Date July 2nd 2015
Contact Sanne van den Boom / Alejandro M. Aragón
Address Gebouw 34, Kamer G-1-130 / Kamer G-1-380
Mekelweg 2, 2628 CD Delft
Telephone 015 278 6512 / 015-278 2267
E-mail s.j.vandenboom@tudelft.nl / a.m.aragon@tudelft.nl

TU Delft Delft University of Technology

Modeling of metamaterials with differential thermal expansion

Master of Science project

Abstract

This M.Sc. project consists in the computational modeling of metamaterials consisting of regions of higher thermal expansion. The student will implement advanced numerical methods for the optimization of such complex materials within hybrida, a rapidly growing in-house finite element library that is currently being developed at the Structural Optimization and Mechanics (SOM) group.

Introduction Contrary to natural materials, whose behavior is mainly determined by their composition, metamaterials obtain functionality that is not often seen in nature by means of the way they are structured at relatively small length scales. Metamaterials have tremendous potential as they broaden the spectrum of functionalities with new applications that not too long ago were undreamed of. The realm of metamaterials has spread out from its origin in the field of electromagnetism, and regarding mechanical metamaterials alone, many new functionalities have been investigated, including energy absorption, acoustic/phononic wave propagation, heat conduction, and negative Poisson's ratio.

Responsive and tunable metamaterials are the latest trend in metamaterial research. Differential thermal expansion can drastically change the shape and mechanical response of a structure. This effect can be used for self-folding across different scales, as illustrated in Figure 1. A next step would be to explore the buckling due to a mismatch in the thermal expansion to achieve more complex shapes. The aim of this project is to create a numerical tool for the analysis and design of these responsive metamaterials.

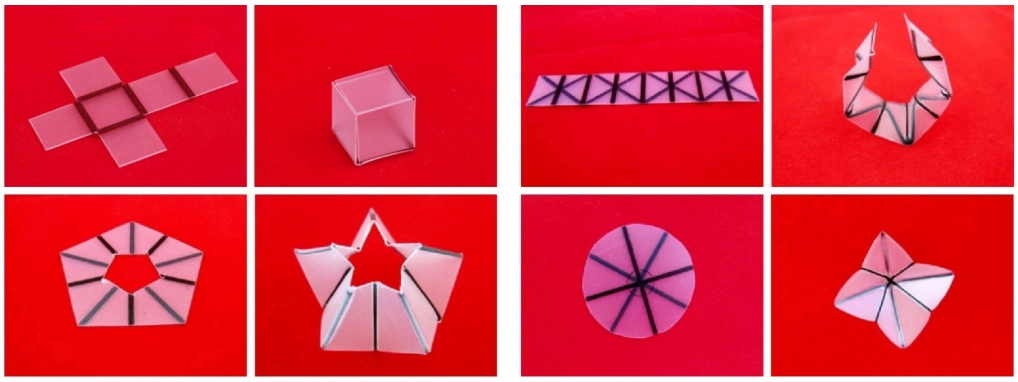

Figure 1: Self-folding of flat sheets into 3D objects by inducing localized heat shrink [1].

Tasks *i)* Conducting a thorough literature review on the different methodologies used for the modeling of thermal expansion; *ii)* Implementing the required formulation within hybrida, our in-house finite element library; *iii)* Analysis of thermal response of different metamaterials with differential thermal expansion; *iv)* Presenting the results and preparing a report that could lead to a peer-reviewed journal publication.

Requirements The student should have modeling experience and basic knowledge of finite element analysis. Python programming experience is recommended.

References

[1] Michael Dickey, Ying Liu, and Jan Genzer. Light-induced folding of two-dimensional polymer sheets. *SPIENewsroom*, 2012.