweeter. The Focal Be domes are hot formed from



Figure 4. JBL Pro 045Be High Frequency Compression Driver with 25mm Acoustic Grade Beryllium Diaphragm

foil material using a forming die and heat. Other companies have also implemented acoustic grade Be foil diaphragms in their best high frequency transducers including compression drivers from JBL Pro (**fig. 4**) and tweeters from Revel (**fig. 5**) and Paradigm (**fig. 6**).



Figure 5. Revel's 25mm Acoustic Grade Beryllium Dome Tweeter



Figure 6. Paradigm's 25mm Acoustic Grade Beryllium Dome Tweeter

Scan-Speak has updated their Illuminator 25mm Tweeter with an acoustic grade beryllium dome. The D3004/664000 is illustrated in **fig. 7**. The MSRP is more than US\$1,000 per pair.

S. M. Audio Engineering offers complementary symmetrical push-pull drive tweeters with no ferrous material whatsoever within the transducer assembly. The experimental 30mm Be dome STEALLUS Air Core tweeter with 2x60mm faceplate (rear enclosure cup removed) is shown in **fig. 8**.



Figure 7. Scan-Speak D3004/66400 25mm Acoustic Grade Beryllium Dome Tweeter

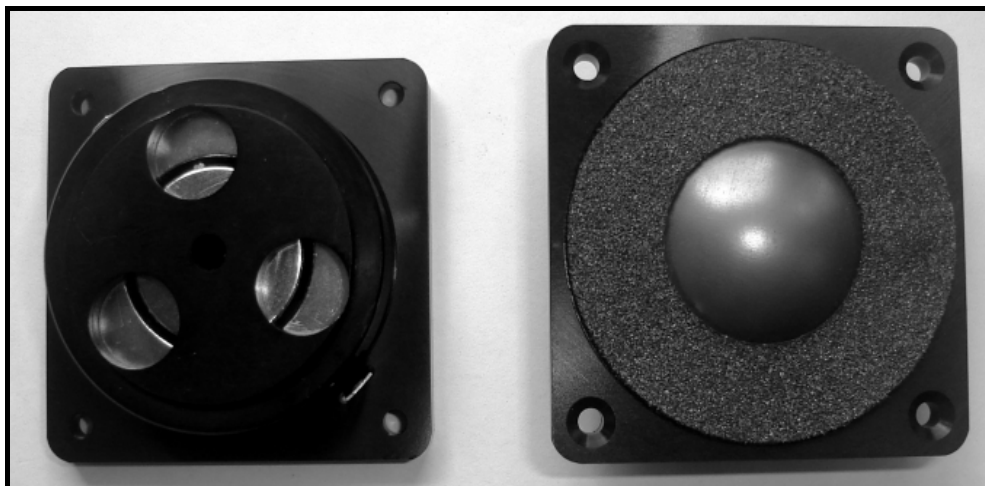


Figure 8. S. M. Audio's 30mm Acoustic Grade Beryllium Dome STEALLUS Air Core Tweeter

PROCESSES

Beryllium has a reputation for being brittle. Beryllium is inherently a “hard” metal; however, the level of brittleness is process related. There are two processes that are currently used to manufacture beryllium acoustic parts.

Physical Vapor Deposition (PVD) is a method used to deposit thin films by the condensation of the vaporized form of the material on the surface of a substrate. The process is widely used to fabricate semiconductor devices. This process is used to manufacture common items including semiconductor devices, metalized films, and coated cutting tools for metalworking. There are challenges that limit this process's capability, can the dome be made thick enough and the inherent brittleness of the resultant part. This process is used by TAD, a division of Pioneer Electronics to form Be parts.

Powder Metallurgy (Powdweed Metal) is a forming and fabrication technique consisting of seven major processing stages. First, the bertrandite and/or beryl ore is mined. Second, the ore is mechanically and chemically processed to produce beryllium pebbles. Third, the beryllium pebbles are melted into a solid block of material. Fourth, the beryllium block is chipped into powder. Fifth, the beryllium powder is consolidated into a rough shape. Sixth, the rough shape of beryllium is rolled into foil. And finally, the seventh and final step is transforming the beryllium foil into domes. There also limitations on this process's capability, can the foil be made thin enough and depth and complexity of part geometry. However, the inherent brittleness of the beryllium is much less as a result of the powdered metal technology utilized to form the beryllium foil into the finished diaphragm. This is the process is used to form Truextent® Be diaphragms. Then using Finite Element natural frequency and bucking analysis, the appropriate thickness and geometry can be identified for a robust diaphragm to the very highest performance standards.

