Electromagnetics
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/uemg20

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Published online: 14 Apr 2014.

To cite this article: Branislav M. Notaroš (2014) Introduction to the Special Issue on Finite Elements for Microwave Engineering, Electromagnetics, 34:3-4, 141-142, DOI: 10.1080/02568543.2013.877721

To link to this article: http://dx.doi.org/10.1080/02568543.2013.877721

Electromagnetics, 34:141–142, 2014

ISSN: 0272-6343 print/1532-527X online
DOI: 10.1080/02568543.2013.877721

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Introduction to the Special Issue on Finite Elements for Microwave Engineering

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This special issue features selected papers from the *11th International Workshop on Finite Elements for Microwave Engineering (FEM2012)*, held from 4–6 June 2012 in Estes Park, Colorado, USA. FEM international workshops are highly focused biannual events providing an ideal meeting place for researchers and practitioners active in the area of the finite-element method (FEM) for electromagnetics. *FEM2012* boasted about 100 attendees, with equally split U.S. and non-U.S. participations, representing 13 countries (Notaroš, 2013). The technical program combined 82 papers organized in 12 special sessions, dedicated to novel finite-element and hybrid methods, vector basis functions, higher-order elements, domain decomposition methods, discontinuous Galerkin methods, adaptive FEM, and model order reduction techniques, as well as a variety of cutting-edge FEM applications in antennas, microwave devices, circuits, packaging, metamaterials, optics, etc.

Unfortunately, only a limited number of selected papers could be included in this double special issue of *Electromagnetics*—14 in total. These 14 articles are representative not only of the workshop technical program but also of the geographical participations at the workshop—7 from the United States and 7 from other countries. The topics of these articles, sorted herein in alphabetical order according to the first author, are as follows.

Burgard, Sommer, Farle, and Dyczij-Edlinger present an order reduction technique for FEM models featuring shape and material parameters that uses polynomial interpolation to resolve implicit parameter dependencies and employs parameter-dependent bases. de la Rubia proposes a reduced-order model for a fast and reliable frequency sweep in FEM analysis of microwave devices by representing the frequency behavior of the field solution as a linear combination of solutions at properly chosen frequency points. Graglia, Peterson, Matekovits, and Petrini develop scalar and vector basis functions for modeling corner singularities in electromagnetic fields by adding singular bases to a full set of existing hierarchical nonsingular polynomial basis functions. He and Jiao demonstrate a more than "optimal" speedup of an explicit and unconditionally stable time-domain FEM by significantly accelerating the explicit time-marching-based revealing of the stable modes for any given time step without sacrificing the accuracy. Koczka, Bauernfeind, Preis, and Bíró present an iterative domain decomposition method for antenna and scattering problems, comparing it to various conventional iterative and direct solution

Received 18 November 2013; accepted 17 December 2013.
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techniques that do not use domain decomposition. Manić, Olćan, Ilić, and Notaroš propose a new diakoptic domain decomposition method for analysis of arbitrary linear dielectric and magnetic scatterers combining the FEM and method of moments and using dual sets of higher-order hierarchical basis functions. Ntibarikure, Pelosi, and Selleri address time-harmonic analysis of nonlinear passive microwave devices combining finite elements and harmonic balance to handle the nonlinearity and use Schur complement domain decomposition to speed up the nonlinear iterative solution. Peng, Sertel, and Volakis propose a new fully overlapping domain decomposition method for FEM modeling of electrically small details (such as wire antennas) embedded within large media, featuring decorrelation of highly detailed and quasi-uniform subdomain meshes. Tobón, Ren, and Liu present new triangular prism finite elements for discretization of multiscale layered structures within the discontinuous Galerkin time-domain framework that enable combining the flexibility of triangles with the accuracy of spectral elements for layered structures. Tuncer, Shanker, and Kempel develop a hybrid vector generalized FEM for time-domain electromagnetic analysis using average and jump operators of discontinuous Galerkin method to establish a domain decomposition framework and enable hybridization with the classical FEM. Webb describes a simple and effective adaptive hp-strategy for FEM analysis of microwave devices that builds on the strength of p-adaption by extending it to allow unlimited decrease in the error with the use of Bey h-refinement algorithm for hierarchical elements. Wilton, Vipiana, and Johnson present a detailed implementation of schemes for evaluating singular, near-singular, and non-singular integrals on curvilinear elements and show how singularity cancelation quadrature rules derived on linear (tangent) elements can be adapted to curvilinear ones. Xue and Jin extend the previously developed discontinuous Galerkin method for scalar problems to solving vector curl-curl Helmholtz equations by defining vector plane waves and vector Lagrange multipliers within tetrahedral elements and on element boundaries. Zdunek and Rachowicz present a direct generalized scattering matrix technique for calculating the radar cross-section of jet engine air intakes based on a higher-order FEM and reduced-order modeling and discuss h- and p-refined results for a generic S-shaped air-intake channel.

These 14 articles clearly indicate that the state of finite elements for microwave engineering and other applications is very strong. However, in spite of the great progress reported in this special issue, as well as in all other papers presented at *FEM2012*, many problems remain open, and many challenges in FEM-based analysis, modeling, and design are yet unmet, which is exciting.

I would like to sincerely thank all authors of the special issue articles for their excellent contributions as well as for their cooperation in submitting and revising the manuscripts and meeting the set of very tight deadlines. Special thanks go to the 30-plus reviewers who did an outstanding job and helped the authors to significantly improve the quality of their submissions with extreme promptness. The help of Prof. B. Shanker, who took over the editor's role for the article by Manić, Olćan, Ilić, and Notaroš, is greatly appreciated. I am also grateful to the editor-in-chief of *Electromagnetics*, Prof. H. Y. David Yang, for his encouragement and collaboration on this special issue.

Branislav M. Notaroš, Guest Editor

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