DREXEL UNIVERSITY
School of
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Portable, Low Cost, Radiation-Free Breast Cancer Detection for Dense Breasts

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Breast Cancer

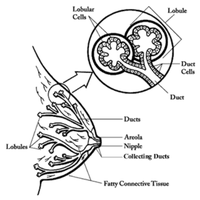
- Most breast cancers begin in the ducts (*ductal carcinoma*), some begin in the lobules (*lobular carcinoma*), and the rest in other tissues.
- Globally, the incidence of breast cancer is increasing as Western diet and child bearing practices are adopted.

Worldwide, there are 1 million new cases and 0.5 million deaths each year.

- There is a rapid increase in breast cancer incidence with high mortality rate in developing countries such as India and China.

Breast cancer is the leading cancer in women.

- There is a significant correlation between breast tissue histology and stiffness.



Occurrence	Cancer Type
30%	Breast
14%	Lung & bronchus
9%	Colon & rectum
6%	Uterine corpus
5%	Thyaroid
4%	Non-Hodgkin lymphoma
4%	Melanoma of skin
3%	Kidney & renal pelvis
3%	Ovary
3%	Pancreas
19%	All Other Sites

Tissue Type	Elastic Modulus at 1% Strain (kPa)
Fat	4.8
Gland	17.5
Invasive Ductal Carcinoma	47.1
Ductal Carcinoma in Situ	71.2

http://www.cancer.org/Cancer/BreastCancer/DetailedGuide/breast-cancer-key-statistics. http://www.breastcancer.org/symptoms/understand_bc/statistics.jsp
Wellman et al., Harvard BioRobotics Laboratory Technical Report, 1999. Elisa E. Konofagou, Tim Harrigan, Jonathan Ophir, "Shear strain estimation and lesion mobility assessment in elastography," Ultrasonics 38, pg: 400-404, 2000. E. Chen, Ph.D. dissertation, University of Illinois at Urbana-Champaign, 1995.

Limitations of Current Technologies

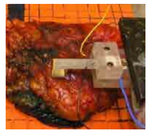
- Mammography:
  - i. Accuracy decreases significantly in women with dense breasts.
  - ii. Compression of the breast during examination may lead to distortion artifact.
- Magnetic Resonance Imaging (MRI):
  - i. Requiring use of injected contrast material.
  - ii. Expensive.
- Ultrasound:
  - i. Cannot reliably measure calcifications, tiny calcium deposits associated with many breast cancers.
  - ii. Highly operator and equipment dependent.

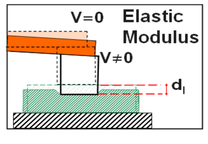
Radiology Info; http://www.radiologyinfo.org/content/mammogram.htm, imaginis; http://imaginis.com/breasthealth/mri.asp?mode=1
http://www.sdearthtimes.com/et0798/et0798s16.html, http://www.radiologyinfo.org/en/info.cfm?pg=breastus#part_ten
*S. Srinivasan, T. Krouskop, and J. Ophir, Ultrasound in Medicine and Biology, Vol. 30, No. 7, pp.899-918, 2004

Piezoelectric Finger (PEF)

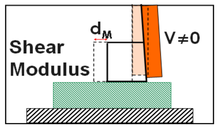
- Piezoelectric finger (PEF) is a piezoelectric cantilever with both an actuator and a sensor in one device that works all electrically to measure tissue stiffness much like a finger.
- With a square tip design such as shown below, a PEF can conduct both the compression and the shear measurements.

i. Indentation

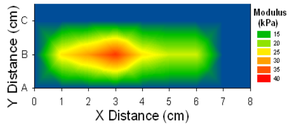




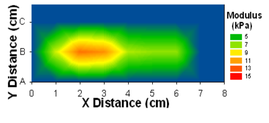
ii. Indentation Shear



Elastic Modulus



Shear Modulus Scan



H. O. Yegingil, W. Y. Shih and W.-H. Shih, *J. Appl. Phys.,* 101, 054510 (2007)

ex vivo Experiments

- G / E ratio is obtained using the elastic (E) and shear (G) modulus scans.
- G / E ratio, according to our statistical data, is >0.7 for invasive tumors ~0.5 for hyperplasia, and ~0.3 for mobile breast tumors, e.g., precancers and benign tumors.