MATERIAL PROPERTIES

For a given geometry the first bending (break-up) frequency is proportional to the material Speed Of Sound, where the speed of sound within a material is defined as the square root of the Young's Modulus divided by the Mass Density, $\sqrt{E/\rho}$ (m/s); the higher the better. However, the Mass of the diaphragm must also be considered. Then the ratio of the Speed Of Sound to the Mass Density can be used as the materials' acoustic figure of merit, $\sqrt{E/\rho^3}$ (m⁴/kg/s); the higher the better. **Table 1** lists the material properties of audio transducer diaphragm materials. A look at the material properties for typical diaphragm materials listed in **table 1** shows that Beryllium is all around the “best” material for high frequency audio transducer diaphragm applications.

Even CVD diamond cannot top beryllium. CVD diamond's speed of sound is very high but its mass density is almost twice that of Be and the CVD diamond is very brittle. AlBeMet 140 (40% Be / 60% Al) finished third behind Be and CVD diamond, see **table 1**.

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PROPERTY	Beryllium	Beryllia	Aluminum	Alumina	CVD Diamond
Density, ρ	1,840 kg/m ³	2,850 kg/m ³	2,700 kg/m ³	3,960 kg/m ³	3,515 kg/m ³
Young's Modulus, E	303 x 10 ⁹ Pa	350 x 10 ⁹ Pa	68 x 10 ⁹ Pa	370 x 10 ⁹ Pa	1,050 x 10 ⁹ Pa
Speed of Sound, $\sqrt{E/\rho}$	12,830 m/s	11,000 m/s	5,020 m/s	9,700 m/s	17,300 m/s
Tensile Strength	240 x 10 ⁶ Pa	220 x 10 ⁶ Pa	90 x 10 ⁶ Pa	300 x 10 ⁶ Pa	750 x 10 ⁶ Pa
Poisson's Ratio, ν	0.07 – 0.18	0.26	0.33	0.22	0.10
Thermal Conductivity	216 W/m/K	285 W/m/K	210 W/m/K	30 W/m/K	1,800 W/m/K
Electrical Conductivity	2.3 x 10 ⁷ 1/Ω/m	~ 0	3.7 x 10 ⁷ 1/Ω/m	~ 0	~ 0
Figure of Merit, $\sqrt{E/\rho^3}$	6.97 m ⁴ /kg/s	3.86 m ⁴ /kg/s	1.86 m ⁴ /kg/s	2.45 m ⁴ /kg/s	4.92 m ⁴ /kg/s

AlBeMet 140	Titanium	Bogusium	Deceptium	CuBe2	302 Stainless
2,280 kg/m ³	4,500 kg/m ³	3,750 kg/m ³	1,350 kg/m ³	8,250 kg/m ³	7,860 kg/m ³
158.5 x 10 ⁹ Pa	116 x 10 ⁹ Pa	120 x 10 ⁹ Pa	3.5 x 10 ⁹ Pa	130 x 10 ⁹ Pa	193 x 10 ⁹ Pa
8,338 m/s	5,080 m/s	5,660 m/s	1,610 m/s	3,970 m/s	4,955 m/s
172 x 10 ⁶ Pa	140 x 10 ⁶ Pa	150 x 10 ⁶ Pa	1.0 x 10 ⁶ Pa	300 x 10 ⁶ Pa	500 x 10 ⁶ Pa
0.20	0.34	0.33	0.33	0.30	0.25
210 W/m-K	17 W/m/K	20 W/m/K	1.0 W/m/K	130 W/m/K	16 W/m/K
2.8 x 10 ⁷ 1/Ω/m	1.8 x 10 ⁷ 1/Ω/m	2.0 x 10 ⁷ 1/Ω-m	~ 0	10.0 x 10 ⁷ 1/Ω/m	1.4 x 10 ⁷ 1/Ω/m
3.66 m ⁴ /kg/s	1.13 m ⁴ /kg/s	1.50 m ⁴ /kg/s	1.19 m ⁴ /kg/s	0.48 m ⁴ /kg/s	0.63 m ⁴ /kg/s

TABLE 1. MATERIAL PROPERTIES

PLACEBOES

Beryllium is commonly used as an alloy with copper (CuBe2). This alloy typically is no more than 2% beryllium with the balance copper. It retains the copper color. Beryllium Copper or Beryllium Bronze is used in everything from battery-operated toys to aerospace. Tang Band markets a tweeter that uses this material for the diaphragm, the [TW25-1743S](#); see [fig. 9](#). The MSRP is approximately US\$225 / pair. When I saw Tang Band's claims of "Beryllium" tweeter in late 2008, I decided to investigate. A colleague whom assisted me is also an expert had this to say regarding Tang Band's claims.

