Acousto-mechanical investigation of melt electro written PCL Scaffolds

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INTRODUCTION

Closure and restoration of the tympanic membrane is crucial for hearing restoration. Most defects can be successfully closed with autologous tissue patches. Due to unknown tissue properties, a compromise between function and stability of the reconstruction is needed to be found by the surgeon (Mürbe, et al. 2002). As an **alternative, artificial replacement materials** are being investigated, aiming for consistently good and reproducible results in the restoration of tympanic membrane defects. Synthetic materials like **biopolymers** can be fabricated in various shapes with different tissue engineering technologies. Additionally, their material properties like biocompatibility are advantageous for further investigation as a tympanic membrane replacement. In this work, it was investigated, if melt electro written **Polycaprolactone (PCL)** scaffolds are able to **provide a mechanical behaviour like the human tympanic membrane**.

EXPERIMENTAL METHODS

For the comparison of the **vibration behaviour** of the scaffolds and human tympanic membranes, it is necessary to acquire their **sound transfer function with Laser-Doppler vibrometry (LDV)**.

Varied parameters in combination for each scaffold batch (5 specimen each):

- Number of layers (4, 6 and 8 layers)
- Fiber thickness (10 µm and 15 µm)
- Fiber strand spacing (150 µm and 250 µm)
- Layer orientation (90° and 45° layer-to-layer rotation)

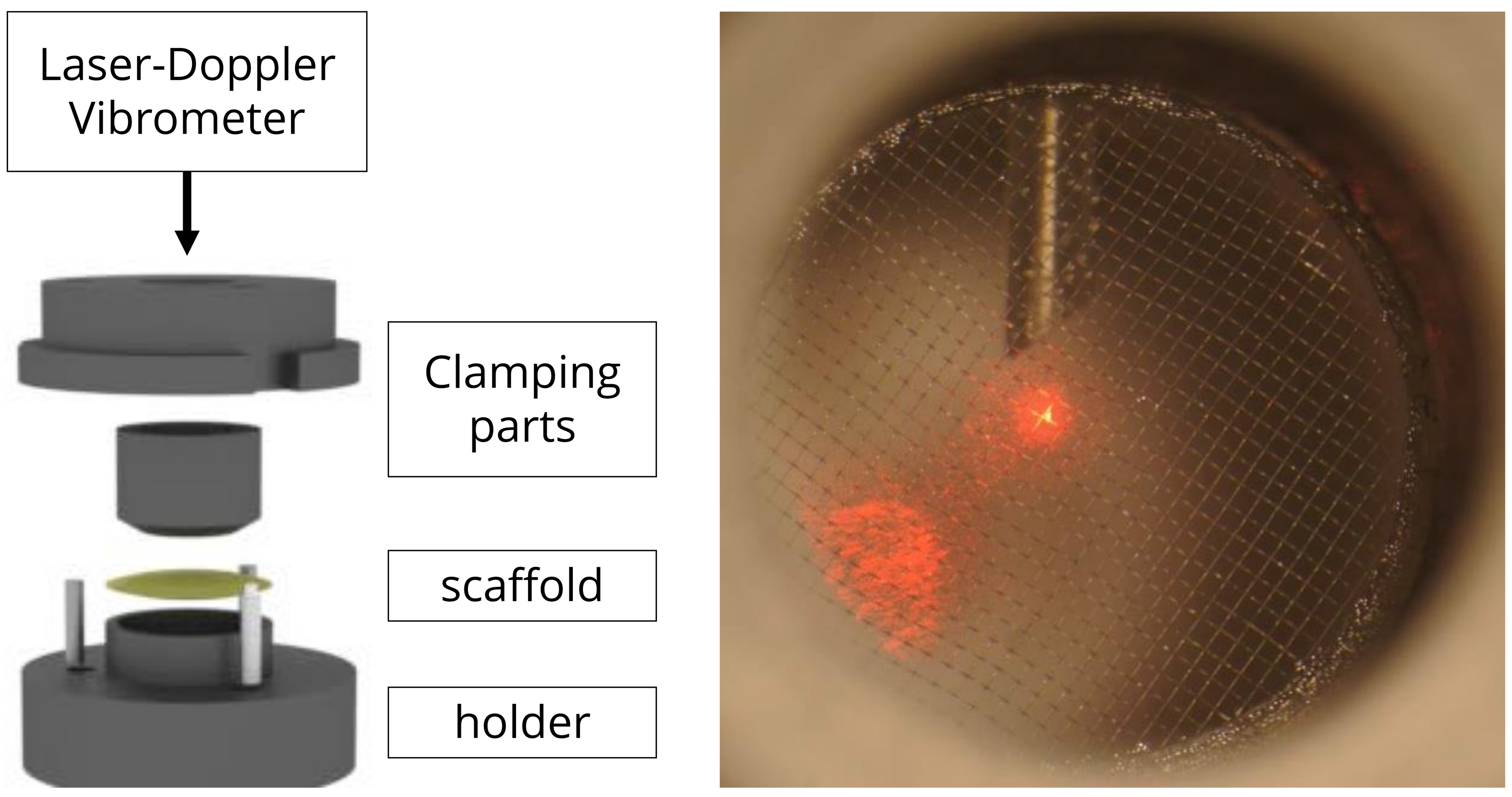

Fig. 1: Test stand (left);clamped 90 degree layer orientation scaffold with red LDV point in center and visible microphone below the scaffold (right)

