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A thermal sensor for minimally invasive blood flow assessment

Arjen van der Horst¹,², Dennis van der Voort², Benjamin Mimoun¹, Marcel Rutten², Ronald Dekker¹, and Frans van de Vosse²

¹ Delft University of Technology, ECTM, Flexible and Stretchable Electronics
² Eindhoven University of Technology, BME, Cardiovascular Biomechanics

Introduction

Accurate hemodynamic measurements are required to assess the functional significance of coronary artery disease. In contrast to pressure, accurate flow measurement in coronary arteries is still a major challenge. In previous studies, a flexible flow sensor to be bent around a guide wire has been designed [1] and manufactured [2]. Here, the first flow experiments with the sensors on a flat surface, are presented.

Fig. 1 Picture of a guide wire with a pinhead and a schematic representation of the flexible sensor bend around a guide wire and a top view with the heating element and the two thermopiles.

Methods

The sensor consists of two thermopiles (Fig. 1) measuring the temperature difference between $T_h$ and $T_u$ and between $T_d$ and $T_f$. The heater is controlled such that $T_h-T_f$ remains constant at 5K. The power required is then used as a measure for the shear rate.

The flexible sensors are mounted across a channel, through which flow/shear rate can be applied to the sensors (Fig. 2). Two types of shear rates were used to characterize the sensors: Sinusoidal shear rates with different amplitudes ($\lambda = 500,1000,2000$ s$^{-1}$) and frequencies ($f = 1/3,1,2$ Hz) and typical shear rate dynamics found in coronary arteries.

Fig. 2 Picture of the actual device and a picture and schematic representation of the part of the experimental set-up with the flexible chip mounted across a channel.

Results & Conclusion

Fig. 3 demonstrates that, in a sinusoidal shear rate, the power is a good measure for the shear rate and that $T_d-T_u$ can be used to detect shear rate reversal.

By constructing a quasi-steady calibration relation between the shear rate and power, valid for all nine sinusoidal shear rates, the shear rate could be measured for a coronary-like shear rate (Fig. 4).

Conclusion: The first experiments clearly demonstrate that the flexible sensors are suitable for shear rate assessment.

Fig. 3 The thermopile output and required power in sinusoidal flow.

Fig. 4 The shear rate determined with the thermal sensor when a coronary-like flow is applied.

References