"We have performed x-ray fluorescence analysis of the Tang Band tweeter diaphragm. Our analysis indicates that the diaphragm is primarily copper. The technique we used for the analysis is not designed to precisely quantify the composition of the sample (parts per million), but I am confident that the copper content in the Tang Band tweeter diaphragm is greater than 90%."

The material properties of CuBe2 are inconsistent with industry standards for metal diaphragms and are similar to stainless steel. So as a result of this, I sent the following message to Tang Band on December 4, 2008.

Dear sir / madam:

The TW 25-1743S seems like a nice product; however, it is being represented as a "Beryllium Tweeter". Please change your description on your websites and in your advertising documentation to "Beryllium Copper Tweeter" at your earliest

convenience.

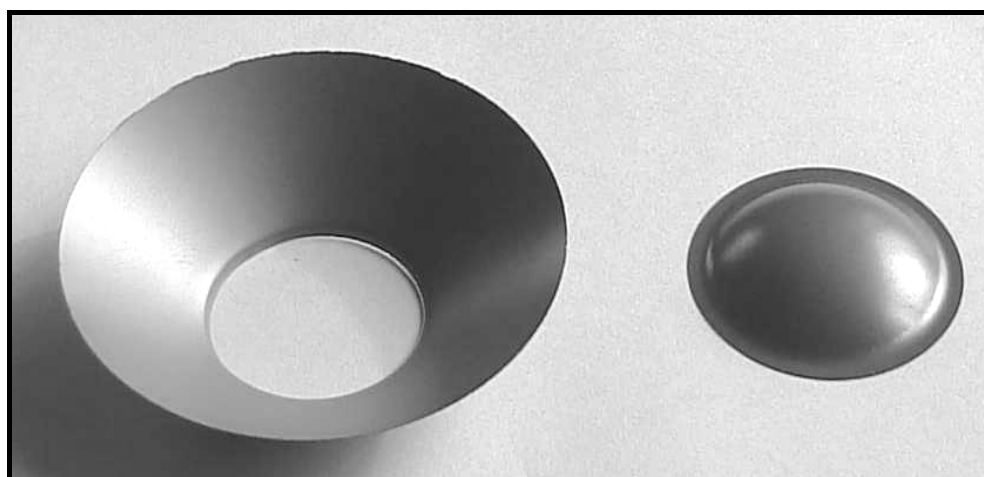
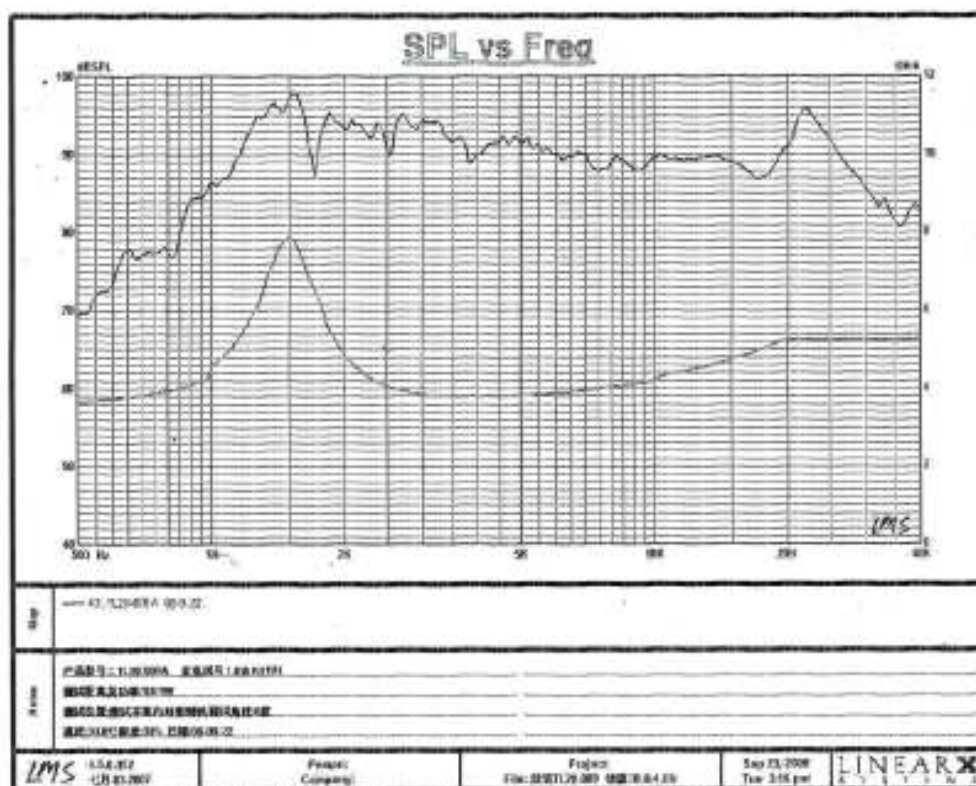
Tang Band replied to me and they thanked me and they did take some corrective action with regards to their claims. They changed their claim from “Beryllium” tweeter to “Beryllium Alloy” tweeter. The updated terminology is technically correct; although, being 98% copper it would seem more reasonable to use the terms “Copper Alloy” but perhaps less effective. The dome does look like copper. There were also comments from TB regarding testing different materials and selecting Beryllium Copper based on those tests. I followed up by asking them if they had tried stainless steel and reminding them that lead has excellent damping. Stainless steel is lower cost with better properties than CuBe2 (**table 1**) but contains no beryllium. This is my first example of the psychoacoustic analogy to the placebo effect. It seems that using material with properties that seem less optimal than any other material in use today is acceptable if approximately 2% beryllium is present. What makes Be so desirable, low mass and high speed of sound but that’s what makes CuBe2 undesirable, high mass and low speed of sound.



