BAYLOR UNIVERSITY
WIRELESS AND MICROWAVE CIRCUITS AND SYSTEMS

# Microwave Applied Metrology Research Group

. . . on our way to the BRIC!

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*Nine Great Years at Baylor and Only Four Different Lab Locations*

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BRIC Baylor Research and Innovation Collaborative

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- Second Floor, East


| Lab | Faculty Member | Research Lab Focus | Dwg # |
|---|---|---|---|
| 1 | Jean, Randall | Microwave Metrology | 219.11 |
| 2 | Duren, Russell | Avionics Lab | 219.10 |
| 3 | Baylis, Charles | Microwave Active Circuits Lab | 219.13 |
| 4 | Li, Yang | Antennas and Wireless Propagation Lab | 219.15 |
| 5 | Marks, Robert | Computational Intelligence Applications Lab | 219.17 |
| 6 | Thompson, Mike | Applied Telecommunications and DSP Lab | 219.19 |
| 7 | Hu, Jonathan | Photonics Research Lab | 219.21 |

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| Lab | Faculty Member | Research Lab Focus | Dwg # |
|---|---|---|---|
| 8 | Grady, Mack | Renewable Energy and Grid Security Lab | 225.03 |
| 9 | Gravagne, Ian | Distributed Power Systems Lab | 225.05 |
| 10 | Lee, Kwang | Power & Energy Lab | 225.09 |
| 11 | Song, Ben | Power Electronics Lab | 300.L |
| 12 | Dong, L./Eisenbarth, S. | Cyber-Physical Systems Lab | 300.M |

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## *Microwave Sensing Fundamentals*

- *Complex p* **WHAT PART OF** *ergy storage and energy* *electric fields.*

$$\nabla \cdot E = \frac{\rho}{\varepsilon_0} = 4\pi k\rho$$

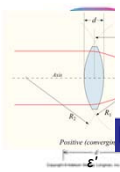
$$\nabla \cdot B = 0$$

$$\nabla x E = -\frac{\partial B}{\partial t}$$

$$\nabla x B = \frac{4\pi k}{c^2} J + \frac{1}{c^2}\frac{\partial E}{\partial t}$$

**Didn't You Understand?**

$\varepsilon(\omega$ ... $\varepsilon''$



$\varepsilon'$ ... $j\varepsilon''$

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*What you always wanted to know about Microwave Applied Metrology*

**For me it started on the moon . . .**

**. . but my early academic career focused on the earth**

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*What you always wanted to know about Microwave Applied Metrology*

**. . . but I somehow wound up in a hamburger plant. . .**

**and other interesting places with my collection of tools.**

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*What you always wanted to know about Microwave Applied Metrology*

**Today I inflict microwaves on poor graduate students.**

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*The changing faces of WMCS through the years*

2003-2004

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*The changing faces of WMCS through the years*

2011-2012

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*The faculty of WMCS today*

2011-2012

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## Key Factors for Success in Microwave Applied Metrology

- Understanding of Material Properties
- Creative Exploitation of Measurement Geometry
- Robust Algorithms for Extracting Information from the Measurement Data
- Low Cost Implementation of the Measurement System

