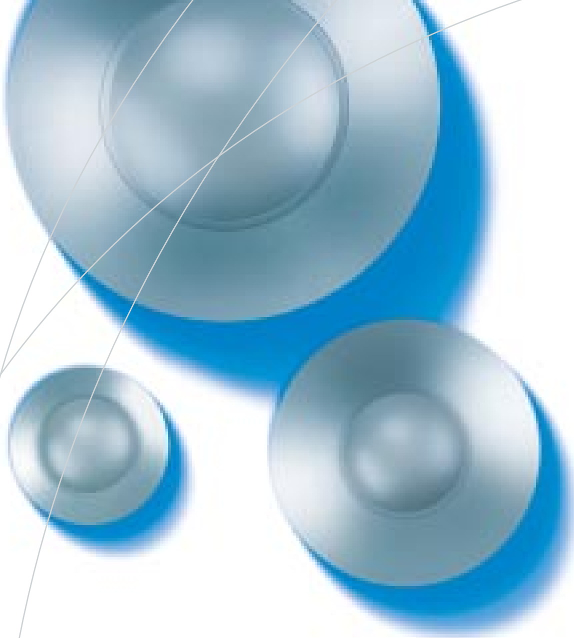
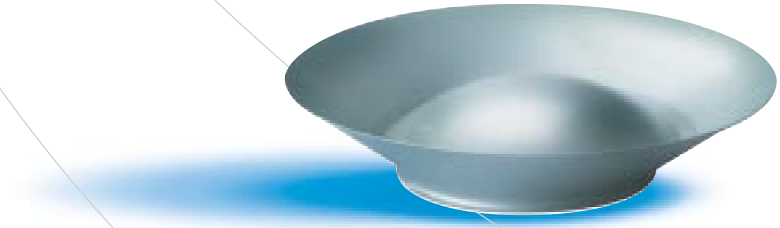


