



Laboratoire de Mécanique des Solides  
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Parrainé par la Chaire André Citroën et la Chaire Arkema



**DESIGN AND MODELING  
OF INNOVATIVE MATERIALS**

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# *Symposium Jean Mandel*

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*Polymers and Composites*

*Polymères et Composites*

**Thursday, June 20<sup>th</sup>, 2019**

Becquerel Amphitheatre  
École Polytechnique

Inscription gratuite à [symposium-mandel@meslistes.polytechnique.fr](mailto:symposium-mandel@meslistes.polytechnique.fr) avant le 10 juin 2018  
Free registration by email at [symposium-mandel@meslistes.polytechnique.fr](mailto:symposium-mandel@meslistes.polytechnique.fr) by June, 10<sup>th</sup> 2018  
Contact : [daniel.weisz-patrault@polytechnique.edu](mailto:daniel.weisz-patrault@polytechnique.edu)

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# Plenary Lecture

by Philippe Geubelle

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## *Multifunctional Microvascular Polymeric Matrix Composites*

Inspired by many living organisms, microvascular composites form a new class of fiber-reinforced polymeric-matrix composites that contain a circulatory system made of an embedded network of microchannels. Based on the choice of the fluid circulating in the microvascular network, a wide range of multi-functionalities are being considered for these materials, including autonomic healing of internal damage, switching embedded antennas, and active cooling. The Autonomic Materials Systems team located at the University of Illinois' Beckman Institute of Advanced Science and Technology recently introduced a new manufacturing process for this class of composites based on sacrificial fibers woven in the original fabric. This development has led to the creation of complex microvascular networks that are integrated directly into the composite microstructure.

The emphasis of this talk is on the development and application of microvascular composites for a variety of active cooling applications, including skin materials for hypersonic aircrafts, active cooling of car batteries and radiative cooling of nanosatellites. The new manufacturing process provides a lot of flexibility in the configuration of the embedded network. To assist with the material design process, a novel numerical tool based on an interface-based generalized finite element method (IGFEM) has been developed to model accurately and efficiently the impact of the coolant flowing through the microchannels on the thermal field in the composite. A gradient-based shape optimization scheme is then used together with the IGFEM solver to optimize the configuration of the embedded microchannel network based on a variety of objective functions and constraints. 2D and 3D configurations of the microchannels are investigated and compared based on their thermal and flow efficiency and on their impact on the structural integrity of the composite. We also optimize the microchannel network for redundancy.

In the last part of the talk, I will present some recent advances made in the development of a manufacturing method for microvascular composite materials based on the frontal polymerization of the thermosetting resin.

## Philippe H. Geubelle

Bliss Professor of Aerospace Engineering  
University of Illinois at Urbana-Champaign

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Originally from Belgium, Philippe Geubelle got his B. Sc. in mechanical engineering from the Catholic University of Louvain in 1988, and his M.S. and Ph.D. in aeronautics at Caltech in 1989 and 1993, respectively. After a year as Postdoctoral Research Associate at Harvard, he joined the University of Illinois at Urbana-Champaign in January 1995, where he is currently Bliss Professor in the Department of Aerospace Engineering, with joint appointments in Mechanical Science and Engineering, at the National Center for Supercomputing Applications and at the Beckman Institute of Advanced Science and Technology. He served as the Head of the AE Department from 2011 to 2018, and was recently appointed as the Executive Associate Dean of the College of Engineering. His research interests pertain to the theoretical and numerical treatment of complex problems in solid mechanics and materials, and, in particular, the multidisciplinary computational analysis and design of

multifunctional biomimetic materials, dynamic fracture mechanics, multiscale modeling of heterogeneous materials, composite manufacturing, and thin films for MEMS and microelectronics applications.