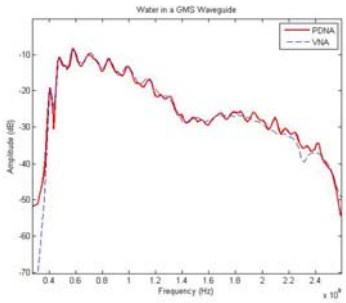


## Current Projects

- Time Domain VNA Development



## Guided Microwave Spectrometer measurement comparison





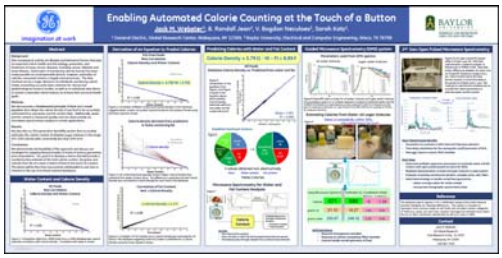

## Current Projects

- Time Domain VNA Development



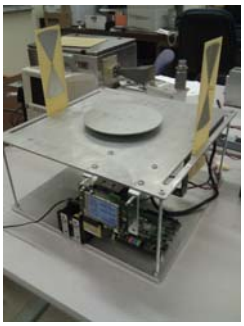
## Current Projects

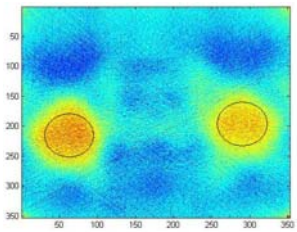
- Automatic Calorie Counter






## Transit Time Tomography





## Current Projects

- W/CM Ratio in Fresh Concrete

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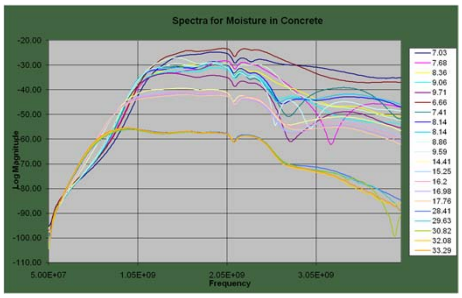
## Varying Moisture Data Set for Paste, Mortar and Concrete

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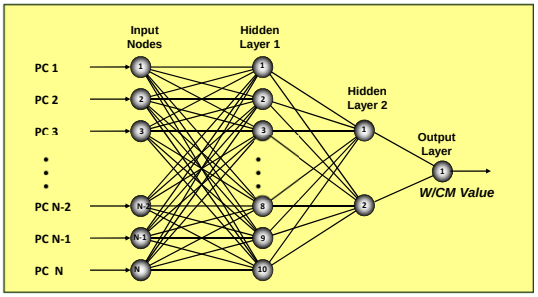
## Typical Artificial Neural Network Structure

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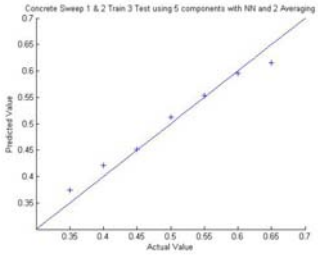
## Properly Trained ANN Performance

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## Current Projects

- Wave Propagation in Forests (Dr. Yang Li)

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## Recent Interests in Ground Sensors

http://www.dei.unipd.it/~schenato/pics/SensorNetwork.jpg

- Wireless sensor networks for scientific and military applications (e.g. forest fire detection).
- Measurement campaigns: Joshi et al., 2005; Buhl and Rogers, 2008; Meng et al., 2009.
- For near-ground, short-distance communication in the forest, the propagation mechanisms are more complex.

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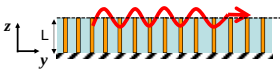
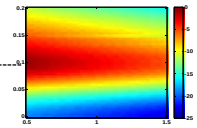
## Mode Strength

Low passband:
Surface wave

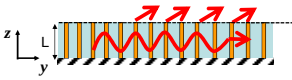



z=L

600MHz, $E_z$

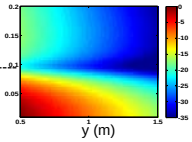


High passband:
Leaky wave




z=L

1800MHz, $E_z$

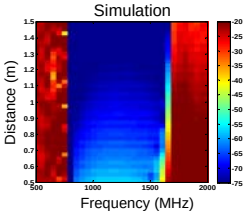




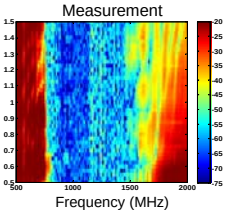

## Transmission Loss-Magnitude

(Li et al., 2008)

Simulation




Measurement

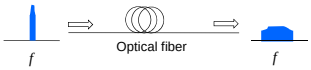



- Passband/stopband behaviors are clearly observed.
- Boundaries of passband/stopband correpsond to quarter-wave wire resonance at 800MHz plasmonic cut-off frequency at 1600MHz



## Mid-IR Supercontinuum Generation (Dr. Jonathan Hu)

Supercontinuum generation
- ✓Nonlinearity
- ✓Dispersion

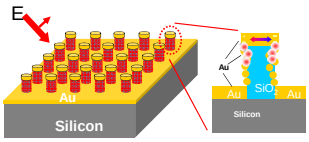


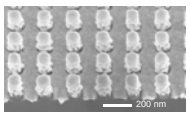


*Generate light with wide spectrum for gas sensing*



## Nanophotonic Biosensor (Dr. Hu)




Scanning Electronic Microscope (SEM)

*Use nanotechnology to build biosensor*



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*General Tire Becomes the BRIC*