Saravana Prakash Natarajan

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PROFILE

Doctoral candidate with 7 years of laboratory experience, specializing in design, fabrication, measurement and modeling of planar and MEMS based RF and microwave circuits, sensors and antennas

EDUCATION

Doctor of Philosophy Dec.15, 2007
University of South Florida
Dissertation: Three Dimensional Micro Coaxial Transmission Line based Circuits and Applications
Advisor: Prof.Thomas M. Weller

Master of Science 2002
University of South Florida
Thesis: Microwave Characterization of Zinc Oxide Capacitors and Toroidal Inductors for Sensing Applications
Advisor: Prof.Thomas M. Weller

Bachelor of Engineering (Electrical & Electronics Engineering) 2000
University of Madras, Chennai, India

SKILLS

- **Design and Analytical Skills**
  - RF/Microwave circuit design and modeling of **passive devices (100 MHz to 65 GHz)** and RF **sensors** using ***Agilent's Advanced Design System (ADS)***
  - Electromagnetic simulation of **millimeter wave antennas** and **RF MEMS** devices using **Agilent Momentum (2.5-D**) and ***Ansoft High frequency Structure Simulator (3-D)***
  - **Modeling**, Optimization, Statistical analysis and curve-fitting using MathCAD and Microsoft Excel
- **MEMS Fabrication Processes**
  - Standard Class 1000 ***cleanroom*** procedures
  - ***Lithography*** – Quintel Mask Aligner, all common photoresists including sacrificial, planarizing polymers like PMMA, PMGI, polyimide, BCB etc
  - Plating - ***Electroless and Electroplatin***g of copper and gold including through via metallization
  - Wet Chemistry – metal wet etches and wafer cleans
  - Bulk ***Micromachining*** – deep silicon etching using TMAH and KOH
  - ***Thin Film*** Deposition – thermal/E-beam evaporation and RF/DC sputtering of metals and dielectrics
  - Dry ***Etching – Reactive ion*** and plasma etching using the Plasmatherm 700 RIE system
  - Critical Point Dry – Tousimis Automatic Critical Point dryer
- **Measurement and Characterization**
  - Millimeter Wave Measurements –***1-65 GHz measurements on-wafer*** using Anritsu, ***Agilent network analyzers*** and a ***Karl Suss semi-automatic probe station***
  - Familiarity with **NIST** Multical and Cascade Wincal software
  - ***Impedance Measurements*** – on-wafer impedance measurements using custom calibration techniques on the ***Agilent 4287A LCR meter***
  - ***Antenna Measurements*** – radiation pattern measurements using coaxial detectors and on-wafer chip diodes in an **anechoic chamber** using DAMS automated measurement software

AWARDS AND ACHIEVEMENTS

- Center for Wireless and Microwave Information Systems Tuition Assistance Fellowship (Doctoral Studies)
- Published 13 papers in peer-reviewed conferences and journals and one pending patent

- Best Student Paper Award - IEEE Wireless and Technology Conference, Dec. 2006
- Student Poster Award – Third Place, Commercialization of Micro and Nano Systems conference, Aug. 2006
- Best Student Poster Award - IEEE Wireless and Technology Conference, Apr. 2005

EXPERIENCE

Graduate Research Assistant Sep. 2000-present

Center for Wireless and Microwave Information Systems Tuition Assistance Fellowship

RF Microsystems Group, University of South Florida, Tampa, FL

Perform research in RF MEMS, sensors and antennas to fulfill the requirements of the doctoral degree

- Trained and possess good working knowledge of various design and simulation software tools, fabrication and measurement equipment
- Involved in lab inventory management
- Training and mentoring undergraduate and graduate students
- Assisted in drafting proposals to federal funding agencies for procuring equipment and lab setup
- Attended and presented technical papers in several international conferences
- **Trouble Shooting/Maintenance/Training**
    - Performed managerial duties in the microwave characterization and the microfabrication laboratory including new user training
    - Developed procedures and trained several new students on fabrication and characterization equipment
    - *Performed maintenance/trouble shooting vacuum systems and fabrication equipment, inventory management, lab safety enforcement and hazardous waste disposal*

Graduate Teaching Assistant Aug. 2005-Dec 2005

Dept. of Electrical Engineering, University of South Florida, Tampa, FL

Assisted professor with the RF and Microwave Circuits- I course

- Conducted help sessions for homework and lab exercises
- Graded homework and lab exercises