# Thursday, June 20<sup>th</sup>, 2019 Program

Becquerel Amphitheater

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08:45 - 09:20 am *Registration and Welcome Coffee*

09:20 - 09:30 am **Welcome Address** by **Patrick Le Tallec**, LMS director

09:30 - 10:30 am **Plenary Lecture** by **Philippe Geubelle**  
*Multifunctional Microvascular Polymeric Matrix Composites*

10:30 - 11:00 am *Coffee Break*

*Session Chair: J. Diani*

11:00 - 11:30 am **Foucault de Francqueville**  
*Modelling highly filled elastomers with an account for particle/matrix damage*

11:30 - 12:00 am **Estève Ernault**  
*Influence of thermal treatments on mechanical properties of polyphenylene sulfide*

12:00 - 12:30 am **Martin Avila Torrado**  
*Ageing and fatigue of conductive glue with polyimide and silicon matrix*

12:30 - 2:00 pm *Lunch*

*Session Chair: A. Constantinescu*

2:00 - 2:30 pm **Othmane Zerhouni**  
*Quantitative analysis of the deviation on the elastic properties of porous materials using 2nd-order statistical descriptors*

2:30 - 3:00 pm **Dipayan Mukherjee**  
*Modeling dissipation in NdFeB particle-filled magnetorheological elastomers*

3:00 - 3:30 pm **Filippo Agnelli**  
*Optimal design of microarchitected auxetic polymeric sheets*

3:30 - 4:00 pm *Coffee Break*

*Session Chair: M. Jabbour*

4:00 - 4:30 pm **Ludovic Gil**  
*Finite strain poroelasticity with chemical species diffusion with application to subcutaneous injections*

4:30 - 5:00 pm **François Kimmig**  
*Multi-scale modelling of the cardiac contraction*

5:00 - 5:30 pm **Nicolas Hanappier**  
*A general multiphysics theory for solids with application to the design of electric motors*

5:30 - 5:40 pm **Closing Address** by **Patrick Le Tallec**

# Jean Mandel

Founder of the Laboratoire de Mécanique des Solides

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After brilliant secondary studies, Jean Mandel went on to École Polytechnique in 1927 and later to École des Mines. In 1932 he became a professor at École des Mines de Saint-Étienne and in 1948 at École des Mines de Paris. From 1951 to 1973 he was professor of mechanics at École Polytechnique.

Jean Mandel's research career was devoted mainly to the mechanics of solids and the strength of materials. In 1961 he created the Laboratoire de Mécanique des Solides, a laboratory common to École Polytechnique, École des Mines de Paris, École des Ponts et Chaussées and associated to the Centre National de la Recherche Scientifique. In October 1964 he founded and became the first president of the Groupe Français de Rhéologie. In 1980 he became "honorary member" of this group.

The scientific work of Jean Mandel covers a very wide field with a bibliography listing more than 150 articles and 5 books. He presented original ideas on the buckling of beams and shells, the finite deformations of solids, laminar flow in porous media, the bearing capacity of shallow foundations, the punch resistance of a two-layer medium, the stability of underground cavities, the plastic flow of metals, and the effect of cyclic loading on structures, as well as contributions to the fields of thermodynamics, rolling friction and homogenization.

But Jean Mandel's influence extended far beyond the field of his personal research. A good many students were trained, under his direction, in the Laboratoire de Mécanique des Solides. A fine teacher and a constant stimulus to his research group, he gave his time generously to study the details of manuscripts that were sent to him and to suggest the minor modifications he deemed necessary. Those who had the privilege of working with him were left with an impression of palpable scientific passion and moral rigor that will continue to be an example for generations to come.

Jean Mandel passed away on the 19th of July 1982, the victim of a tragic accident at the very height of his intellectual prime.

Biography by Pierre Habib

***The Jean Mandel Symposium is open to all students, researchers and scientists interested in the proposed topic. It combines, in an informal setting, a keynote presentation by an internationally renowned scientist and talks given by young researchers associated with the laboratory. A large amount of time is dedicated to scientific discussions.***