Eighteen Sound

Patented TPM (True Piston Motion)

This technology has been developed by Eighteen Sound in order to improve the high frequency behaviour of top of the range compression drivers.

The further big advancement achieved with TPM technology, when compared to already optimum performances of all titanium diaphragms, has been obtained by extensive research made on the new material treatment.

The special Titanium Nitride Coating dome dramatically improves stiffness with obvious benefits in transient and intermodulation distortion response. With its very high value of elasticity modulus (five times more than titanium), nitride thin film is capable to increase by 45% regular titanium stiffness.

The piston frequency range motion extends 25% higher in frequency, showing a predictable, ideal frequency response decay and avoiding top-end spurious resonances. The nitride-free ellipsoidal suspension shape is designed to maintain inherent titanium constant stiffness, assuring a 3rd harmonic distortion lower than 0.05% over all working frequency range.

Introduction

It is well known that a diaphragm for electro-acoustic transducer (for example compression driver) must be light weight and with high value of flexural rigidity because of its superior reproducing characteristic (higher efficiency, lower distortion, faster transient response). It is also well know that the flexural rigidity EI is given by the product between young modulus E and the second moment of inertia I of the cross sectional area around a neutral axis.

Therefore the most important material physical properties for diaphragm applications are:

- density ρ (Kg/m^3)
- Young Modulus E (GN/m^2)

By the higher value of the E/ ρ ratio, it is possible to widen the range of piston motion and consequently to improve the frequency characteristic. Here on the table below are summarized the physical properties of the main usual metal foils used for compression driver diaphragm

	E (GN/m^2)	**ρ (Kg/m^3)**	**E/ρ ($(m/s)^2$)**
Titanium	119	$4{,}54 \times 10^3$	26×10^6
TiN	600	$5{,}22 \times 10^3$	115×10^6
Titanium - TiN composite	**173**	**$4{,}60 \times 10^3$**	**37×10^6**

State of the art

The most popular metal film used for diaphragm for compression driver is titanium. This because it has high E modulus, it is easily formed, it isn't quite expensive, it is reliable and its sound characteristic became a reference on the sound reproduction market. Other interesting metal foil for compression driver diaphragms are aluminium, magnesium and beryllium.

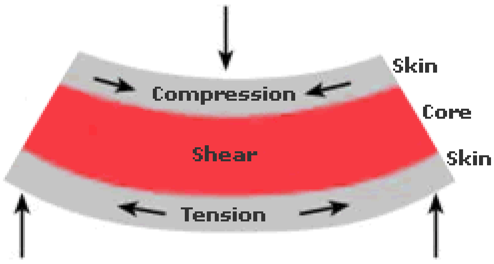
TPM technology

Eighteen Sound has developed a **TPM** (True Piston Motion) technology; it consists in a composite board diaphragm formed with two skin layers of a ceramics material on both side of a light weight titanium core layer. Through the PVD (Physical Vapour Deposition) technology, Eighteen Sound has deposited a thin film of TiN (Titanium Nitride) on both side of titanium diaphragm. Moreover, in order to keep constant the original suspension stiffness of titanium diaphragm, a special PVD suspension masking has been developed and adopted during deposition process.
By the picture below it is easily understood how the two TiN skin layers operate on the

composite material during diaphragm vibration. It looks clearly evident that higher composite diaphragm compression and tension resistance can reached by the:

1. bigger distance between two skin
2. higher value of E skin young modulus
3. higher thickness of the skin

The most important properties of the skin layers is the flexural (or stiffness) rigidity that is a function of the intrinsic material properties E (young modulus) and by the geometry of the composite diaphragm (i.e. distance between two skin layer).



For physical point of view we could calculate the flexural rigidity of the composed diaphragm by the formula:

$$EI = E_{TiN}I_1 + E_{Ti}I_2 + E_{TiN}I_3$$

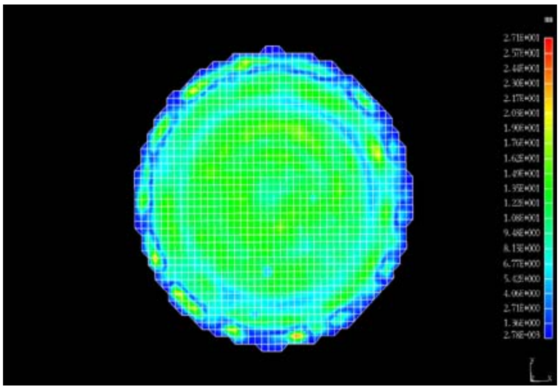
where:

