جامعة عبد المالك السعدي
Université Abdelmalek Essaadi

Pole for Doctoral Studies
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ANNOUNCEMENT OF DOCTORAL THESIS DEFENSE

M. BOUCHIKHI Ahmed

Will present their research work with the aim of earning a Doctorate

Doctoral program: Mathematical, Physical Sciences and New Technologies
Discipline: Physical science of the engineer
Specialty: Mechanics of materials

On 12/09/2026 at 10H30 at the Thesis Defense Hall, Faculty of Sciences of Tetouan UAE
Under the Theme

Multi-scale Modeling of the Effective behavior of Elastic, Viscoelastic, and Visco-Magneto-Electro-Elastic Multilayered Composites with Imperfect Interface Effects

Front of the jury composed of :

First Name & Last Name	Establishment	Designation
Pr. OUARDOUZ Mustapha	FST of Tangier, UAE	President
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Pr. EL BAHAOUI Jalal	FS of Tetouan, UAE	Reviewer
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Pr. ABOU El HANOUNE Younes	ENSA of Al-Hoceima, UAE	Examiner
Pr. EL-BAKARI Abdelali	ENSA of Tetouan, UAE	Examiner
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Host Research Structure: Energy Laboratory, Department of Physics of Tetouan

Abstract

This thesis presents various mathematical and micromechanical models developed to predict the effective behavior of multi-scale composite materials, particularly elastic, viscoelastic, and visco-magneto-electro-elastic (VMEE) multilayer composites. The structure and behavior of these materials have been studied and modeled. These multifunctional materials combine mechanical properties with other physical properties, particularly electrical or magnetic properties. The methods developed within this study are based on the general matrix method to determine the macroscopic properties of elastic, viscoelastic, and visco-magneto-electro-elastic multilayer composites while explicitly accounting for the impact of imperfect interfaces. A hybrid approach combining the Mori-Tanaka method and the matrix method has also been proposed for the precise estimation of the effective properties.

Analytical, semi-analytical and numerical approaches were then proposed to estimate the macroscopic properties of the multilayer composite material with an imperfect interface, using a multi-scale homogenization process. This process uses the properties of its constituents and its microstructure as inputs. The research was executed through a series of progressive modeling developments. Initially, a two-step homogenization procedure was developed to predict the effective behavior of N-layered elastic composites reinforced by aligned short fibers. Integrating the Mori-Tanaka micromechanical model with a general matrix method then allowed analytical expressions to

be derived for the overall properties of these structures under the assumption of perfect interfacial bonding. The analysis was then extended to address the time-dependent response of viscoelastic, multi-layered composites with imperfect interfaces. This was obtained by applying the Laplace–Carson transform (frequency domain) to convert constitutive relations into algebraic form, and by using a linear spring-type law to model interfacial imperfections. The effective properties were then determined directly in Carson space. The properties in time space (time domain) are then obtained by inverse transform. The proposed approaches provide solutions within a general framework and under certain limiting assumptions, such as constant microscopic or macroscopic viscoelastic Poisson's ratio, constant compressibility modulus, and a constant volume fraction and interface thickness. These assumptions were systematically examined and validated against alternative interface representations.

The modeled behavior was finally generalized to include visco-magneto-electro-elasticity, which is essential for the development of multifunctional intelligent materials. A direct micromechanical approach was adopted to consider the combined response to mechanical, electrical and magnetic stresses. The matrix formulation was adapted to account for magneto-electro-elastic effects using an imperfect hybrid model. The validity of this approach was confirmed by comparing the results with those obtained using a perfect hybrid model, in which imperfect interfaces were considered to be thin layers. This approach was used to predict the effective properties of composite materials presented for different volume fractions, and produced consistent results. Overall, this study provides a robust, computationally efficient framework for designing and optimizing advanced, multilayered composites for a variety of engineering applications.

Keywords: Elastic, Viscoelasticity, Visco-magneto-electro-elastic, Multilayered Composites, Effective properties, Micromechanics, Homogenization, Laplace-Carson transform, Time space, Mori-Tanaka Model, Matrix method, Imperfect Interfaces.