Proceedings of the Canadian Society for Mechanical Engineering International Congress
32nd Annual Conference of the Computational Fluid Dynamics Society of Canada
Canadian Society of Rheology Symposium
CSME-CFDSC-CSR 2025
May 25–28, 2025, Montréal, Québec, Canada

PDMS OPTICAL WAVEGUIDES FOR PRESSURE SENSING: A DESIGN OF EXPERIMENTS APPROACH

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ABSTRACT

Poly(dimethylsiloxane) (PDMS) optical waveguides have garnered significant attention for optical (pressure) sensing applications owing to their high optical sensitivity, particularly in the biomedical range (2.7–5.3 kPa), favorable optical and mechanical properties, and biocompatibility. Typically, PDMS is supplied as a two-component material consisting of a PDMS base and a curing agent. Although it is well-known that optical and mechanical properties can be adjusted by varying the mixing ratio and cure conditions, the magnitude of these effects and their possible interactions remain unclear. In this sense, a design of experiments (DoE) approach represents an efficient statistical method for planning and analyzing experimental tests, enabling the quantitative estimation of the effects of experimental parameters and their interactions using a reduced sample size. Based on that, this study explores the optomechanical response of square optical PDMS waveguides under transverse compression. Using a full-factorial three-level two-factor (3^2) design, we systematically examined the impact of varying Sylgard 184 mixing ratios and cure temperatures on key mechanical and optical properties. The results indicate that the mixing ratio is the most statistically significant factor affecting optomechanical sensitivity, secant modulus at 0.1 MPa, refractive index, and propagation loss. The interaction between mixing ratio and cure temperature is the second most significant factor, followed by the cure temperature alone in order of significance. Notably, although changes in cure temperature have a smaller impact on the evaluated properties, the cure temperature presents a statistically significant effect when varied concurrently with the mixing ratio within the tested ranges. Furthermore, we investigated the correlation between secant modulus and optomechanical sensitivity, revealing a linear correlation. In summary, this study provides valuable insights for the fabrication and optimization of the optomechanical response of PDMS waveguides for optical sensing applications.