MMD™

Metal Matrix Diaphragms

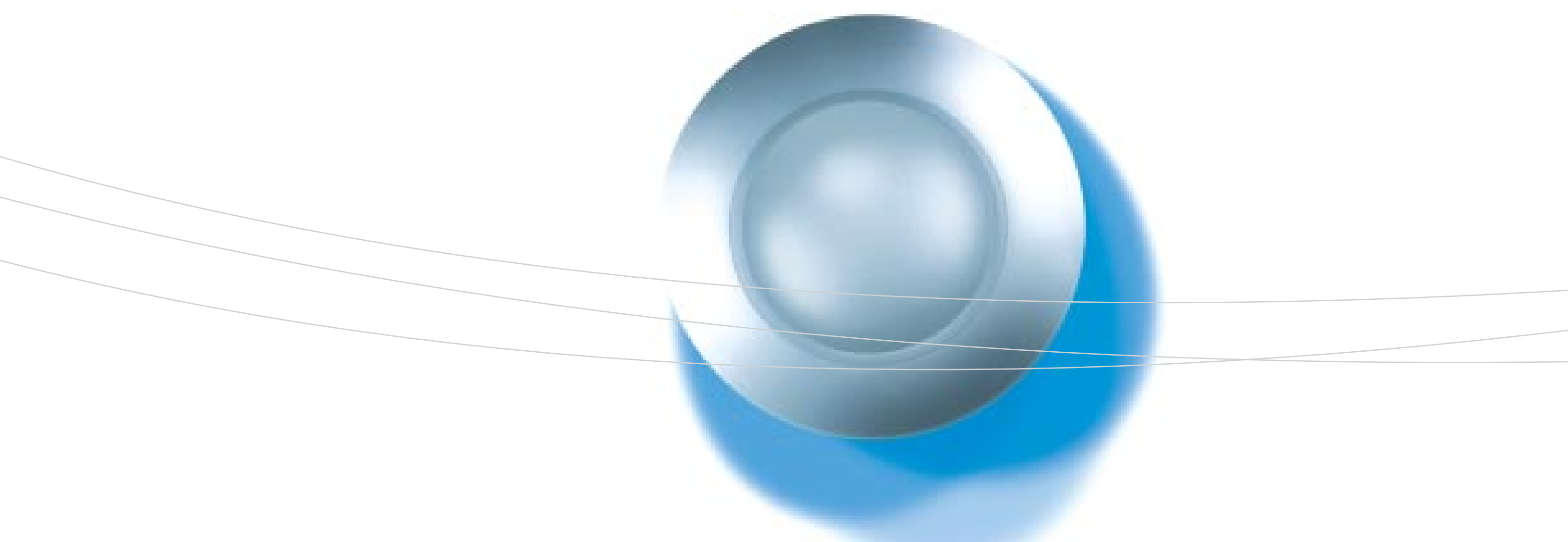
Infinity®

Technology • Performance • Design

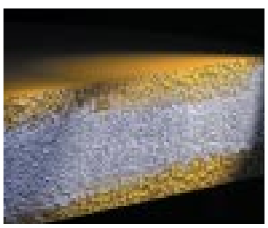


A Technical Report on Metal Matrix Diaphragms MMD™

Loudspeaker systems should be neutral devices, converting electrical signals from power amplifiers into exact acoustical equivalents, adding and subtracting nothing. Art is in the music itself, and in the musical sounds from fine instruments, played by talented musicians. The task of loudspeaker systems is to reproduce this art transparently, without "editorial" changes. Our objective is to build loudspeakers that are as neutral as possible, that accurately reproduce the subtle identifying characteristics, or timbre, of voices and musical instruments.



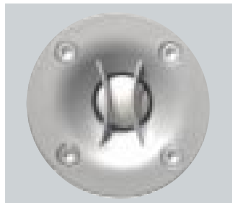
Many factors are involved in the design of a superb loudspeaker system. There are the transducers, or drivers, that convert electrical signals into sound; the electrical crossover networks that divide the frequency range, sending the appropriate frequencies to the woofer, midrange and tweeter; and the enclosure, which is a critical acoustical part of the woofer system, and an acoustical and decorative baffle for the other components. Excellent performance is required of each of these elements if the system as a whole is to be a success, but transducers are, in fact, the most critical components. They are the heart of a loudspeaker system.



An electron microscope photograph showing a cross section of an MMD cone.

New MMD™ Driver Technology

Derived from our patented CMMD™ technology, Infinity's new Metal Matrix Diaphragms (MMD™) continue the Infinity tradition of using advanced materials to improve sonic accuracy. By anodizing both sides of an aluminum core, we're able to significantly improve cone performance and outperform cones made of paper, polypropylene or Kevlar.®



By virtue of its extreme rigidity and resistance to resonance, MMD is far more than just another diaphragm material – it is an ideal diaphragm material for the ultimate listening experience.

Listening Evaluations

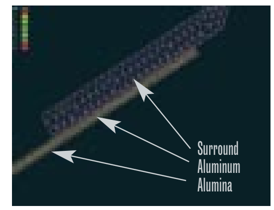
Because listeners are the final judges of how well loudspeakers perform, we ask them to help us determine what various technical measurements mean. It takes many tedious subjective evaluations, with many listeners and different kinds of loudspeakers, to determine the audibility of various kinds of defects.

Of all the problems that surface in these investigations, resonances stand out as being one of the principal causes of listener dissatisfaction. Why are resonances so important? Probably because almost all of the sounds we want to hear are made up of resonances. In voices and musical instruments, high-Q (narrow-band) resonances define the pitches (the notes), while combinations of medium- and low-Q resonances constitute the timbral character that makes a violin sound like a violin, and Pavarotti sound like himself. Loudspeakers with strong resonances of their own alter the timbre and, therefore, the sound of instruments and voices. We work diligently to eliminate resonances from our transducers and systems. Working in collaboration with metallurgy specialists, the resourceful Infinity transducer engineers identified a special combination of materials that exhibit a remarkably useful set of mechanical properties. Infinity's new Metal Matrix Diaphragms are much stiffer than standard metal diaphragms, moving the natural modes significantly upward in frequency outside the driver's band of operation.

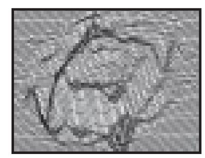
A computational model of the moving assembly of a loudspeaker: voice coil, voice-coil former, cone and surround. The model is used to calculate the resonant modes of the system for different cone materials.

Laminated Materials

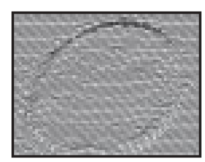
This is accomplished by first forming the cone to shape in aluminum. A unique process is then used to deposit a skin of alumina on each side of the aluminum core. The alumina supplies strength and rigidity, and the aluminum substrate supplies the resistance to shattering, which is problematic in conventional ceramic. The resulting laminated material is less dense and less brittle than traditional ceramics, yet is stiffer than aluminum, and much stiffer than nonmetallic materials.



