
Characterization and Modeling of PolyJet Materials for Realistic Anatomical Models

Vincent Martin^{*1,2}, Mathilde Maillard³, Annie Morch⁴, Pauline Lecomte⁴, Jean-François Witz⁴, Marion Dehurtevent^{3,5}, and Romain Nicot^{3,6}

¹INSERM U1008 – Laboratoire d'Électrotechnique et d'Électronique de Puissance - ULR 2697, Univ. Lille, Inserm, CHU Lille, U1008 – Controlled Drug Delivery Systems and Biomaterials, 59000 Lille, France – France

²LaMcube - UMR 9013 – Univ. Lille, CNRS, Centrale Lille, FRE 2016 - LaMcube, F-59000 Lille, France – France

³INSERM U1008 – Univ. Lille, Inserm, CHU Lille, U1008 – Controlled Drug Delivery Systems and Biomaterials, 59000 Lille, France – France

⁴LaMcube - UMR 9013 – Univ. Lille, CNRS, Centrale Lille, FRE 2016 - LaMcube, F-59000 Lille, France – France

⁵Department of Prosthodontics, Faculty of Dental Surgery, University of Lille, Lille, France, – Department of Prosthodontics, Faculty of Dental Surgery, University of Lille, Lille, France, – France

⁶Université de Lille, CHU Lille, Inserm, Service de Chirurgie Maxillo-Faciale et Stomatologie – Université de Lille, CHU Lille, Inserm, Service de Chirurgie Maxillo-Faciale et Stomatologie – France

Abstract

Additive manufacturing is playing an increasingly important role in healthcare, particularly through its use in the production of anatomical models. These models have become essential tools in various contexts, such as surgical planning, enabling better anticipation of complex procedures, and in training programs for healthcare professionals. They are evaluated not only for their anatomical accuracy-encompassing geometric precision, modeling relevance, and color fidelity-but also for their ability to replicate the structures and mechanical properties of biological tissues.

The PolyJet additive manufacturing process (Stratasys) offers an innovative solution to this challenge, thanks to its capability to print multi-material polymer parts with different mechanical properties. This process allows for the creation of property gradients within a single part or the assignment of specific Shore hardness values to localized areas by modifying the resin mixing ratios. This flexibility unlocks new possibilities for the design of realistic anatomical models by assigning each element mechanical properties that closely resemble those of biological tissues. Moreover, the technical solution under study enables fine control of material selection at the voxel level, providing a degree of realism that meets the demanding standards of modern medicine.

A deep understanding of the mechanical behavior of materials produced through the PolyJet process is critical for improving the quality of anatomical models, particularly their ability to realistically replicate the tactile sensations experienced by healthcare professionals under real-use conditions. In this context, research conducted by the LaMcube laboratory on the

*Speaker

modeling of nonlinear hyperelastic behaviors (1), initially focused on silicones and soft biological tissues, provides a robust theoretical framework and advanced characterization tools. These studies extend this knowledge to the complex composite materials manufactured by PolyJet, paving the way for more precise modeling of their mechanical properties. This scientific approach helps optimize the performance of anatomical models, ensuring they meet the high standards required for demanding biomedical applications.