Figure 9. Tang Band's 25mm CuBe2 Dome Tweeter

There are also reports of ~90% titanium foil from Russia and/or China that contains less than 1% beryllium and other elements such as aluminum and magnesium at trace levels. The material has the color of beryllium but the density is approximately twice the density of beryllium foil. This material is being marketed by SONIC in Taiwan as beryllium, what I call “Bogusium”. I obtained a test report from SONIC’s representative that was performed by a certified facility in Taiwan, SGS. The report can be downloaded at www.s-m-audio.com/grayfoil.pdf. **Fig. 11** contains a picture taken in my lab of a gray foil (88.47% Ti with 0.6075% Be) Bogusium cone and an acoustic grade beryllium (98% or better) dome. See **table 1** for approximate material properties. SONIC’s representative in Taiwan sent me a message on October 10, 2008 informing me that he has resigned and would no longer market SONIC’s products. In June 2009, SONIC changed the name of their material from “Beryllium” to “Beryllium alloy” at their website. This is technically incorrect. In this case, metallurgy practices for terminology would be to call this material a “Titanium alloy”. That’s still a long way from acoustic grade Be.

I have a colleague in China who provided a client with Bogusium diaphragm tweeter sample (s). The counterfeit Be dome was obtained from SONIC. No wonder his customer rejected the sample for performance reasons. **Fig. 10** contains the output from an SPL magnitude acquisition at 1.0m on axis.



I have seen the SONIC guy or his representative at just about every trade event that I have attended including the NAMM (Los Angeles), CES (Las Vegas), MUSIKMESSE (Frankfurt), and the Hong Kong Electronic Fair. SONIC must have or is selling Bogusium diaphragms to transducer and/or loudspeaker




Figure 12. Usher's 28mm Dome Tweeter

Usher Audio manufactures the award-winning Dancer Series Loudspeakers that have a Manufacturer's Suggested Retail Prices (MSRP) from US\$2,795 / pair for the Be-718's to US\$18,860 / pair for the Be-20's! The tweeter driver used in all the Dancer Series loudspeakers is shown in **fig. 12**. It has a remarkable resemblance to Dayton Audio's RS28A shown in **figs 14A** and **14B**. **Fig. 13** shows a measurement of the Usher 28mm tweeter that was provided by SONIC's representative in October 2008. **Fig. 13** contains an SPL magnitude measurement of Usher's 28mm tweeter that was provided to me by SONIC's representative in Taiwan.

