TIME TABLE

TIME	Monday	Tuesday	Wednesday	Thursday	Friday
	September 30	October 1	October 2	October 3	October 4
09.00 - 09.45	Registration	De Borst	Voyiadjis	Marsavina	Czamota
09.45 - 10.30	De Borst	De Borst	Voyiadjis	Marsavina	Czamota
11.00 - 11.45	De Borst	Altenbach	Voyiadjis	Czamota	Marsavina
11.45 - 12.30	De Borst	Altenbach	Marsavina	Czamota	Marsavina
14.00 - 14.45	Sadowski	Voyiadjis	Altenbach	Sadowski	
14.45 - 15.30	Sadowski	Voyiadjis	Altenbach	Sadowski	
16.00 - 16.45	Altenbach	Voyiadjis	Sadowski	workshop	
16.45 - 17.30	Altenbach	De Borst	workshop	workshop	
18.00	Welcome aperitif				

ADMISSION AND ACCOMMODATION

The course is offered in a hybrid format, allowing participants the flexibility to attend either in person or remotely via the Microsoft Teams platform. Limited spots are available for on-site attendance and will be allocated on a first-come, first-served basis.

Registration fees:

- **On-site participation: 600.00 Euro + VAT***

Includes a complimentary bag, five fixed menu buffet lunches, hot beverages, downloadable lecture notes.
Deadline for on-site application is August 30, 2024.

- **Live Streaming Online Participation: 250.00 Euro + VAT***

Includes downloadable lecture notes.
Deadline for online application is September 18, 2024.

Application forms should be submitted online through the website: http://www.cism.it.
A confirmation message will be sent to accepted participants.

Upon request, a limited number of on-site participants can be accommodated at CISM Guest House at the price of 35 Euro per person/night (contact: foresteria@cism.it).

** where applicable (bank charges are not included) - Italian VAT is 22%.*

CANCELLATION POLICY

Applicants may cancel their registration and receive a full refund by notifying the CISM Secretariat in writing (via email) no later than:
- August 30, 2024 for on-site participants (no refunds after the deadline);
- September 18, 2024 for online participants (no refunds after the deadline).
Cancellation requests received before these deadlines will be subject to a 50.00 Euro handling fee. Incorrect payments are also subject to a 50.00 Euro handling fee.

GRANTS

A limited number of participants from universities and research centres who do not receive support from their own institutions can request a waiver of the registration fee and/or free lodging.
Requests should be sent to the CISM Secretariat by **July 20, 2024**, along with the applicant's curriculum vitae and a letter of recommendation from the head of the department or a supervisor confirming that the institute cannot provide funding. Preference will be given to applicants from countries that sponsor CISM.

For further information please contact:
CISM (Seat of the course)
Palazzo del Torso - Piazza Garibaldi 18 - 33100 Udine (Italy)
tel. +39 0432 248511 (6 lines)
e-mail: cism@cism.it | www.cism.it

ACADEMIC YEAR 2024
The G. Del Piero Session
Centre International des Sciences Mécaniques
International Centre for Mechanical Sciences

TIME AND RATE-DEPENDENT DAMAGE EVOLUTION AND FRACTURE IN ADVANCED COMPOSITES

Advanced School
coordinated by

Tomasz Sadowski
Lublin University of Technology
Poland

Holm Altenbach
Otto-von-Guericke-Universität Magdeburg
Germany

Udine ***September 30 - October 4*** **2024**

TIME AND RATE-DEPENDENT DAMAGE EVOLUTION AND FRACTURE IN ADVANCED COMPOSITES

Novel and advanced multiphase materials are required by various innovative industrial applications, e.g. in aerospace, military, aeronautics, automotive, civil, and other applications. The basic question in designing new composites is how to optimally arrange the reinforcing phase to get the required material response to the applied load. The most important of these are fibrous composites, laminates, and complex multiphase materials, including interpenetrating and functionally graded composites, with complicated architectures of an internal structure consisting of porosity, and different types of reinforcement. It is widely recognized that important macroscopic properties like macroscopic stiffness and strength are governed by multiphysics processes that occur at one to several scales below the level of observation.

A thorough understanding of how these processes influence the reduction of stiffness and strength is key to the analysis of existing, and the design of improved, complex materials.

The aim of this course is to present a series of lectures by researchers specialized in (1) multiscale modelling of complex materials, and (2) developing novel experimental methods of observation of damage and fracture processes in these materials subjected to high strain rate loading. The basic principles will be formulated of multiscale modelling strategies towards modern complex multiphase materials subjected to dynamical or impact loadings.

