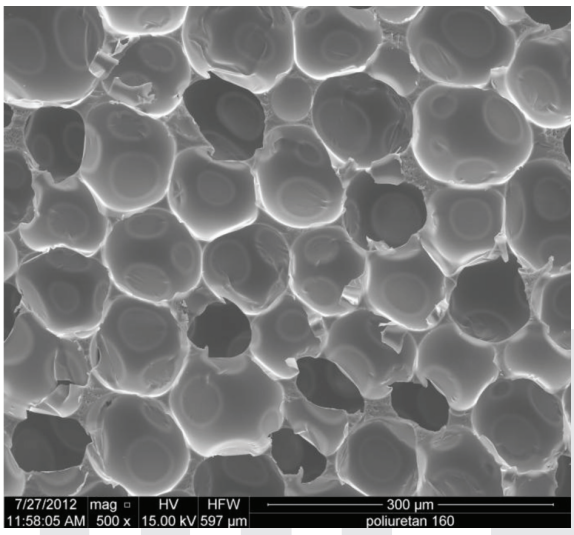
Micro-mechanical modelling of cellular materials with refinements on fracture and damage

Goal of the project: Cellular materials are widely used as cores in sandwich composites, for packing and cushioning. The main characteristics of foams are light weight, high porosity, high crushability and good energy absorption capacity. Present project propose to develop micro-mechanical models in order to predict the mechanical properties of cellular materials with a focus on modeling the fracture and the influence of damage on the mechanical response.

Short description of the project:
Project combines analytical methods, with numerical micro-mechanical finite element analysis and experimental investigations: materials testing and investigating the damage mechanisms by Digital Image Correlation and Thermoelastic Stress Analysis. The novelty of the project will be highlited by the size and notch effect for cellular materials, and by investigating the effect of microstructural damage on the mechanical response of cellular materials.



SEM microstructure for the 160 kg/m³ polyurethane foam

Main activities:
•Better understanding of mechanical behavior of cellular materials.
•Develop micro-mechanical models to estimate mechanical properties of cellular materials.
•Implementation of constitutive material models in Finite Element Analysis.
•Investigating the size effect and notch effect on cellular materials Evaluating the behavior of cellular materials under dynamic (impact and fatigue) loading.
•Identification of damage mechanisms in cellular materials.
•Investigating the effect of microstructural damage on the mechanical properties of cellular materials.

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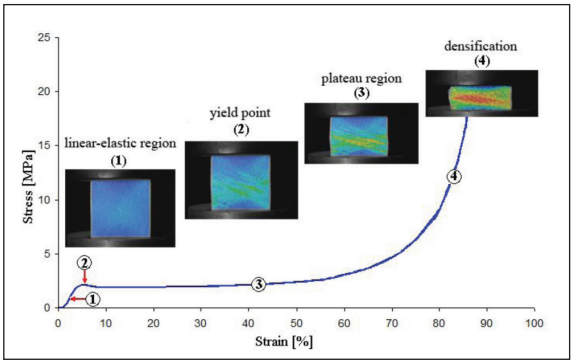


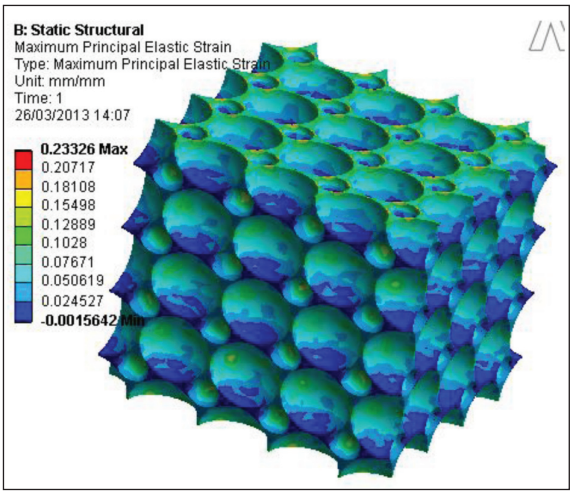
Strees – strain response and maximum principal strain field using Digital Image Correlation technique for 160 kg/m³ polyurethane foam under compression tests

Fields of interest:
•Composite and cellular materials
•Mechanical testing
•Finite Elament Analysis
•Fracture and Damage Mechanics

Implementation period:
05.10.2011 – 04.10. 2014

"Somewhere, something incredible is waiting to be known."

Dr. Carl Sagan



Finite Element maximim principal strain distribution for Representative Volume of foam

Results:

Journal Papers:

•Linul E., Marsavina L., Sadowski T., Knec M., *Size Effect on Fracture Toughness of Rigid Polyurethane Foams,* Solid State Phenomena, Vol. 188, p. 205-210, 2012.

•Marsavina L., Linul E., Voiconi T., Sadowski T., *A Comparison Between Dynamic and Static fracture toughness of polyurethane foams,* Polymer Testing (OnLine First).

Conference Papers:

•Apostol D.A., Constantinescu D.M., Stoica M.O., *Modeling the influence of speed of testing and temperature on the behavior of polyurethane foams,* ECCM15 – 15th Eurpean Conference on Composite Materials, Venice, ITALIA, 24-28 June 2012.

•Marsavina L., Linul E., Sadowski T., Knec M., Apostol D., Constantinescu D.M., *On fracture toughness of polyurethane foams*, 19th Eurpean Conference on Fracture, Kazan, RUSIA, 26-31 August 2012.

•Linul E., Marsavina L., Apostol D., Constantinescu D.M., Sadowski T., *Effect of density, loading rate, material orientation and temperature on dynamic compression behavior of rigid polyurethane foams*, FOAMS 2012, Barcelona, SPANIA, 12-13 September 2012.

•Apostol D.A., Constantinescu D.M., Linul E., Marsavina L., *Densification and energy efficiency of polyurethane foams,* Proceedings of the 29th Danubia-Adria-Symposium on Advances in Experimental Mechanics, Belgrade, SERBIA, 26-29 September 2012.

Research team:

Prof. Dr. Eng. Liviu Marsavina – Project Manager
Prof. Dr. Eng. Dan M. Constantinescu – Senior Researcher
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Research cooperation:

•Lublin University of Technology, Lublin, Poland
•Slovak Academy of Science, Bratislava, Slovakia
•Polymer Competence Centre Leoben, Austria

Aplicability and transferability of the results:

Results will be used by foams manufacturers Necumer and Spumotim to improve their technologies. Also, companies using foam componets like TRW Automotive and Adidas will benefit by our developed micro-mechanical models to characterise their componens and in the product design.

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