



HAL
open science

Experiments and modeling of smart silicone elastomer membranes reinforced with shaped NiTi textiles

François Tissot, Thierry Rey, Ludek Heller, Nathanaël Connesson, Grégory Chagnon, Yohan Payan, Denis Favier, Petr Sittner

► **To cite this version:**

François Tissot, Thierry Rey, Ludek Heller, Nathanaël Connesson, Grégory Chagnon, et al.. Experiments and modeling of smart silicone elastomer membranes reinforced with shaped NiTi textiles. 8th EUROMECH - Solid Mechanics Conference, Jul 2012, Graz, Austria. hal-01875139

HAL Id: hal-01875139

<https://hal.science/hal-01875139>

Submitted on 17 Sep 2018

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Experiments and modeling of smart silicone elastomer membranes reinforced with shaped NiTi textiles.

Tissot François[†], Rey Thierry[†], Heller Ludek[‡], Connesson Nathanael[†]
Chagnon Grégory[†], Yohan Payan^{*}, Favier Denis[†], Sittner Petr[‡]

[†]Laboratoire 3SR, Université de Grenoble/CNRS, BP 53, 38041 Grenoble cedex 9, France.

François.Tissot@grenoble-inp.fr, Thierry.Rey@grenoble-inp.fr, Nathanael.Connesson@grenoble-inp.fr, Grégory.Chagnon@grenoble-inp.fr, Denis.Favier@grenoble-inp.fr

[‡]Institute of Physics, ASCR, Na Slovance 2, 182 21 Prague, Czech Republic
heller@fzu.cz, sittner@fzu.cz

^{*}Laboratoire TIMC, Université Joseph Fourier - CNRS, 38706 La Tronche cedex, France.
ypayan@imag.fr

ABSTRACT

Over the past few years, thin NiTi wires textiles have received increasing attention. The opportunity to create new kind of composites using NiTi textiles inserted in elastomer matrixes has emerged. *Villa et al.* [1] introduced thin NiTi wires into Lycra/PA textiles to obtain high rigidity and recovering strain textiles. Prototype of small diameter vascular prosthesis made of a fibre reinforcement silicone material were proposed by Zidi and Cheref [2]. Coupling NiTi shape memory alloy textiles and silicone elastomer would allow a wide variety of mechanical behavior and controlled anisotropy, to reproduce, for example, mechanical behavior of softer tissues like oesophageal tissues [3]. Different studies have already been performed, for example including a unique thin NiTi wire into silicone elastomer matrix [4]. Yet, single wires inserted in polymer matrix were subjected to slip during loadings. Using textile rather than single wires could limit the textile slip inside the polymer thanks to interaction between the wires. For example, *Heller et al.* [5] molded a NiTi textile tube into a polymer matrix and analyzed the mechanical behavior of this composite.

Two main research fields can be devised: using those composites as actuator or/and to mimic real biomaterials. A first goal in using those composites as actuators would be to increase its maximal strain. To increase the maximal strain, one might think about increasing length of NiTi wires. Therefore, the idea to use a preformed to snake-like shape NiTi textile has been introduced [6]. Yet,

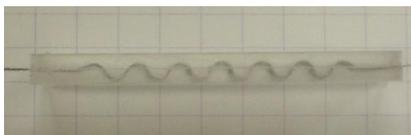


Figure 1: Snake-like NiTi textile molded in silicone elastomer matrix

few studies deal about inclusion of a preformed NiTi textile into a silicone matrix. This study is a preliminary work to understand and model such a composite mechanical behavior.

A NiTi textile is preformed in a specially designed device and heated at 450°C to print the parent shape to the textile. The

textile is then molded into a membrane-like silicone matrix in a specially designed mold. The silicone is reticulated at room temperature (*Figure 1*).

