SCIENTIFIC AND PROFESSIONAL RESUME
of Igor Emri

Born May 22, 1952 in Murska Sobota; Doctor of Technical Sciences (University of Ljubljana/California Institute of Technology, 1981), Chair Professor of Mechanics, and Chairman of the Institute for Sustainable Innovative Technologies.

Professor Emri has made significant contributions to the field of mechanics of time-dependent materials, as a *scientist*, as an *inventor*, as well as a *patron* of this new field.

In 1993 Professor I. Emri, together with prof. W. G. Knauss from California Institute of Technology, **created the new research field called "Mechanics of Time-Dependent materials - MTDM".** MTDM was organized as a Technical Division (TD) of the American scientific association "The Society of Experimental Mechanics - SEM". That same year he became the first chairman of this TD.

MTDM research area was established as a response to the needs (at that time mainly U.S. aviation industry and army) for a better understanding of time-dependent structural behavior of polymers and their composites at extreme thermo-mechanical loading. These needs have led to the start of organizing international conferences in this field. The first MTDM conference was organized by I. Emri in 1995. Two years after, in 1997, the international publishing house Springer started to publish the international journal "Mechanics of Time-Dependent Materials", which now belongs to the top third of journals in the field of Mechanics and Rheology. Prof. I. Emri, together with professor W. G. Knauss from California Institute of Technology, was selected as the Editor-In-Chief of this journal. In 2000 he was the first foreigner to be elected as a president of the American scientific association "The Society of Experimental Mechanics - SEM".

Research work of I. Emri is focused on mechanics of dissipative systems with emphasis on studying the effect of the rate of changing of thermo-mechanical boundary conditions on processes of structure formation of polymeric materials and their macro-, micro- and nano-composites. He has developed the first constitutive non-linear viscoelastic model, in literature known as *Knauss-Emri* model, which enables modeling of nonlinear behavior of polymers exposed to a complex time-dependent thermo-mechanical loading. In the book of Alan S. Wineman and K.R. Rajagopal »*Mechanical Response of Polymers. An Introduction, Cambridge University Press, 2000*«, the *Knauss-Emri* model is regarded as "*classical theory*" of nonlinear viscoelasticity. For this scientific achievement he was awarded by the Russian Academy of Natural Sciences - RANS with the *Kapitsa Medal*, which is the highest award of the Academy. Based on these achievements, he became a full member of RANS Academy, Russian Academy of Engineering and a corresponding member of the American Academy of Mechanics - AAM. In 2000 he was placed on the list of the world's leading experts in the design of polymeric materials in the book "*Who's Who in Polymers and Plastics*", published by the Society of Plastics Engineers (SPE), U.S..

In the *Knauss-Emri* model, the process of structural reorganizations in dissipative systems, e.g. polymers at the molecular level, is described by relative "internal time", which is a measure of the rate of material structure formation. Complexity and kinetics of reorganization of material structure is reflected in the level of time-dependency of its mechanical and other physical properties. Time dependence of mechanical properties is described by relaxation spectrum $H(\tau)$, which is through the molecular theory related to the molecular weight distribution of polymers. Determination of the mechanical spectrum requires an inverse solution of Fredholm's integral equation of the first or second order, which is numerically ill-conditioned problem (ill-posed problem). For the integral forms that appear in the theory of viscoelasticity, this problem has been satisfactorily resolved only at the end of the last millennium. One of the most successful numerical algorithms for the determination of mechanical spectrum was also developed by dr. Emri. In literature, this numerical approach is known as **Emri-Tschoegl algorithm.**

Research aimed at understanding the macroscopic properties of polymeric materials as a typical representatives of dissipative systems, have shown that the structure and any associated physical properties of polymeric materials can be controlled and modified either by changing the initial kinetics of material (ie, molecular distribution and topology of molecules), and on the other hand, by varying thermo-mechanical boundary conditions to which the material is exposed (i.e., technology).

For the experimental study of the influence of thermo mechanical boundary conditions on the process of structure formation of the material dr. Emri developed a completely new measuring system, which was named "**CEM Measuring System**" (CEM is an acronym for Center for Experimental Mechanics, which is led by I. Emri under the ULJ). The apparatus is under this name described in the handbook "Springer Handbook of Experimental Solid Mechanics", Springer, 2008.

Model *Knauss-Emri*, *Emri-Tschoegl* algorithm, and the newly developed *CEM Measuring System* were used as a new innovative theoretical and experimental approach in researching the processes of structure formation of dissipative systems, in this case, the polyamide materials under the influence of complex thermo mechanical boundary conditions.

Materials with appropriately modified initial kinetics, which can be achieved by changing the molecular weight distribution from mono- to multi-multimodal distribution (multimodal polymers), are showing at the particular thermo mechanical boundary conditions extremely nonlinear (chaotic) behavior. This means that even very small change in boundary conditions leads to a completely different structure of the material in solid state. It turns out that the changes in boundary conditions on the macro-scale can cause changes in the structure of materials at the nano-scale. The relevant thermo-mechanical boundary conditions (technology) can thus change the structure of the material as a result of nonlinear interaction processes of reorganization of polymer chains in different time-space scales, from nano- to macro-scale. This may lead to changes of material physical properties for several orders of magnitude!

