Aachener Berichte aus dem Leichtbau
herausgegeben von Univ.-Prof. Dr.-Ing. Kai-Uwe Schröder

Band 1/2015

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Shaker Verlag
Aachen 2016

Bibliographic information published by the Deutsche Nationalbibliothek
The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at http://dnb.d-nb.de.

Zugl.: D 82 (Diss. RWTH Aachen University, 2015)

Printed in Germany.

ISBN 978-3-8440-4624-3
ISSN 2509-663X

Shaker Verlag GmbH • P.O. BOX 101818 • D-52018 Aachen
Phone: 0049/2407/9596-0 • Telefax: 0049/2407/9596-9
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Nonlinear Finite Element Modeling and Analysis of Coupled Multi-Physics Smart Composite Structures

In this dissertation descriptions and derivations of a thermodynamically consistent fully coupled thermopiezomechanical finite rotation shell element and a magnetoelectroelastic (MEE) shell element are presented. Full geometrically nonlinear strain-displacement relations and finite rotations are considered in the framework of FOSD hypothesis. The four node thermopiezomechanical shell element (FOSD FRT) has 5 mechanical DOFs, 3 electrical DOFs and 4 thermal DOFs per node.

The thermopiezomechanical shell element is developed to deal with problems of isotropic, FGM and composite laminated structures. Various numerical examples are studied which range from simple single field mechanical problems to complex multi-field problems. For comparison purposes, numerical simulations are performed for certain examples with simplified nonlinear theories like refined von Kármán type (FOSD RVK), moderate rotation theory (MRT) models, and using the commercial FE software Abaqus. Additionally, the presented results are compared with those available in literature
as far as possible.

In the later part of this thesis, the magnetoelectroelastic shell finite element is developed to deal with static analysis of multilayered composite plates/shells integrated with fully coupled MEE layers. The electric and magnetic potentials have been assumed to vary quadratically over the cross-section of the MEE layer. It is noteworthy to mention that no literature is available concerned with the full geometrically nonlinear 2D-shell element to investigate laminated composite shells integrated with fully coupled MEE layers.