As the membrane is composed of NiTi textile and silicone elastomer matrix, both components have first been tested separately in tensile loading (*Figure 2*). These results have been used to better understand the behavior of composite samples. The influence of different parameters have been studied such as: the NiTi wires diameter, the snake-like shape winding diameter, temperature, *etc.*

Simulations using finite element software and superelastic model (ABAQUS software / Auricchio mechanical model) have been developed. The mechanical behavior in tensile loading of the snake-like thin NiTi wires textile, the silicone elastomer matrix and the combination of both NiTi textile and silicone matrix has been analyzed (*Figure 3*).

Further studies will be performed with different silicone matrixes, and with knitted NiTi textiles.

References

- [1] Elena Villa, Sergio Arnaboldi, Ausonio Tuissi, Marco Giacomelli, and Elena Turco, *Mechanical Analysis of Hybrid Textile Composites with NiTi Wires*, JMEPEG (2009) 18:517-521
- [2] Arturo N. Natali, Emanuele L. Carniel, Hans Gregersen, *Biomechanical behavior of oesophageal tissues: Material and structural configuration, experimental data and constitutive analysis*, J. MedEngPhy (2009)
- [3] M. Zidi, M. Cheref, *Mechanical analysis of a prototype of small diameter vascular prosthesis: numerical simulations*, Computers in Biology and Medicine 33 (2003) 65–75
- [4] Yves Chemisky, Arnaud Duval, Boris Piotrowski, Tarak Ben Zineb, Vanessa Tahiri and Etienne Patoor, *Numerical tool for SMA material simulation: application to composite structure design*, Smart Mater. Struct. 18 (2009) 104012
- [5] L. Heller, D. Vokounb, D. Majtás, P. Šittner, *Thermomechanical characterization of shape memory alloy tubular composite structures*, Advances in Science and Technology Vol. 59 (2008) pp 150-155 (2008)
- [6] Adelaide Nespoli, Elena Villa, Stefano Besseghini, *Thermo-mechanical properties of snake-like NiTi wires and their use in miniature devices*, J. Therm. Anal. Calorim. 2011

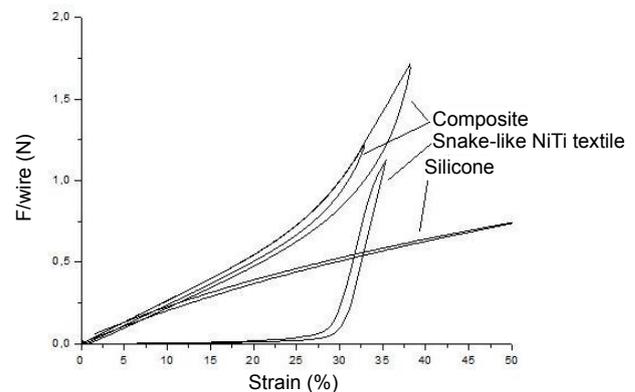


Figure 2: Tensile behavior of snake-like NiTi textile, silicone elastomer, and snake-like NiTi textile molded into silicone matrix

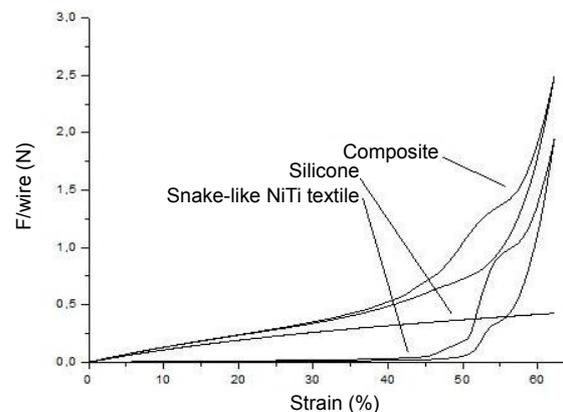


Figure 3: Results of simulation of the tensile behavior of snake-like NiTi textile, silicone elastomer, and snake-like NiTi textile molded into silicone matrix