The scaffolds (diameter of 11 mm) were excited on a circular area of 8 mm with a multi-sinusoidal signal between 100 Hz and 5 kHz at a sound pressure level of about 90 dB SPL. A probe was placed about 1 mm in front of the scaffolds to measure the applied sound pressure. All scaffolds were fixed in a test stand with two states of **defined and reproducible clamping (Fig. 1)** (compare Allardyce, et al. 2016).

REFERENCES

(1) Dirk Mürbe, Thomas Zahnert, Matthias Bornitz, and Karl-Bernd Hüttenbrink. „Acoustic Properties of Different Cartilage Reconstruction Techniques of the Tympanic Membrane." Laryngoscope 112, Nr. 10 (October 2002): 1769–76.

(2) Benjamin J. Allardyce, Rangam Rajkhowa, Rodney J. Dilley, Zhigang Xie, Luke Campbell, Adrian Keating, Marcus D. Atlas, Magnus von Unge, and Xungai Wang. „Comparative acoustic performance and mechanical properties of silk membranes for the repair of chronic tympanic membrane perforations". Journal of the Mechanical Behavior of Biomedical Materials 64 (December 2016): 65–74.

RESULTS AND DISCUSSION

The scaffold's structural parameters influenced the sound transfer function of the scaffolds differently. The **first resonance frequency** of the scaffold, as a characteristic property, was shifted in frequency and magnitude, dependent on the specific design. For example, an increase in scaffold stiffness usually causes a **lowering of the magnitude and an increase in the resonance frequency**, e.g. at an increased number of layers (Fig. 2, left). Multiple measurements on each scaffold showed a variation in results, since the **fragile structures can easy be manipulated and influenced** by external and test stand factors (Fig. 2, right). Thus, all graphs are showing averages of one scaffold batch for multiple measurement of each scaffold.

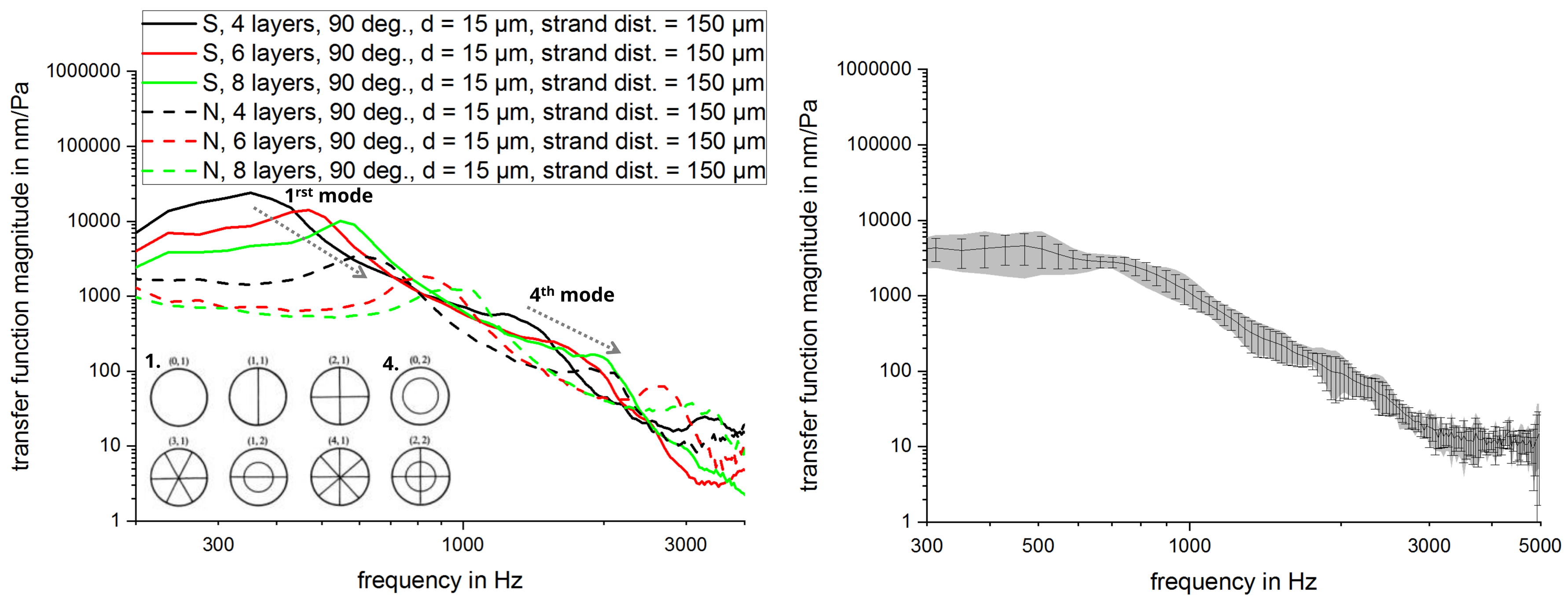

Fig. 2: Influence of number of layers for two different clamping states („S" and „N" (slightly increased clamping force)) with visible shift of magnitude and resonance frequencies; the first and fourth vibration modes are visible (left); mean and deviation of mean values for one scaffold batch (N, 4 layers, 45 deg., d = 10 µm, strand distance = 150 µm) (right)