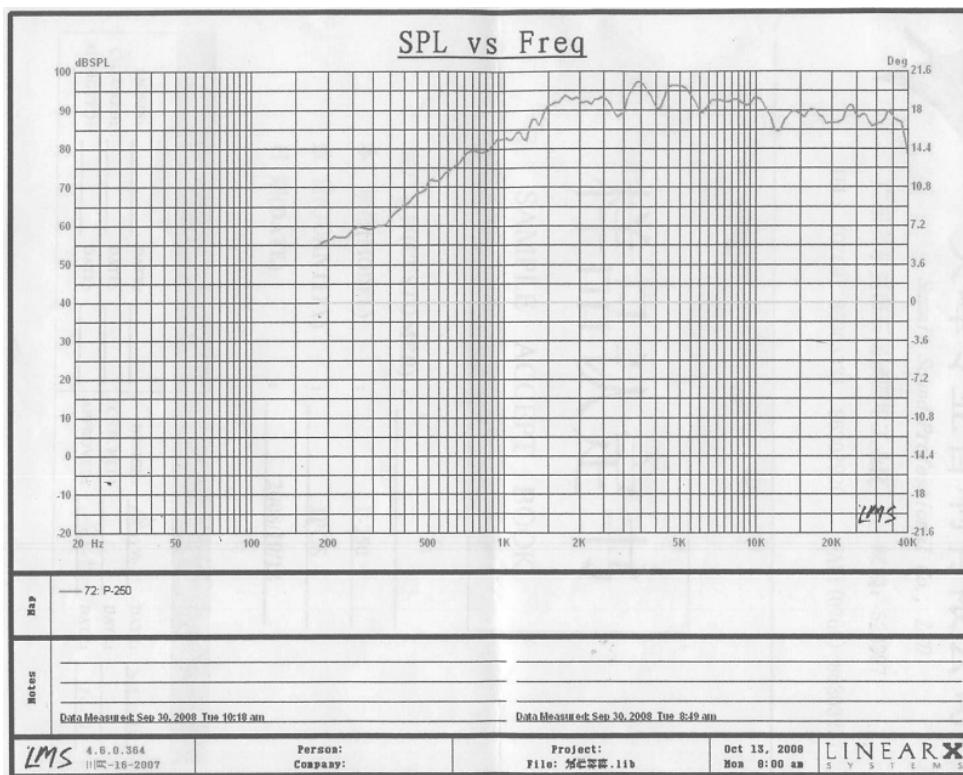


Figure 13. SPL Measurement of Usher's 28mm Dome Tweeter



Figure 14A. Dayton Audio's RS28A 28mm Black Anodized Aluminum Dome Tweeter with an MSRP of US\$125 / pair



Figure 14B. Replacement Diaphragm Assembly

A smoothed quasi-anacohic SPL magnitude measurement at 0.5m of the Dayton RS28A was obtained courtesy of [Dave's Speaker Page](#) and is shown in **fig.15**.

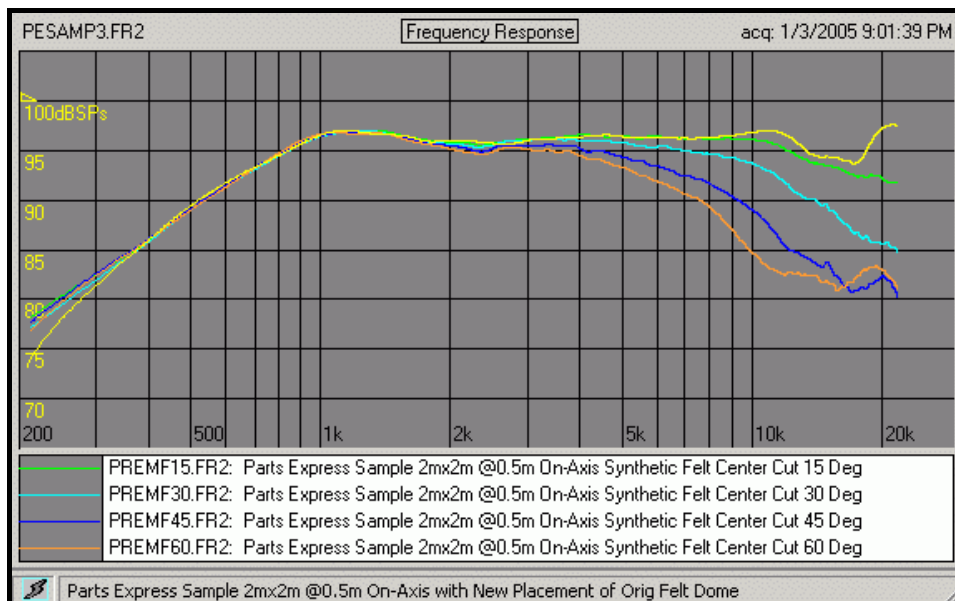


Figure 15. PRAXIS Magnitude Acquisitions of Dayton RS28A Tweeter

After Chris Marten's review of the Dancer CP-8571 II published in the June/July 2005 issue of the Absolute Sound. Mr. Tsai, Usher's transducer engineer made comments to Chris Marten that are disturbing to me. Tsai seems to belittle beryllium foil and to confuse the reader by quickly shifting from objective to subjective comments. Engineers' typically don't use highly subjective terms like the ones contained below. Had he been coached?