Statistics on 71 Excised Breast Tissues

All 71 patients	Sensitivity	Specificity
Malignancy	96% (45/47)	54% (13/24)
Invasive Carcinoma	89% (34/38)	82% (27/33)
Abnormality	100%(71/71)	

25 of 71 cases are dense breasts

25 patients	Sensitivity	Specificity
Malignancy	94% (16/17)	63% (5/8)
Invasiveness	93% (14/15)	80% (8/10)
Abnormality	100% (25/25)	

H. O. Yegingil, W. Y. Shih and W.-H. Shih, *J. Appl. Phys.,* 101, 054510 (2007)

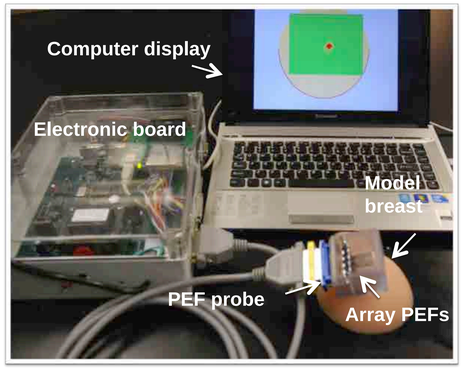
Objectives

- To investigate PEF as a tool for in vivo breast cancer imaging to identify patients for further mammography screening.
- Investigate the size and the location of the tumor in vivo and compare with pathological results.

in vivo Measurement Device

- PEF array provides faster measurements.

in vivo measurement system



PEF probe

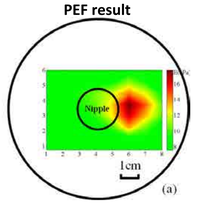
Patients are in a supine position with minimal or no discomfort

in vivo Breast Cancer Detection

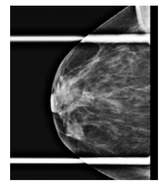
- We have tested the PEF probe on 41 women.
- *Examples*

Subject A

PEF result



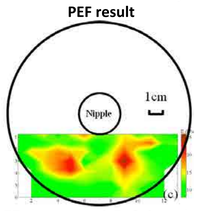
Mammography



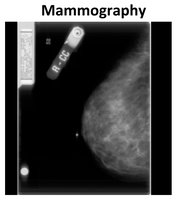
PEF showed a 2.4×2.5cm lesion at 3 o' clock on the border of nipple. Mammogram showed an irregular mass with a spiculated margin in the subareolar region.

Subject B

PEF result



Mammography



PEF showed a 1.5×2.1 cm lesion at 5 o' clock and 4 cm from nipple and a 2.4×2.0 cm lesion at 7 o' clock and 4 cm from nipple, both of which were confirmed by pathology as DCIS. Mammogram showed a dense breast and missed the two lesions.

- PEF both palpable and non-palpable tumors.

Comparison of PEF scan with palpation (use ±2 o' clock tolerance)

	Tumor Type	PEF	Mammography
Palpable lesions (17)	Malignant (10)	10/10	9/10
	Benign (7)	7/7	7/7
Non-palpable lesions (13)	Malignant (3)	3/3	2/3
	Benign (10)	9/10	10/10

- PEF detected 4 cancers missed by mammography

Comparison of PEF scan with mammography by tumor (use ±2 o' clock tolerance)

Pathology	# tumors detected by mammography	# tumors detected by PEF
Malignant (15)	11[a]/15	15/15
Benign (18)	18/18	17/18

[a]Mammography missed 4 cancers in 3 patients, including 1 IC, 1 ILC, and 2 DCIS.

- PEF can detect tumors in mammographically dense breasts.
- sizes determined by PEF agree with the sizes determined by pathology.

Conclusions

- PEF is able to detect palpable and non-palpable breast tumors *in vivo*.
- PEF is able to detect tumors in both dense breasts and non-dense breasts.
- Most of the sizes determined by PEF agree with the sizes determined by pathology.

Other Applications

- Skin cancer detection, prostate cancer detection and etc.

Acknowledgment

• The work was supported in part by the Wallace Coulter Foundation and the QED Grant of the University City Science Center.
Current Funding: $890,000 by PA Department of Health 6/1/2012-5/31/2014 "Commercial Prototype Development & Clinical Validation of Low-Cost Hand-Held Breast Scanner".

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Coulter-Drexel Translational Research Partnership Program