

# Ultrasonic Array of Thick Film Transducers for Biological Tissue Characterization

**Sergio N. Gwirc**

sng@inti.gob.ar

*Instituto Nacional de Tecnología Industrial – Electrónica e Informática,  
San Martín, Buenos Aires, Argentina.*

**Néstor R. Mariño**

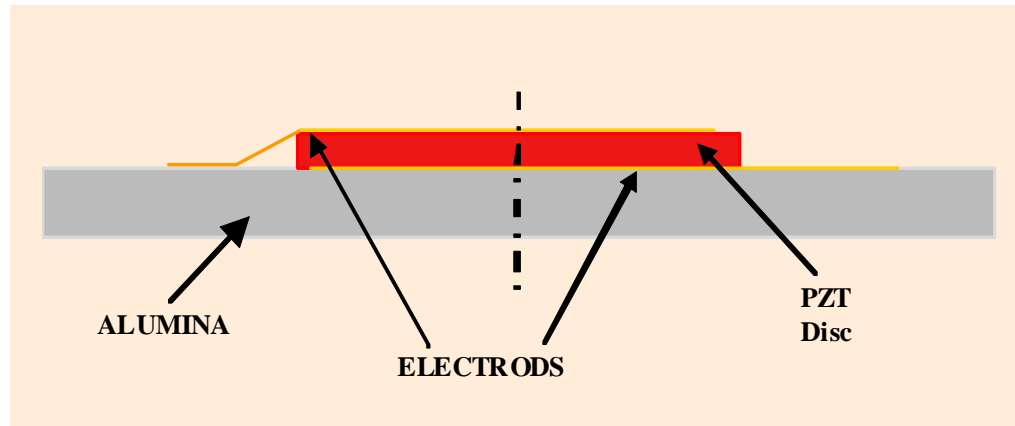
nmarino@inti.gob.ar

**Carlos A. Negreira**

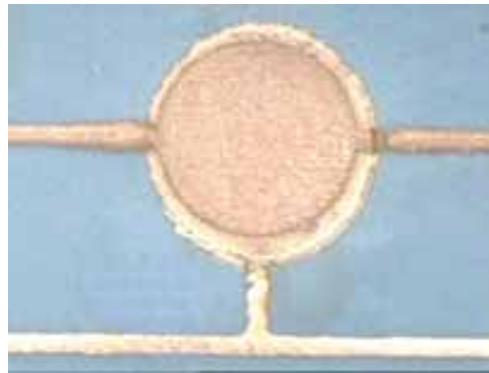
carlosn@fisica.edu.uy

*Instituto de Física, Laboratorio de Acústica Ultrasonora, Facultad de Ciencias,  
Montevideo, Uruguay.*

# Thick Film Transducer



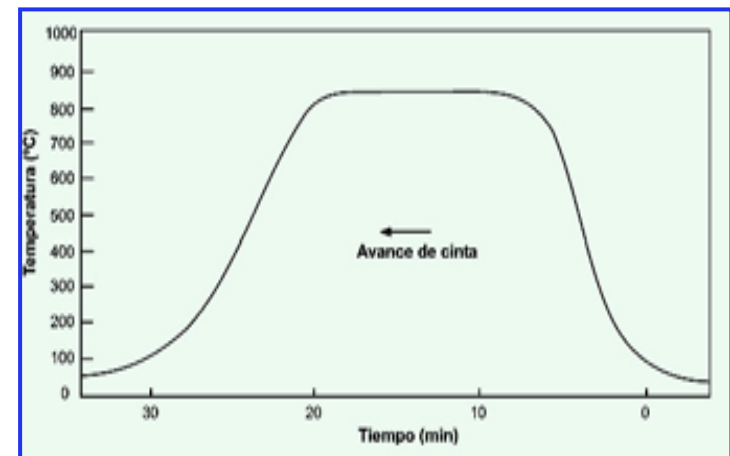
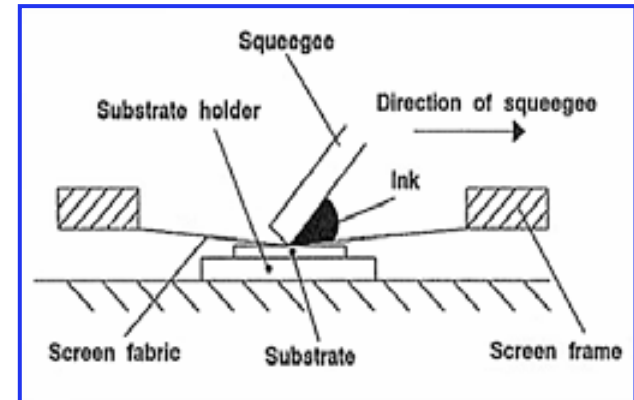
Outline of the Basic Thick Film Transducer



