

Preface

Multi-functional materials as piezoelectric/ferroelectric ceramics, magnetostrictive and shape memory alloys are gaining increasing applications as sensors, actuators or smart composite materials systems for promising high tech areas. One primary problem is, however, that these functional materials suffer from various mechanical and/or electromagnetical degradation mechanisms as fatigue, damage and fracture. As a consequence of field coupling effects, fabrication processes and service loads, smart materials systems are exposed to high mechanical and/or electromagnetical field concentrations under internal and external loading of static, cyclic and dynamic type. For this reason, the investigation of fatigue, damage and fracture plays a decisive role for the optimum design, reliability and durability of smart materials systems. Thus, the topic of the symposium represents an active international research area in mechanics of materials. From the experience and investigations during the last decade it has become evident that progress in this scientific discipline is only possible, if material models are based on the true physical nature of the phenomena and if theoretical predictions are verified by skilful experiments. Therefore, the scientific challenges can only be solved by

- A multi-scale modelling at several length scales from atomistic to macroscopic level
- An interdisciplinary cooperation between solid mechanics, materials science and physics

To promote the international scientific exchange in this important field, in 2006 the General Assembly of IUTAM approved the proposal to host this symposium in Freiberg, Germany and appointed the International Scientific Committee. The IUTAM Symposium (GA. 06-16) “Multiscale Modelling of Fatigue, Damage and Fracture in Smart Materials Systems” was held on September 1–4, 2009 at Technische Universität Bergakademie Freiberg, Germany, organized by the Institute of Mechanics and Fluid Dynamics.

This symposium stands in a line with former symposia on related topics held under the auspices of IUTAM in 2000 at Magdeburg and in 2004 at Beijing. The helpful assistance of the International Scientific Committee to communicate the symposium and to recommend invited speakers is thankfully appreciated.

According to the rules and tradition of IUTAM, the aim of the Symposium is to bring together internationally leading researchers working in the area of smart materials. The goal is to exchange recent scientific results, to discuss new achievement and actual problems in an open and frank atmosphere. The organizers were happy to welcome a lot of outstanding scientists in this field from all parts of the globe as well as many young researchers. In total there were 44 participants coming from 14 countries: Australia (1), Austria (3), Belgium (1), Canada (1), China (8), Great Britain (1), France (2), Germany (19), Israel (1), Italy (1), Japan (2), Slovakia (1), Ukraine (1) and USA (2). The scientific program covered 35 invited oral contributions presented in 10 sessions.

The following main topics have been addressed during the symposium:

- Development of computational methods for coupled electromechanical field analysis, especially extended, adaptive and multi-level finite element techniques in combination with boundary elements.
- Constitutive modeling of smart materials with coupled electric, magnetic, thermal and mechanical fields, especially of nonlinear dissipative hysteresis behavior. Major trend is the development of micromechanical models. Especially for ferroelectric materials and shape memory alloys the simulation of microstructure (domain switching, martensitic transformation etc.) are of paramount concern.
- Further understanding and modeling of fracture and fatigue in piezoelectric and ferroelectric ceramics, especially the modeling of fracture process zone and of electric boundary conditions at crack faces. Applications of phase field simulation and configurational mechanics.
- Reliability and durability of sensors and actuators under in service loading by alternating mechanical, electrical and thermal fields. The role of interface cracks between layers and in thin films is addressed.
- Experimental methods to measure fracture strength and to investigate fatigue crack growth in ferroelectric materials under electromechanical loading. It has been pointed out that complicated theoretical predictions have to be contrasted and verified by skilful experiments.
- New ferroelectric materials, compounds and composites with enhanced strain capabilities.

The chairman and its organizing team tried to make this IUTAM symposium not only a successful scientific meeting but an outstanding social event, too. Many thanks are due to Prof. Dr. A. Ricoeur, who carried the main workload in organizing all details of this symposium.

The Technische Universität Bergakademie Freiberg is located in the East German Federal State Saxony. Besides Dresden and Chemnitz, TU Bergakademie Freiberg is considered as the “smallest” but “smartest” among these Technical Universities. Its history started with the discovery of silver in the middle ages. The “Mining Academy” Freiberg was founded by the Saxon King in 1765 in order to promote the technologies in surveying, mining and metallurgy. Thus, TU Bergakademie Freiberg possesses a long and famous tradition as one of the oldest montanistic universities in the world. Nowadays, TU Bergakademie Freiberg is established as modern

Technical University focusing mainly on Geoscience, Resources, Materials Science, Energy and Environmental Technologies.

Freiberg has one of the largest and most splendid mineralogical exhibitions “Terra Mineralia” in the world hosted in the old castle “Freudenstein”. The participants of the symposium enjoyed the visit very much.

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Meinhard Kuna
Chairman of the Symposium

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