Marten: *How does Usher's Beryllium Oxide tweeter construction differ, say, from Focal's Beryllium tweeter. What is different/better about BeO as used by Usher? What performance improvements does BeO bring vs. fabric dome tweeter used in CP 8571 MkI?*

Tsai: *As far as we know all the Beryllium drivers on today's market use the same diaphragm material, because there is only one supplier (Brush Wellman) who can provide Beryllium foil in useful thickness for speaker diaphragms...*

The Beryllium diaphragm was heated to over 700 degrees during the manufacturing process and turned into a brittle, though of extremely high strength, Berylla (Beryllium Oxide) ceramic, hence the name BeO.

The ultra-high specific strength (strength over weight) of the BeO dome has pushed the tweeter's transient and distortion performance to a new level that just isn't possible with the traditional fabric dome. In audiophile terms, BeO eliminates yet another layer of haze from the reproduced music. It's a further step towards complete transparency. Just as important, the sonic signature (if any) of the BeO material has proven to be very neutral and musically favorable (unlike most high tech diaphragm materials of the yore).

I discussed these claims by Tsai with several industry colleagues and they all agree that these claims are incredible. Beryllia (BeO) is a whitish color. Usher's diaphragms have beryllium's steel gray color. The inherently brittle nature of Beryllia, BeO would require great care to be exercised for proper handling in order to minimize potential health concerns. To transform a beryllium diaphragm into a beryllia diaphragm would take more than just heat. It would require a process like KERONITE's Plasma Electrolytic Oxidation. This is similar to what ACCUTON does to aluminum foil diaphragms, deep anodizing overnight with subsequent firing at high temperature, to transform Al to Al_2O_3 , Alumina. ACCUTON drivers are popular with DIY's and salon loudspeaker companies but contain no beryllium.

Usher Audio's inverted dome midrange driver with a tall cup spider, aluminum shorting rings, foam surround, and single ferrite magnet is shown in **fig. 16**. It has been claimed to be the first "Beryllium" midrange. This claim is highly controversial and I cannot verify this claim. On December 10, 2000, I sent the following message to Usher Audio.

Dear Paul,

There are only a handful of transducer and/or loudspeaker companies that claim to use beryllium diaphragms. When I investigated this topic I discovered inconsistencies in Usher's claims. I have discussed your claims with other industry engineers and scientists and the controversy of your claims just cannot be resolved.

I believe that Usher purchases diaphragms for your "Beryllium" tweeter and midrange from SONIC, located in Taiwan. I am attaching a copy of material analysis of SONIC's Russian Beryllium Foil for your review.

Subsequently Usher Audio USA replied to me and did indicate that Usher had received material test reports on material supplied by SONIC. The reports showed a low content of beryllium in their beryllium. Usher also told me that SONIC was removed from their supplier base.

Usher posted similar Information at www.usheraudiousa.com that is contained below.



Figure 16. Usher's Inverted Dome Midrange

News December 2008 Usher Audio, Taipei, Taiwan has announced they are looking in to a possible materials content discrepancy in the current beryllium tweeter and beryllium midrange drivers. Usher is currently analyzing the driver's raw materials to check for the proper percentage of beryllium alloy.

News February 2009 Usher Taipei has now completed content analysis of several different batches of diaphragm materials provided by their original materials supplier. The reports show inconsistent results in the beryllium content for the diaphragms. In short, some of the diaphragms have lower beryllium content than the supplier represented to Usher.

Fortunately, all of the diaphragms still exceed Usher's criteria by a comfortable margin in terms of measured performance. As a result of the testing Usher has chosen to drop their original supplier and work with Brush Wellman on sourcing pure beryllium diaphragms.

Keep in mind that the material from SONIC that they were (are) using has twice the mass of Be. Frankly, it's hard to miss this for high frequency transducers. A simple incoming Quality Control check is to weigh (10) diaphragms and then divide that quantity by 10 giving the average dome mass. Then using common hand held mechanical measurement tools, determine the thickness and geometry (surface area). Multiply these quantities to get volume. Then just divide the mass by the volume to get density. The result should be approximately 1.85 g/cc.

Then what's the difference between an 25mm aluminum dome and a 5mm Truextent® Be dome? Even in small quantities (~1,000) quantity, the cost increase is no more than US\$30.00 more per tweeter.