The above illustration shows detail of the modeled structure. One can see the ceramic (alumina) outer layers of the diaphragm (red), the aluminum core (green), and the much thicker surround material (purple).



A scanning-laser vibrometer measurement of cone movement for a 6-1/2" Kevlar-weave cone, at a frequency of 3.5kHz.



A scanning-laser vibrometer measurement of cone movement for a 6-1/2" CMMD cone, at a frequency of 3.5kHz.

MMD is an ideal diaphragm material for the ultimate listening experience.

The construction of a cone assembly, showing the diaphragm connected to the voice coil that drives it, and spider and surround that support it.

Moving the Modes Up In Frequency

$$\text{velocity} = \sqrt{\frac{\text{stiffness}}{\text{density}}}$$

For a given diaphragm geometry, the frequencies of the natural modes are determined by the speed of the sound in the material which, in turn, is determined by the formula above. Thus, for every doubling of the speed of sound, we move the cone modes up a full octave.

At the same time, MMD cones have more damping than metal cones, making this an excellent cone material for all transducers: woofers, midranges and tweeters.

Naturally, neither MMD nor any other diaphragm material can magically transform a loudspeaker system into a perfect reproducer. The other variables referred to at the beginning of this article are also critical, and top-notch engineering of every element of the system is needed in order for the integrated system to "shine." "The proof of the pudding is in the eating," as they say, which in audio terms translates into "it isn't good until it sounds good."

Material	Material Class	Young's Modulus (stiffness)	Density	Speed of Sound
Polypropylene	Polymer	1.5 x 10^9 Pa	0.9 g/cm^3	1300 m/s
Kevlar® Fabric	Composite	3.1 x 10^9 Pa	0.9 g/cm^3	1860 m/s
Paper	Composite	4 x 10^9 Pa	0.7 g/cm^3	2390 m/s
Aluminum	Metal	70 x 10^9 Pa	2.7 g/cm^3	5100 m/s
Alumina	Ceramic	340 x 10^9 Pa	3.8 g/cm^3	9460 m/s

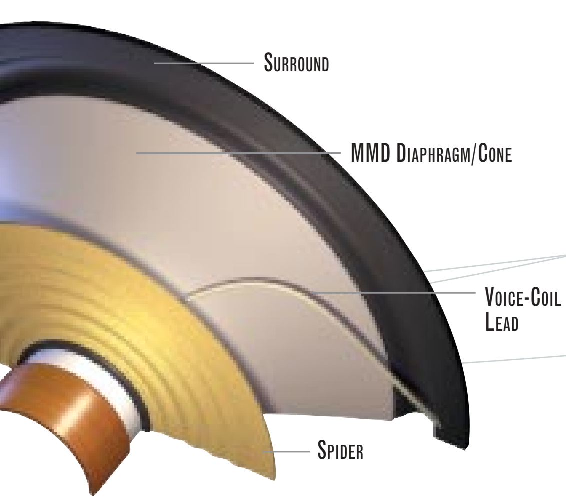
Table 1. Sound propagates at a higher velocity in metals than in materials such as polymers and papers. A third class of materials, ceramics, has an even higher speed of sound. Table 1 shows the speed of sound in several common diaphragm materials. The figures chosen are representative of specific types of materials, but individual examples may differ slightly.

Engineering concepts and technical data are topics for intellectual discussion but, in the end, we simply want to know how it sounds.

In our characteristically thorough manner, all Infinity loudspeakers are put through a demanding battery of listening tests, using a variety of rooms, music, listeners and configurations (mono, stereo, multichannel). The "acid test" is a proper double-blind listening evaluation in our unique, positional substitution, Multichannel Listening Laboratory (MLL), where every Infinity product is compared with the best products we know how to build, and the best of our competitors' products. Only when a product is judged by listeners to be best-in-class do we release the design for production.

Cone Material	Frequency of First Cone-Bending Mode (Hz)
Polypropylene	1500
Kevlar®	1920
Paper	2160
Aluminum	6700
Ceramic	10800
Metal Matrix Diaphragm (MMD)	7200

Table 2. The first cone-bending modes for various moving assemblies. Table shows the frequency of the first natural cone-bending mode for the entire moving assembly of a 5-1/4" driver for each of seven different cone materials attached to a typical voice coil and surround.



MMD: Technology, Performance, Design

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Ceramic Metal Matrix Diaphragm (CMMD) patent nos. 6,327,372 and 6,404,897.
Infinity continually strives to update and improve existing products, as well as create new ones.
The specifications and construction details herein are therefore subject to change without notice.