The study of how these various length scales and multiphysical processes (1) can influence damage and fracture processes of advanced composites and (2) can be bridged or considered simultaneously during a time- and rate-dependent material loading. They have a well-defined architecture or internal structure at the nano-, micro-, and mesolevels. For this reason, advances in multiscale modelling and analysis made here, pertain directly to classes of materials that either have a wider range of relevant microstructural scales, such as polymers, and metals, or have random microstructures, e.g. metal-matrix composites, fiber-reinforced laminates, interpenetrating phase composites, FGMs or cellular materials and voided solids.

With regard to ceramic composites (CCs) and ceramic matrix composites (CMCs) the damage and fracture processes will be described with a triple-scale approach. The important problem of the damage process of interfaces surrounding particles, grains, whiskers or fibres included in composites will be analysed for different properties of the inclusions and in different scales.

The challenge in modelling time-dependent problems is to solve space and time multiscale, multiphase, and multiphysics initial-boundary value problems. Therefore, various methods applicable to time- and rate-dependent problems in novel composite materials will be discussed during the course including FEM, phase-field, or peridynamics.

The experimental part of the lectures includes a description of the newest achievements in (1) micro-CT assessment of internal structures of complex composites, (2) testing under low-velocity impact including temperature effects, and (3) high-velocity strains experiments with application Split Hopkinson Pressure Bar.

PRELIMINARY SUGGESTED READINGS

R. de Borst and T. Sadowski, Lecture Notes on Composite Materials, Springer, 2008.

H. Altenbach, J. Altenbach, W. Kissing: Mechanics of Composite Structural elements, 2nd ed. Springer Singapore, 2018.

T. Antoun, L. Seaman, D.R. Curran, G. Kanel, S. Razorenov, A. Utkin, Spall Fracture, Springer, Berlin, 2003.

V.F. Nesterenko, . Dynamics of heterogeneous materials. Springer-Verlag, New York, 2001.

M.A. Meyers, Dynamic Behavior of Materials. John Wiley & Sons, New York,1994.

C. Czarnota, Molinari, S. Mercier, Steady shock waves in porous metals: Viscosity and micro-inertia effects. International Journal of Plasticity (135), 102816, 2020.

E. Postek, T. Sadowski, Impact model of the Al2O3/ZrO2 composite by peridynamics. Compos. Struct., 271, 114071, 2021.

E. Linul, D. Pietras, T. Sadowski, L. Marsavina, D.K. Rajak, J. Kovacik, Crashworthiness performance of lightweight composite metallic foams at high temperatures, Compos. Part A 149,106516, 2021.

M. Tahani, E. Postek, T. Sadowski, Effect of vacancy defect content on the interdiffusion of cubic and hexagonal SiC/Al interfaces: A molecular dynamics study. Molecules. 28:744-763, 2023.

M. Fathalian, E. Postek, T. Sadowski, Mechanical and electronic properties of Al(111)/6H-SiC interfaces: A DFT study, Molecules, 28(11):4345-1-19, 2023.

LECTURES

All lectures will be given in English. Lecture notes can be downloaded from the CISM web site. Instructions will be sent to accepted participants.

INVITED LECTURERS

Holm Altenbach - Otto-von-Guericke-Universität Magdeburg, Germany
6 lectures on: Time-dependent Damage and Failure Events in Advanced Composites. Examples of different types of damage and failure behaviour in advanced composites; rational description of damage and failure; classical and non-classical models for new advanced materials like foams, etc.

René de Borst - University of Sheffield, UK
6 lectures on: Computational Approaches to Intralaminar and Interlaminar. Failure Discussion phenomena in laminated composite structures leading to failure: matrix cracking, inter and intra-laminar cracking, and pull-out of fibres. Nonlinearities at macro, meso and micro-scales. Cohesive and damage models, interface elements in XFEM.

Christophe Czarnota - Université de Lorraine, France
4 lectures on: Modelling and experimental characterization of different nature materials under dynamic loading. Experimental methods like SHPB, shock wave experiments, dynamic ring expansion, and perforation; analytical and numerical modelling of high strain rates response of heterogeneous materials including voided solids.

Liviu Marsavina - Universitatea Politehnica Timisoara, Romania
5 lectures on: Static and dynamic behavior of cellular materials. Damage and fracture processes of cellular structures and composite structures incorporating cellularmaterials; static and dynamic loading including impact and fatigue; the size effect, the notch effect,and the mixed-mode loading; damage identification.

Tomasz Sadowski - Lublin University of Technology, Poland
5 lectures on: Description of Damage and Fracture Processes in Polycrystalline Ceramics,Interpenetrated and FGM Composites. Damage and fracture processes at high strain rates will be described by micromechanical modelling of multiphase composites and experimental verification of damage and failure criteria under impact.

George Z. Voyiadjis - Louisiana State University, USA
6 lectures on: Damage Mechanics: Theory, Computations, and Applications. Recent advances in continuum damage mechanics for metal matrix composites; different constitutive models; different scales approach in damage mechanics: overall, local, and interfacial; various experimental damage investigations; damage fabric tensors.