PUBLICATIONS

Patent

1. Contact-Less Fluid Conductivity Sensor Based on RF Detection, USF Ref. No. 05A017, filed 3/10/2005 (Pending)

Papers/Presentations

1. **S.P. Natarajan** and T. M. Weller, “Micro-Coaxial Fed Millimeter-wave Slot Antenna”, Accepted for publication at the Proceedings of *IEEE Radio and Wireless Conference, Jan. 2008*
2. **S. P. Natarajan** and T.M. Weller, “Sensitivity Tunable Fluid Conductivity Sensor based on RF Phase Detection”, *IEEE Sensors Journal*, vol. 7, no. 9, pp. 1300-1301, Sep. 2007.
3. R. Heindl, H. Srikanth, S. Witanachchi, P. Mukherjee, A. Heim, and G. Matthews, S. Balachandran, **S. P. Natarajan**, and T.M. Weller, “Multifunctional ferrimagnetic-ferroelectric thin films for microwave applications”, *Applied Physics Letters*, vol. 90, 252507, June 2007
4. **S.P Natarajan** and T.M. Weller, “3-D Micro Coaxial Lines with Integrated MEM Capacitors” (Accepted for Publication in *IEEE Microwave and Wireless Components Letters*)
5. **S. P. Natarajan** and T. M. Weller, “MEMS Based 3-D Micro Coaxial Transmission Lines”, *Proc. IEEE Annual Wireless and Microwave Technology Conference*, Dec. 2006, pp. 1-3 **(Best Student Paper Award)**
6. **S. P. Natarajan**, T. M. Weller, “MEMS based 3-D Micro Coaxial Structures”, Student Poster presented at the *Commercialization of Micro and Nano Systems Conference*, Aug. 2006 **(Third Place Award)**
7. **S.P**. **Natarajan,** T.M. Weller and A. M. Hoff, “Integrated Micro Coaxial Air-Lines with Perforations”, *Proc. IEEE Intl. Microwave Symposium Digest*, Jun. 2006, pp. 424-427

8. **S. P. Natarajan,** T. M. Weller, A. M. Hoff, “Air Core Micro-Coaxial Transmission Lines”, Poster presented at *the IEEE Wireless and Technology Conference*, April 2005 **(Best Poster Award)**
9. C. R. Trent, **S. P**. **Natarajan**, T. M. Weller and M. Smith, “A 3 × 3, K-Band CPW-fed, Aperture-Coupled Antenna Array for Radiometer Applications”, *Proc. of the European Microwave Conference*, Oct. 2005, pp. 523-526
10. **S.P. Natarajan**, T. M. Weller and D. P. Fries, “3-D PCB Toroidal Inductors for RF Applications”, *Proc. of IMAPS* 2005
11. D. Fries, H. Broadbent, G. Steimle, S. Ivanov, A. Cardenas-Valencia, J. Fu, M. Janowiak, T. M. Weller, **S. P. Natarajan,** L**.** Guerra, “PCBMEMS for environmental sensing systems” *Proc. of the 32nd Annual Conference of IEEE Industrial Electronics Society*, 2005.
12. **Natarajan, S.P**, J. Huffman, T. M. Weller and D. P. Fries, ”Contact-less toroidal fluid conductivity sensor based on RF detection” ,*Proc. of IEEE Sensors Conference*, 2004
13. D. Fries, G. Steimle, H. Broadbent, S. Ivanov, **S. P. Natarajan**, A. M. Cardenas-Valencia, M. Janowiak, T.Weller, R. Benson and Fu, ”Maskless Lithographic PCB/Laminate MEMS for Marine Sensing Systems”, *Proc. 35th International Symposium on Microelectronics and Packaging society*, 2002

PROJECTS

Research Projects

- **Micro Coaxial Transmission Line with Embedded MEM Devices**
  - Successfully fabricated and measured micro coaxial transmission line structures of 15, 25 and 40Ω characteristic impedances with embedded variable MEM capacitors yielding a capacitance ratio of 6.5
  - Fabrication of an enhanced design with capacitance ratio > 50 is in progress to realize an RF MEMS Shunt Capacitive Switch for 1 to 40 GHz operation with an isolation of 30 dB and insertion loss of 0.2 dB at 30 GHz
  - Notable features of the design include miniature size (470 μm wide and 20 μm height) and use of common MEMS fabrication techniques
  - Center conductor of the micro coaxial lines rests on a 10μm thick polyimide layer while the top lid(ground plane) is suspended in air
  - Wafer probing compatible due to ground-signal-ground probe pad termination
  - MEM device was realized using a fixed-fixed beam actuated by electrostatic force