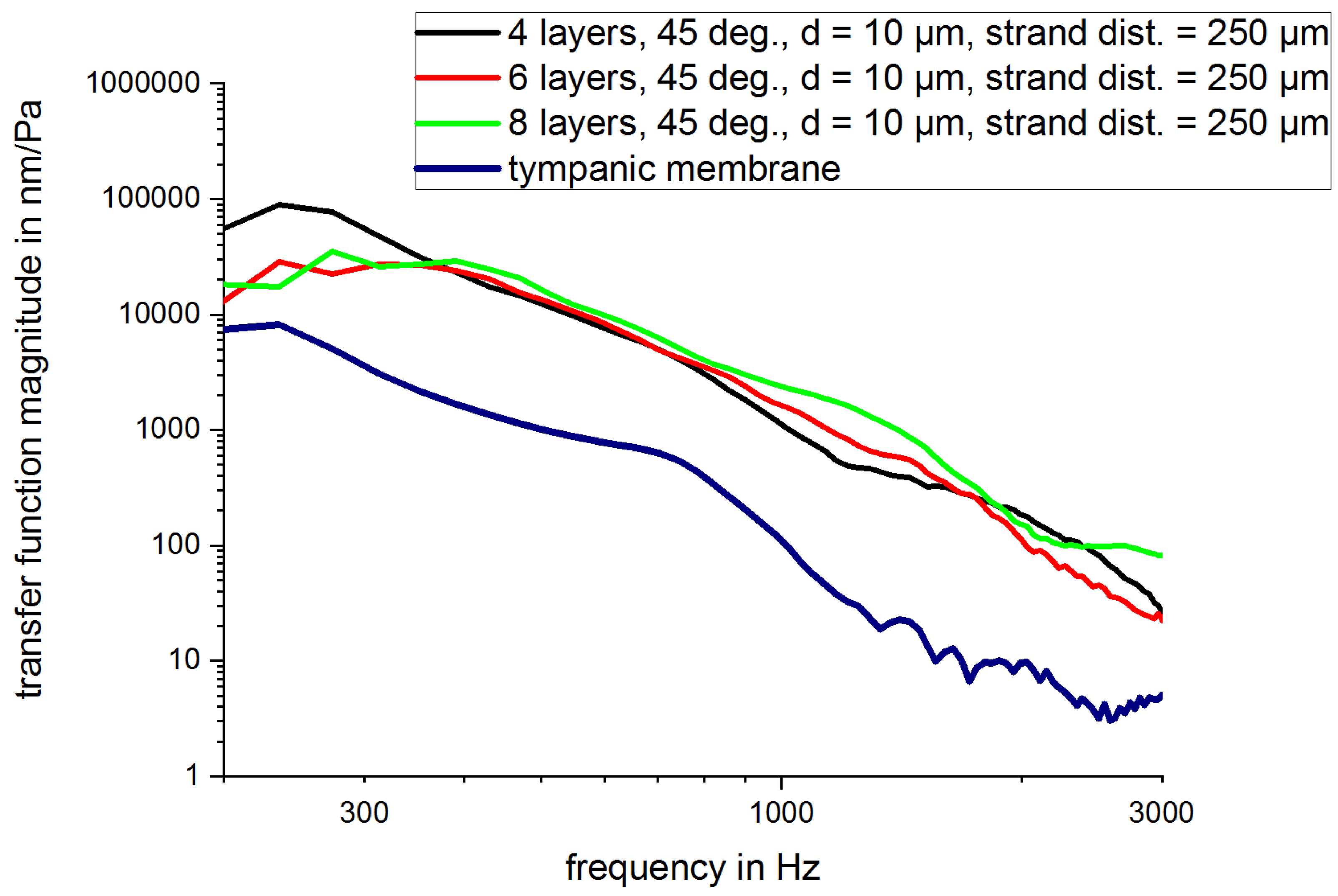

Fig. 3: Influence of number of layers on vibration behaviour, in comparison to a human tympanic membrane; magnitude of the scaffolds is higher, which is benefitial for further modifications.

CONCLUSION

The vibration properties of the scaffolds can be tuned to be comparable to those of human tympanic membranes (Fig. 3).

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Acknowledgement

This measure is co-financed with tax revenue on the basis of the budget adopted by the members of the Saxon Landtag.

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