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# Mechanical Characterizations of elastic layers made by sol-gel

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**Abstract:** To characterize the mechanical properties of elastic thin films to improve the lifetime of LMJ components, two experimental setups have been used: the acoustic picosecond techniques and the Surface Acoustic Wave InterDigital Transducers.

## 1. Introduction

To improve the lifetime of the LMJ components, we would like to introduce elastic layers in order to reduce shockwaves, which are sometimes generated by the laser and therefore to know the mechanical properties. To do so, two experimental setups have been used: the acoustic picosecond techniques [1] and the Surface Acoustic Wave InterDigital Transducers, the latter was already successfully used to characterize sol-gel coatings [2]. Thus, we have been able to extract the viscosity of the thin films, the attenuation length of the acoustic waves, the Young's modulus and the Poisson ratio.

## 2. Experimental setup

### 1.1. Picosecond ultrasonics technique

In order to determine the attenuation length of the sound waves which is a key result to determine the ability of the elastic layers developed to attenuate shockwaves, the time resolved Brillouin scattering signature has been followed on a series of ormosils of silica-PDMS thin films with PDMS concentrations ranging from 0 wt.% to 50 wt.%. Acoustic transducers based on thin layers of aluminum deposited onto silicon wafers on which the ormosils were realized (Fig. 1), proved to be reliable and efficient to follow the evolution of the Brillouin frequency as a function of the PDMS concentration.

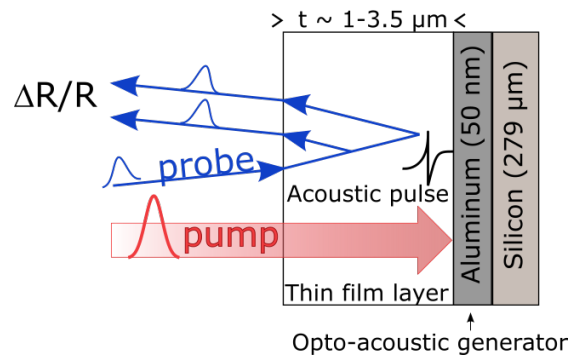


Fig. 1: Principle of the ultrafast acoustic pump-probe experiment performed on the thin films deposited onto the Al/Si substrate

The estimation of the lifetime of Brillouin oscillations allowed estimating the acoustic attenuation around 0.4-1.5  $\mu\text{m}$  in the range of ten GHz (Fig. 2).

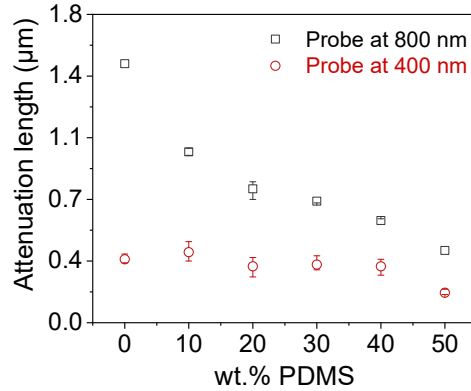


Fig. 2: Attenuation length of the acoustic waves into the media for two different wavelengths of the probe (so two different frequencies).

### 1.2. Surface Acoustic Wave InterDigital Transducers (SAW-IDT)

The design and implementation of Surface Acoustic Wave InterDigital Transducers (SAW-IDT) (Fig. 3) have enabled quasi-monochromatic Rayleigh-type SAW to be generated and to obtain a rapid and accurate estimation of the phase velocity, key information for the characterization of the layers, over a wide frequency range (from 10 to 60 MHz).

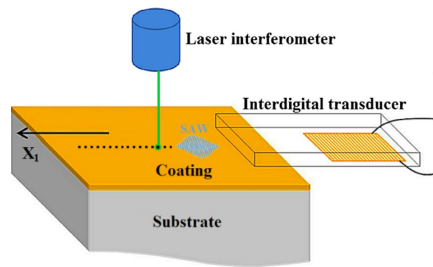


Fig. 3: Sketch of the set up for generation of surface acoustic waves with SAW-IDT and detection with interferometer.

Young's modulus and Poisson's ratio of coatings with a 1-2 μm thickness were estimated using an inverse method (Table 1).

Table 1. Young's modulus and Poisson ratio of the ormosils

| Coating | E (GPa) | Poisson ratio $\nu$ |
|---------|---------|---------------------|
| 10 wt.% | 34.77   | 0.25                |
| 20 wt.% | 29.97   | 0.25                |
| 30 wt.% | 22.77   | 0.25                |
| 40 wt.% | 19.1    | 0.25                |
| 50 wt.% | 14.96   | 0.25                |
| Nafion  | 12.97   | 0.33                |
| Teflon  | 8.82    | 0.46                |

## 2. References

- [1] F. Xu, L. Belliard, D. Fournier, E. Charron, J.-Y. Duquesne, S. Martin, C. Secouard, B. Perrin, "Complete elastic characterization of lithium phosphorous oxynitride films using picosecond ultrasonics", *Thin Solid Films* **548**, 366-370 (2013).
- [2] D. Fall, F. Compoint, M. Duquennoy, H. Piombini, M. Ouafouh, F. Jenot, P. Bogdan, P. Belleville, C. Ambard, "Surface acoustic wave characterization of optical sol-gel thin layers", *Ultrasonics*, **68**, 102-107 (2016).