- **Micro Coax Fed 55-65 GHz Slot Antenna**
  - Return loss better than 15 dB, VSWR <1.35 dB was achieved, radiation pattern close to EM simulations was achieved
  - Slot formed on the top ground plane of the micro coaxial structure
  - Coaxial-fed, fully shielded, integrated design
  - Substantial size reduction achieved by folding the slot and the ground plane

- **Impedance Measurement based Micro Coaxial Bacteria/Microbe Sensor**
  - Open ended Micro Coaxial probe used as an impedance sensor to detect bacteria suspended in saline
  - Successfully designed, fabricated and tested an open-ended micro coaxial probe (cross-sectional area – 75×20 μm^2) with an integrated microfluidic chamber and detected a minimum concentration of 100 CFU/ml of bacteria
  - Test samples as small as 15 μL

- **RF Phase Detection based Fluid Conductivity Sensor**
  - Constructed and tested successfully in the 2-70 mS/cm conductivity range with a worst case error of 4%
  - Contact-less coil design makes it suitable for corrosive environments

- PCB embedded thin toroidal coils specially designed for the sensor using full wave electromagnetic simulations
- PCB based phase detection circuitry was designed and built to convert phase change to output voltage with sensitivity tunability

- **Bulk Micromachined K-Band CPW-Fed 3 × 3 Patch Antenna Array**
  - Successfully fabricated and measured a 3 × 3 patch antenna array integrated with a CPW feed network on a silicon substrate
  - Antennas realized on bulk micromachined 200 μm deep cavity
  - Feed network was fabricated on a second substrate, aligned and bonded to the antenna array
- **Pyroelectric Zinc Oxide Thin Film based Devices**
  - Optimization of RF sputtering parameters and post deposition techniques to obtain pyroelectric Zinc oxide (ZnO)thin films
  - MIM capacitors built out of ZnO dielectric for microwave characterization
  - Modeling of ZnO capacitors

Course Projects

- **4 GHz Receiver Subsystem**
  - Designed, simulated and optimized components including a lumped element IF filter, distributed element LP filter and quadrature coupler using Agilent ADS and Momentum EM tools
  - Integrated components to build the receiver sub-system and optimized performance using a diode-mixer and input/output matching networks
  - Conversion loss of 10 dB was achieved
- **Single Stage Low Noise Microwave Amplifier**
  - Designed for 1.5 GHz operation on a 31-mil thick FR4 substrate using lumped element matching/bias networks and a Motorola MRF947 BJT
  - Amplifier components optimized using Agilent ADS circuit and Momentum EM simulations
  - Achieved a gain of 10 dB, stability over 0.1 to 3.0 GHz, VSWR of 1.2 and a minimum noise figure of 2.4 at 1.5 GHz
- **PIN Diode Measurements**
  - PIN diodes were characterized using I-V curves, forward current-resistance plots and S-parameter measurements at different bias voltages
  - Diodes are modeled for use in a 2 GHz attenuator circuit
- **Term Papers**
  - Saravana P. Natarajan, ”Reliability and Packaging Issues in a RF MEMS Switch”, a detailed review of failure modes in a RF MEMS switch
  - Saravana P. Natarajan, “Towards an Accurate On-wafer Calibration Method”, a review of the new and existing on-wafer calibration techniques used to improve on-wafer calibration accuracy

PROFESSIONAL MEMBERSHIPS

- IEEE / Microwave Theory and Techniques Student Member
- ETA Kappa Nu – USF chapter Member

REFERENCES

- **Dr. Thomas M. Weller**, Professor, Dept. of Electrical Engineering, University of South Florida, E-mail: *weller@eng.usf.edu*, Phone: 813-974-2440
- **Dr. Andrew M. Hoff**, Associate Professor, Dept. of Electrical Engineering, University of South Florida, E-mail: *hoff@eng.usf.edu*, Phone: 813-974-4958
- **Dr. Balaji Lakshminarayanan**, Research Associate, Dept of Electrical and Computer Engineering, University of California, San Diego, E-mail: *blakshmin@ece.ucsd.edu*, Phone: 858-964-5135