- E - composite young modulus
- E_{TiN} - TiN young modulus
- E_{Ti} - titanium young modulus
- I - second moment of inertia of the composite
- I_1 - second moment of inertia of the upper TiN layer
- I_2 - second moment of inertia of the titanium
- I_3 - second moment of inertia of the lower TiN layer

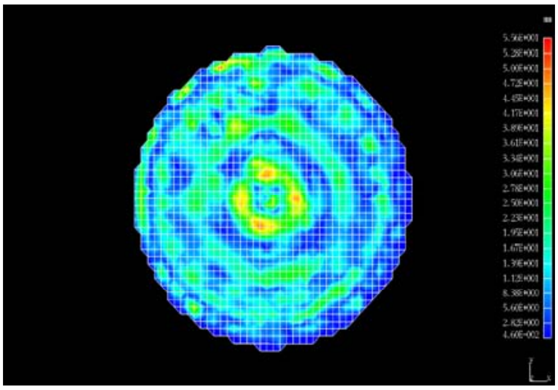
Because the composed diaphragm is symmetric around a neutral axis follow $I_1 = I_3 = I_{TiN}$
Therefore: $EI = 2E_{TiN}I_{TiN} + E_{Ti}I_2$
It is possible to show that with only 8% of diaphragm mass increment we can increase respectively the composite young modulus by the 45% and the composite E/ρ ratio by the 42% (as showed on the above table).

Measurements and Considerations

We have compared two different diaphragms; one made with standard titanium foil and a similar one where it is deposited nitride skin on both side. It is possible to well understand both diaphragm behaviour at different frequency with a Laser Doppler Vibrometry Analysis (below pictures show the diaphragm velocity map at 13kHz of nitride titanium and conventional titanium diaphragm).



LDV map at 13kHz of 3" Nitrided diaphragm



LDV map at 13kHz of 3" Titanium diaphragm

It is well evident how the composite diaphragm break up are moved up on frequency domain. From acoustical point of view, composite diaphragm offer linear piston decay at high frequency (see Fig1), shorter and smoother impulse response (see Fig2) and lower IMD distortion (see Fig3) than conventional titanium diaphragm. In fact the dome break-up modes have very high influence on the IMD and impulse response with clearly audible effects.

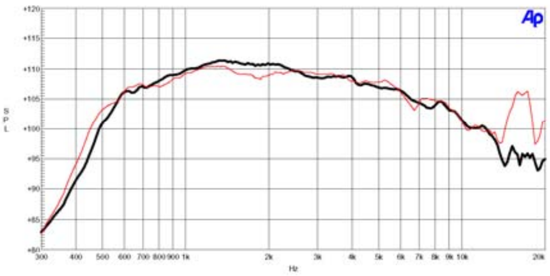


Fig.1 – SPL Response comparison
3" Nitrided diaphragm (black) – 3" Titanium diaphragm (red)

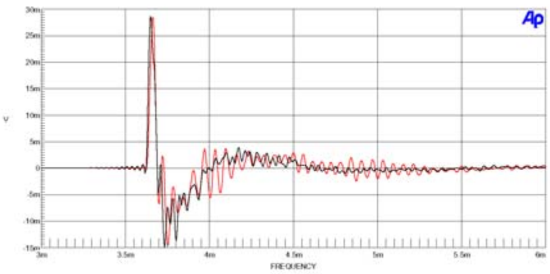


Fig.2 – Impulse Response comparison
3" Nitrided diaphragm (black) – 3" Titanium diaphragm (red)

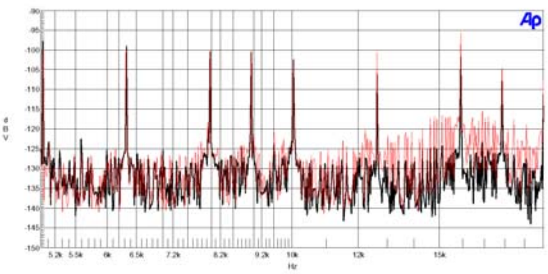


Fig.3 – IMD Response comparison
3" Nitrided diaphragm (black) – 3" Titanium diaphragm (red)

The Eighteen Sound TPM technology based on composite nitride-titanium diaphragm, thanks to its better piston motion behaviour, is capable to improve sound quality and transient response compared to any other titanium diaphragm on the market.