This research, in collaboration with BASF Corporation, led to a break-through new generation multimodal polyamides, called I-PA materials (where "I-" stands for intelligent). Macroscopic properties of I-PA polymers are several orders of magnitude different in comparison to properties of chemically identical mono-modal materials. I-PA materials differ from the conventional materials only in complexity of their structure on the micro-and nano-scale. The difference in materials structure results from interactions between the thermo-mechanical boundary conditions (technology) and processes of material structure formation at the molecular level. For the new generation of multimodal polymers it is typical that their mechanical properties far exceed the known materials for several orders of magnitude, at the same time they exhibit properties which conventional materials do not. For example, temporal stability of the mechanical properties of the new generation of multimodal polyamides is more than 1000-times (!) better than those recorded by conventional chemically identical materials. The technological breakthrough was protected by a series of global, and separate American and Canadian patents, where in all cases I. Emri is the first author.

I. Emri is the recipient of various awards, including the national "*Boris Kidrič*" award and the award "*Ambassador of Science of the Republic of Slovenia*" for the year 2001.

In 1997 he established the Department for Mechanics of Polymers and Composites at the Faculty of Mechanical Engineering in which he teaches subjects from the field of time-dependent materials and related nano-technologies. As a Visiting Professor he lectured at several universities in Europe, Japan and the U.S.. Since 2001, he is a visiting professor at the Department of Aeronautics at the prestigious California Institute of Technology (CalTech) in the USA.

Since 2002 he is a Member of the professional associations WAK (Wissenschaftlicher Arbeitskreis der Universitäts-Professoren der Kunststofftechnik, http://wak.mv.uni-kl.de/), which brings together 25 institutes (24 from EU and 1 from U.S.) in the field of polymer technology. He is also an expert of the European Commission for FP4, FP5, FP6 and FP7. Since 2005 he is also a member of the Executive Council of the European Society of Rheology (http://www.rheology-esr.org).

In the period from 2005 to 2010, following his election as an Associate member of the Slovenian Academy of Science and Arts (SASA), Dr. Emri and his group continued with research work in the field of mechanics of dissipative systems with emphasis on studying the impact of the rate of changing of thermo-mechanical boundary conditions on the process of structure formation of polymeric materials and their macro-, micro- and nano-composites. Of particular note are studies of the behavior of multimodal polyamide materials that he previously developed and patented in cooperation with BASF Corporation. These materials exhibit highly nonlinear behavior and are able, at small changes in extreme thermo-mechanical boundary conditions (high pressures and rapid changes in temperature and pressure), to form a very different structures, that demonstrate the ability to completely proliferate with surrounding tissues, i.e., osteointegration and/or controlled degradation in a pre-defined period of time.

This feature of multimodal materials has opened the possibility of using these materials for medical purpose, mainly in the field of dental and orthopedic surgery. Technology developed helped to manufacture small cylindrical samples (from the before mentioned new generation multimodal polyamide materials) with gradient structure, similar to that of bones. Osteointegration ability of these samples has been verified by in-vivo experiments. Histological examination of the ingrown implant in the radius front leg of a piglet, showed that the proliferation of the implant with surrounding bone tissue is complete! The histological examinations were carried out in Switzerland in "Schupbach Ltd., Research Laboratory for histology and Nanostructures"

Currently, these are the world's first implants that show the ability to complete the proliferation of surrounding tissue and represent a technological breakthrough in the field of implantology.

This achievement has been the motivation to establish the *Institute for Sustainable Innovative Technologies* (2008), which is the first nonprofit institution in Slovenia, organized in accordance with EU legislation as EEIG (http://www.libertas-institut.com), that on its 4500 m^2 of research-production facilities, provides the conditions for bringing together researchers with the aim of creating a synergy of top skills required for the transfer of cutting-edge basic knowledge and skills in the industrial environment, thus raising the competitiveness of Slovenian industry and service sectors. The Institute is fully funded by industrial money (so far it has not received any governmental or EU funds). Since October 2008, ISIT provides excellent conditions for studying of under- and postgraduate students of the University of Ljubljana and for foreign students who are involved in the European postgraduate school EURHEO, which joins together 6 European

Universities. Among them is also University of Ljubljana. Prof. Emri is one of the founders of EURHEO postgraduate school.

Bibliography of I. Emrija in the COBISS data base counts 847 bibliographic units, and close to 1000 citations in journals and books. Full listing is available at (http://izumbib.izum.si/bibliografije/Y20110525233435-04316.html)

Professor Emri is among the world's leading experts in the field of mechanics of time-dependent materials. He has been honored for his superior achievements in the field of Mechanics by the American Scientific Association "The Society of Experimental Mechanics" with the election to "Fellow" members (2009), and with the "B. J. Lazan" Award for 2010. In the same year he was also elected as full member of the "European Academy of Sciences, EAS", from Belgium (2010).

