

---

# Contents

|          |                                                                                                              |           |
|----------|--------------------------------------------------------------------------------------------------------------|-----------|
| <b>1</b> | <b>Introduction</b>                                                                                          | <b>1</b>  |
|          | References                                                                                                   | 4         |
| <b>2</b> | <b>Analysis of the Microstructure Formation Process</b>                                                      | <b>7</b>  |
| 2.1      | Evaluation of PP, PETG, PVC and SAN Thermoplastics' Mechanical Properties up to the Viscoelastic Temperature | 15        |
| 2.2      | Modelling of the Hot Stamping Process Using the Finite Element Method                                        | 17        |
| 2.3      | Evaluation of PP, PETG, PVC, and SAN Thermoplastic Mechanical Properties                                     | 20        |
| 2.4      | Vibration-Based Modelling of the Hot Stamping Process                                                        | 25        |
|          | References                                                                                                   | 31        |
| <b>3</b> | <b>Development of a Magnetostrictive Transducer Used for Microstructure Formation</b>                        | <b>35</b> |
| 3.1      | Theoretical Analysis of the Forming Tool                                                                     | 35        |
| 3.2      | Development and Analysis of Magnetostrictive Transducer                                                      | 40        |
|          | References                                                                                                   | 48        |
| <b>4</b> | <b>Experimental Testing of Functional Prototype of Magnetostrictive Transducer</b>                           | <b>49</b> |
| 4.1      | Pilot Study of Hot Stamping Process                                                                          | 49        |
| 4.2      | Study of the Hot Stamping Process with a Magnetostrictive Transducer                                         | 55        |
|          | References                                                                                                   | 60        |

|          |                                                                                                                                             |     |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------|-----|
| <b>5</b> | <b>Development and Analysis of Electrochemical Reactor with Vibrating Functional Element for Nanoporous AAO Membranes Fabrication</b> ..... | 61  |
| 5.1      | Development of Electrochemical Reactor with Vibrating Functional Element .....                                                              | 61  |
| 5.2      | Analysis of Electrochemical Reactor with Vibrating Functional Element .....                                                                 | 64  |
| 5.3      | Nanoporous AAO Membranes Fabrication Using Electrochemical Reactor with Vibrating Functional Element .....                                  | 69  |
|          | References .....                                                                                                                            | 72  |
| <b>6</b> | <b>Vibration-Assisted Synthesis of Nanoporous Anodic Aluminum Oxide (AAO) Membranes</b> .....                                               | 73  |
| 6.1      | Effect of the Resonance Frequency on the Formation of the AAO Nanopore Structure .....                                                      | 73  |
| 6.2      | The Effect of Ultrasound on the Formation of the AAO Nanopore Structure .....                                                               | 76  |
|          | References .....                                                                                                                            | 81  |
| <b>7</b> | <b>A Free-Standing Chitosan Membrane Prepared by the Vibration-Assisted Solvent Casting Method</b> .....                                    | 83  |
| 7.1      | Fabrication of Chitosan Membrane .....                                                                                                      | 84  |
| 7.2      | Improved Method of Solvent Casting Using High-Frequency Vibrations .....                                                                    | 85  |
| 7.3      | The Effect of the High-Frequency on the Formation of Nanopillars on Chitosan Membrane Surface .....                                         | 86  |
|          | References .....                                                                                                                            | 90  |
| <b>8</b> | <b>Application for Bioengineering</b> .....                                                                                                 | 93  |
| 8.1      | Plasmon Metal Nanostructures for Detection and Sensing Cell-Biological Particles .....                                                      | 93  |
| 8.2      | Microfluidic Channels for Bio Particles Manipulation .....                                                                                  | 104 |
| 8.3      | Identification of Liquid Concentration in Periodic Microstructures .....                                                                    | 121 |
|          | References .....                                                                                                                            | 126 |