Optimizing a thermal based sensor setup for monitoring physical changes of thin films over time using numerical modeling

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The Transient Plane Source (TPS) method is well-known for measuring thermal properties of various materials. At IMO-IMOMEC this method is currently used to monitor biological processes. In order to optimize the sensor setup for this specific task, and to explore new use cases, a numerical model has been successfully developed in which TPS measurements can be simulated.

Introduction

In biosensor applications, physical or chemical changes at the sensor interface often induce changes in thermal properties at the interface [1]. The conventional Transient Plane Source (TPS) method is well-known for measuring absolute thermal properties of various materials. Well-documented test samples are solids, liquids and powders.

In order to determine the absolute thermal properties of thin films using the TPS method, additional work is required. This is because, in the case of a thin film sample, the influence of the insulating material around the sensor, is no longer negligible [2].

In many cases however, the ability to measure relative changes in thermal properties of thin films over time, is of great value. In such cases, the measured change in thermal properties can be used to monitor biological or chemical processes that interact with the layer [1].

In this work, a 2D numerical model of a TPS sensor has been built using COMSOL Multiphysics® software. This model is used to explore new use cases for relative TPS measurements on thin films. Furthermore, this model can also be used to optimize the sensor design for specific use cases.

Results and Discussion

As a demonstrator of the numerical model, simulated TPS measurements were performed on a thin PVC film of varying thickness (Teff_film = 594 Ws1/2/m2K). The material surrounding the film was chosen to be water (Teff_water = 1588 Ws1/2/m2K).

During measurement, a pulse of constant power is applied to a metal sensor structure that is in direct or non-direct contact with the film. The rate at which temperature of the metal structure increases during the pulse depends on the ability of the surrounding materials to dissipate heat.

A change in the thickness of the thin film, will cause a change in the heat up rate of the metal sensor structure (Figure 1).

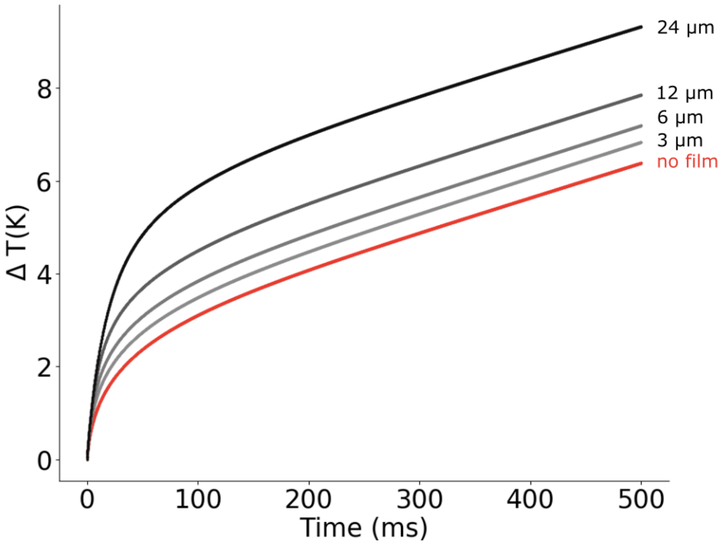

Figure 1: Changes in thickness of the PVC film cause changes in the temperature curves of the sensor structure. This test demonstrates the ability of a TPS sensor to monitor changes in thickness of a thin film.

Conclusions

The developed model proved to be physically correct. It can be used to explore new use cases. Furthermore, optimized sensor- geometry and materials can be determined based on simulation results, facilitating the development of future biosensing applications.

References

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