Main Contributions:
Contributions to understanding of the behavior of dissipative systems under time varying thermomechanical loading and application in different fields of engineering

(1) Establishmet of the new scientific field – "Mechanics of Time Dependent Materials
Lounching MTDM Conferences in this field
Lounching the new MTDM Journal - Editor-In-Chief from the very beginning

(2) Nonlinear constitutive model Knauss-Emri for modeling non-linear rate dependent behavior of dissipative systems with emphasis on structural polymeric materials and their macro-, micro-, nad nano-composites.

(3) Algorithm for solving inverse problems in engineering known as Emri-Tschoegl algorithm, first used for determination of mechanical spectrum in viscoelasticity

(4) Varying complex interactions on molecular level through multimodal molecular size distribution → patented new generation PA materials that exhibit Osseo-integration

(5) New experimental technique – CEM Measuring System for studying pressure and temperature effects on behavior of rate dependent dissipative systems

(6) New generation vibro-acustic damping systems for vibration and noise reduction.

    (i) Patented ultimate solution for noise and vibration reduction in Railway systems
    (ii) New generation Earthquake protection system

(7) Teaching: Cofounder of the European graduate school on Engineering rheology – EURHEO

TECHNOLOGY TRANSFER ON INTERNATIONAL SCALE

Elaborate the concept of the generic technology research as a tool for sustainable growth of emerging coutries.

(1) Establishment of the Institute for Sustainable Innovative Technologies
(2) Establishment of the EKZEC
(3) Establishmnet of PSRC

Record of major professional work experience:

Teaching Assistant, University of Ljubljana, Ljubljana, Slovenia, 1975-1978.
Graduate Teaching Assistant, California Institute of Technology, USA, 1979-81.
Senior Research Fellow, Inst. für Werkstofftechnick, GhK Kassel, Germany, 1982.
Part-time Professor at Institut für Werkstofftechnick, GhK Kassel, Germany, 1983-1990.
Assistant Professor of Mechanics, University of Ljubljana, Slovenia, 1983-1988.
Associate Professor of Mechanics, University of Ljubljana, Slovenia, 1988-1995 .
Visiting Scientists at California Institute of Technology, Pasadena, USA, 1987-1996
Visiting Professor at the University of Waterloo, Canada, Summer 1992, 1993, and 1994.
Invited Professor of the "Special Chair AIB-Vincotte" at the University of Brussels, Brussels, 1995.
Professor and Department Head, University of Ljubljana, Slovenia, 1996-.
Invited Part time Professor at the University of Saratov, Russia, 1996-2000.
Visiting Professor, Lehigh University, Bethlehem, 1998-1999
Visiting professor at California Institute of Technology, Pasadena, USA, 2001
Visiting Professor at Aoyama Gakuin University, Tokyo , Japan , 2003
President and CEO, Institute for Sustainable Innovative Technologies, 2006-
Invited part time Professor he Bauman Moscow State Technical University, Moscow, 2013-
Honourable Professor of the Kazakh National Agrarian University, Kazakhstan, 2013-

Professional recognition (honors, awards, prizes, …)

'Boris Kidrič Foundation' Award for Research Achievements, Slovenian Science Foundation, 1983.
Full Member (Fellow) of The Slovenian Academy of Engineering (associate Member, 1995), Slovenia, 1998.
Full Member (Fellow-Academician) of the *International Academy of Engineering*, Moscow, 1996.
Foreign Corresponding Member of *The American Academy of Mechanics*, USA, 1996.
Foreign Member of the *Russian Academy of Natural Sciences*, Moscow, Russia, 1997.
"Kapitsa Medal", Russian Academy of Natural Sciences, Moscow, Russia, 1997.
Listed in *"Who's Who in Polymers and Plastics",* Society of Plastics Engineers (SPE), USA, 1999.
Award "*Ambassador of Science of the Republic of Slovenia"*, Ministry of Science and Education of the Republic of Slovenia, 2001.
Fellow of the *European Academy of Sciences and Arts*, Salzburg, Austria, 2006.
Fellow of the Society of Experimental Mechanics (SEM), USA, 2009;
"*Lazan Award*", The Society of Experimental Mechanics (SEM), USA, 2010 ;
Fellow of the *European Academy of Sciences,* Liège, Belgium 2010;
"Engineering Glory" of the International Academy of Engineering, Moscow, 2010
"Golden Emblem" of the International Academy of Engineering, Moscow, 2011
"Engineering Glory" of the National Engineering Academy of the Republic of Kazakhstan, 2011
"Golden Emblem" of the Engineering Academy of Ukraine, and Honorary member of this Academy, 2011
Full Member (Fellow) of the *Slovenian Academy of Sciences and Arts* (Associate Member in 2005), Ljubljana, Slovenia, 2013.