In addition to Tang Bang and Usher, my expert source has indicated to me that the award-winning Sonance's AS "Beryllium In-walls" are built with beryllium film (similar to metalizing) deposited on PP, or what I call "Deceptium". An example is shown in **fig. 17**.



Figure 17. Sonance's In-wall with Deceptium Cones and Dome, MSRP US\$3,500 / pair

This information was obtained during a conversation with a Sonance representative at a previous CES in Las Vegas, NV, USA by my expert source.

I never sent a message to Sonance questioning their claims. The fact that Sonance's claims are so bizarre, I decided it just was not worth any effort to question those claims.

Not all companies embrace the placebo approach. KRK Systems manufactures an active 2-way monitor loudspeaker with an AlBeMet 140 dome tweeter, see **fig. 18**. Their claims are clearly stated as an "Aluminum / Beryllium Metal Matrix Composite" inverted dome.

They do not simply claim "Beryllium" and AlBeMet 140 is 40% Beryllium. KRK's 8-inch woofer uses what looks like a molded Arymid fiber-epoxy / hard foam / Arymid fiber-epoxy high performance sandwich composite cone. The MSRP of the Expose E8B is about US\$6,000 / pair.



Figure 18. KRK Systems Expose E8B Active Monitor Loudspeaker

CONCLUSIONS

What fascinates me is that just about all the true "Beryllium" loudspeakers are classics and/or reference systems. These include the Yamaha's, the TAD's, the Focal Utopia's, the REVEL Utlima2's, the Paradigm Signature Series, and the JBL K2 loudspeakers. With the exception of the Yamaha's, all the others are currently available to consumers and users.

At the end of the day, it's still the consumer and the user that identify loudspeaker designs that have merit and value. Can the consumer be fooled by advertising rhetoric and deceptive claims? I don't think so and certainly not in the long run. The life span of the true beryllium loudspeaker products demonstrates the value added by implementing the "best" acoustic solution(s) possible. Brush Wellman Electrofusion Products' Truextent® is simply the "best" diaphragm material on the planet. Brush Wellman Electrofusion Products can form a new

custom diaphragm or diaphragm assembly or they have domes available with surround and without surround (**fig. 19**) and they are developing complete upgrade diaphragm assemblies like the one shown in **fig. 20**. Brush Wellman Electrofusion is currently working on Truextent® 4-inch diaphragm assemblies that are expected to be available for shipment in the late third quarter this year. Other Truextent® diaphragm designs will follow.

As with most elements of an audio system, it's the weak link that limits the system performance.

Beryllium loudspeaker applications require that other updated be designed into the

system for results to reach the full potential of performance and value (value = performance / cost). Specifically, active (powered) loudspeakers are really a must. Passive RLC components are not up to Be performance standards. Even discrete components (transistors or tubes) and/or integrated operational amplifiers lack flexibility, an on board optimizer, and a user interface. The state of the art is DSP crossover, equalization, filtering, compression and expansion et al. with amplifier modules in the box. KSC offers the revolutionary Digmoda active loudspeaker electronics modules with D-PRO Windows user-friendly

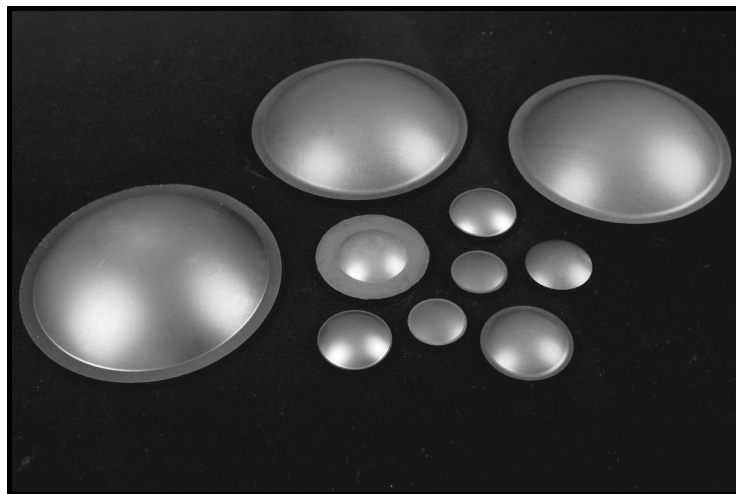


Figure 19. Brush Wellman Electrofusion's Truextent® Acoustic Grade Be Domes



Figure 20. Brush Wellman Electrofusion's Truextent® Beryllium 4-inch Voice Coil Replacement Diaphragm Assembly

software, DSP with the mouse and ICE Power high power and performance amplifiers. The other transducers within the system must also utilize materials and processes that are state of the art and this almost certainly rules out “paper” but does include MAGONITE and sandwich composite cone implementations. Additionally, the traditional transducer topologies could benefit from an upgrade. *STEALLUS* transducer topologies are a more linear and mechanically stable driver implementation. Replacing a Ti or Al dome with Be may not be enough to justify the cost and realize expectations; however, as the performance limits of the other system components are improved, Truextent® might not just be the best but the only reasonable solution.

