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# A compensated radiolucent electrode array for combined EIT and mammography

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## Introduction:

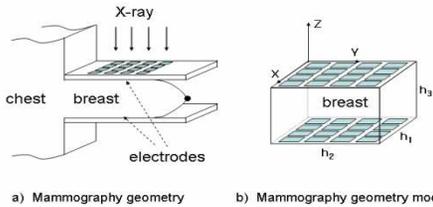
Increasing evidence has been found showing significant differences in impedance between malignant breast tumors and normal tissues. Electrical Impedance Tomography (EIT), a non-invasive technique used to image the electrical conductivity and permittivity within a body from measurements taken on the body's surface, could thus be used as an indicator for breast cancer detection. Because of the low spatial resolution of EIT, combining it with other modalities may enhance its utility. X-ray mammography, the standard screening technique for breast cancer detection, is the first choice for that other modality.

To combine these two techniques, one could take mammography and EIT images separately and use a mapping-based method to place the images into register. However, changes in the breast shape between the X-ray and EIT exams will make the registration mapping very complex and difficult. Here, we describe a radiolucent electrode array that can be attached to the compression plates of a mammography unit, enabling EIT and mammography data to be taken simultaneously and in-register. The radiolucent electrode array is made by depositing thin layers of metal on a plastic substrate. The structure of the electrode array is presented along with data showing its X-ray absorbance and electrical properties with a compensation scheme. The measurement data shows that the electrode array has satisfactory radiolucency and sufficiently low resistance.

## State of the Art:

- Jossinet (1996): Conductivity of tumors differs by up to 4:1 from normal tissue [4].
- Surowiec (1988): Permittivity of tumors differs by up to 10:1 from normal tissue [5].
- Assenheimer (2001): T-scan is the first FDA approved breast tumor detection device. Voltages are applied on the breast surface, and a conductivity image is displayed [6].
- Choi (2004): A simplified model of a mammography geometry for breast cancer detection [3].
- Liu and Xia (2005): The hardware and software of ACT 4, EIT system [1, 2].

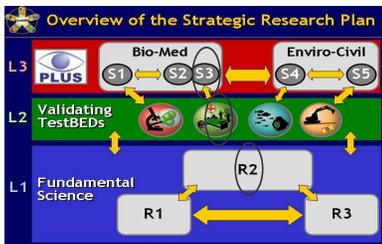
## Dual model of the EIT & mammography :



Radiolucent electrode arrays are attached to the compression plates of a mammography unit enabling EIT and mammography data to be taken simultaneously and in-register.

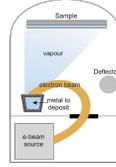
## Importance of the work and technology transfer:

The EIT clinical data and analysis in mammogram geometry will provide a foundation to assess the value of EIT as an adjunct to mammography for breast cancer screening and diagnosis. This is expected to be of significant commercial interest if a pathognomonic signature can be identified transcutaneously.



This work is supported in part by CenSSIS, the Center for Subsurface Sensing and Imaging Systems, under the Engineering Research Centers Program of the National Science Foundation (Award Number EEC-9986821), and by NIBIB, the National Institute of Biomedical Imaging and Bioengineering under Grant Number R01-EB000456-02.

## Electron Beam Evaporator:

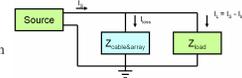


E-beam evaporation is a system for the deposition of very thin metallic films. The sample is placed in the deposition chamber in a vacuum of approximately  $5 \times 10^{-7}$  torr, and the metallic target is heated to high temperature by the electron beam. This process leads to the evaporation of the metal and its deposition onto the sample.

## Cable and Array Compensation

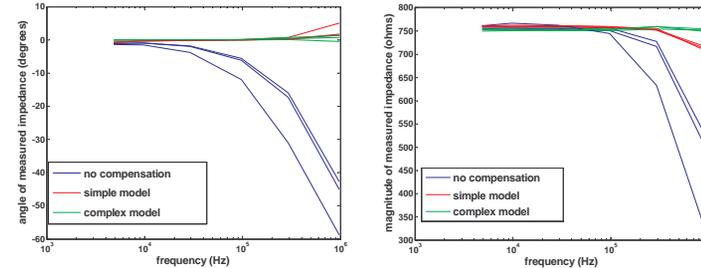
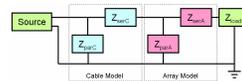
### Simple Model

• Measure cable and electrode open circuit impedance,  $Z_{cable,array}$ , as seen by instrument and determine load current by subtracting current in  $Z_{cable,array}$  from the source current.



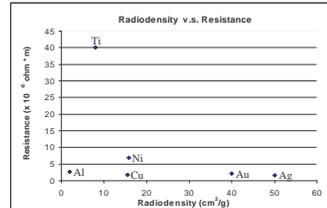
### Complex Model

• Model both cable and array separately with series and shunt elements. Find values using open and short circuit measurements with the cable alone and with the cable + array attached



Results of measurement of a 750 ohm resistor placed between three different pairs of electrodes.

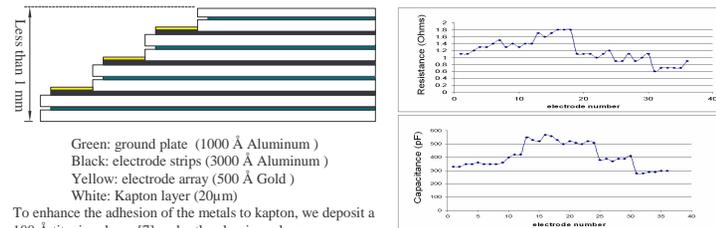
## Radiodensity vs. Resistance:



To choose the material of the electrode, we investigated the radiolucency and the resistance of several metals. The figure shows the radiodensity at photon energy of  $2 \times 10^5$  MeV and the resistivity of several candidates.

Aluminum has the lowest radiodensity and a low resistivity, but the aluminum oxide,  $Al_2O_3$ , is a very poor conductive material. To protect the surface from oxidation, we cover it with a thin layer of titanium. The metals were deposited on the 2 mil (50µm) Kapton, polyimide film, a radiolucent electrical insulator.

## Fabrication and Electrical Properties:



To enhance the adhesion of the metals to kapton, we deposit a 100 Å titanium layer [7] under the aluminum layer.

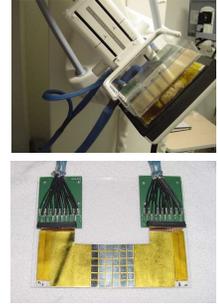
## Electrode Array & Tomosynthesis Mammography :



EIT system, ACT 4



ACT 4 with electrodes in place on Mammography Tomosynthesis machine



The Radiolucent Electrode Array

## Future Plans:

We have designed, built, tested and applied a system, ACT4, to perform regional impedance spectroscopy on breasts simultaneously and in-register with 3-D mammograms. The system has been used to study breast cancer patients at Massachusetts General Hospital. The study, involving a small number of patients who will be undergoing biopsies, will establish the ability of EIT to detect cancer by directly comparing EIT results with biopsy results. We presently continue to collect and analyze data set. Meanwhile, the reconstruction algorithm and the electrode arrays for different sized breasts will be improved and used in the clinical trail.

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