For the very highest performance high frequency transducer, Truextent® beryllium foil can also be utilized for the voice coil bobbin as well as the diaphragm. However, a few words of caution are offered, any company that claims to utilize a beryllium cone is suspect. Brush Wellman Electrofusion has yet to implement a beryllium foil cone as of the date of this discussion. The development of the forming process for a Be cone up to 150mm outside diameter is being considered for a future project. TAD is the only company presently offering a transducer with a beryllium cone (*fig. 2*).

Mike Klasco and John Schaffer said in the September 2001 Voice Coil. “While there are about four sources for beryllium worldwide, only one operation can provide beryllium foil in useful thickness for speaker diaphragms, and that is Brush Wellman Electrofusion.” Mike and John were correct and this has not changed. Mike Klasco and John Schaffer also wrote about “Bogus Beryllium” or what I call “Bogusium” in the September 2004 issue of Voice Coil. That discussion was also based in part on a test report from Brush Wellman on Be domes also from SONIC. The issue of counterfeit beryllium hasn’t changed much in five years. SONIC found a way to add trace amounts of Be (0.6075%). This was verified by the SGS report. SONIC along with a few other companies have demonstrated a propensity to claim a material is “Beryllium” if it contains 2% or even less beryllium. Suppose someone purchased “Red Wine” or any commodity that was 2% or less pure, how could that ever be considered acceptable to anyone of reasonable intelligence? This is a highly controversial topic to say the least and there is no place for this nonsense in the loudspeaker industry or any industry for that matter. Yet an aura of arrogance seems to be associated those whom choose to practice the art of deception through psychoacoustic placebos. Material science plays a significant role in the fundamental skill set of transducer and/or loudspeaker engineers and scientists. Companies such as Yamaha, Pioneer Electronics, Focal, Harman International, Paradigm, KRK Systems, Brush Wellman Electrofusion Products, and S. M. Audio Engineering have ethics and are dedicated to advancing and improving the listening experience. Frankly, consumers must resist deceptive claims from those who lack respect for the “laws” of acoustics. The honorable disciplines of engineering and science are related to capability and credibility. In an orderly society, consumers have the right to fair and reasonable product material claims.

Not only can beryllium diaphragms improve transducer and loudspeaker performance, just the claim that there is beryllium present regardless of the percentage, seems to add value to loudspeaker products in the short run. The

people that have worked to develop the processes to make acoustic beryllium diaphragms possible deserve respect for their accomplishments. If unfair competition from companies that distribute or utilize counterfeit beryllium and/or misrepresent 0.5% to 2.0% beryllium combined with titanium and a bit of steel gray paint or copper as “Beryllium” Grade products were to cause a disruption in the supply of acoustic beryllium foil and beryllium diaphragms, we would have to settle for the inherently deceptive acoustic placebo effect analogy. With respect to economies of scale, counterfeit beryllium just increases the cost of acoustic beryllium and misrepresents the true value of acoustic beryllium parts to the consumer and user.

If readers have questions, concerns, interests, and/or comments regarding acoustic beryllium products and/or applications, feel free to contact me at steve@s-m-audio.com.

AUTHOR

Steve Mowry was significantly responsible for the design and development of the Bose 2 $\frac{3}{4}$ " plastic-basket-baffle multimedia AM5 Lifestyle “cube” transducer in 1997-1998, “Hotshot”. This in raw quantity is one of the largest-selling electrodynamic audio transducers of all time and is still being manufactured today. Steve is currently an independent researcher, lecturer, and consultant in transducer, loudspeaker, and headphone design and new product development with open R&D projects concerning large signal nonlinear FEA simulations and measurements, *KERONITE* surface treatments, metalizing polymers, active loudspeakers, DSP, acrylic surrounds, sandwich composites, and *STEALLUS* transducer topologies along with being a frequent contributor to *Voice Coil* and *MultiMedia Manufacturer*.