Actual Thick Film Transducer  
Diameter: 4 mm

# Manufacturing Process

- Screen printing on substrate
- Drying  $\rightarrow$  (120 °C to remove solvent)
- Sintering (850 °C)
- Paste  $\rightarrow$  Solid
- Polarization: 2500 V/mm, 110 °C  
(Curie Temperature:  $\sim$ 350 °C)



# Structure of the Paste and Sintered PZT

- Material

PZT powder:

PZ27 (Ferroperm) →

	$\rho$ (kg/m <sup>3</sup> )	$K_{33}$ ( $\epsilon/\epsilon_0$ )	$d_{31}$ (C/N)	$d_{33}$ (C/N)	$k_{33}$	$k_t$
<b>PZ 27</b>	$7,7 \times 10^3$	1800	$-170 \times 10^{-12}$	$425 \times 10^{-12}$	<b>0,70</b>	<b>0,47</b>

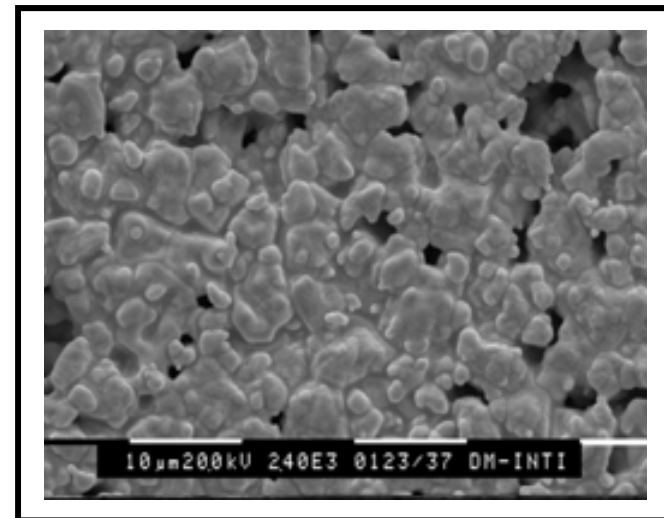
- Frited glass:

Substrate adhesion

Glue PZT particles

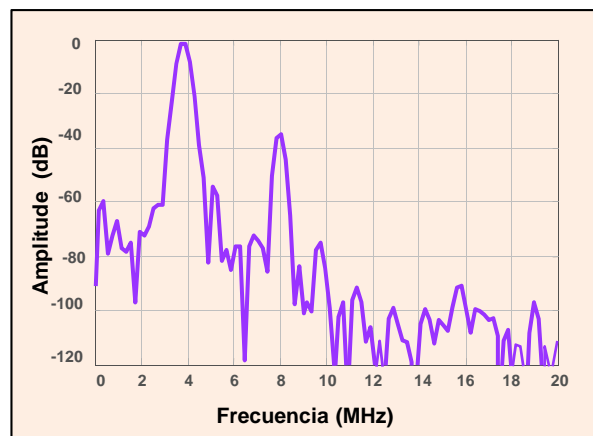
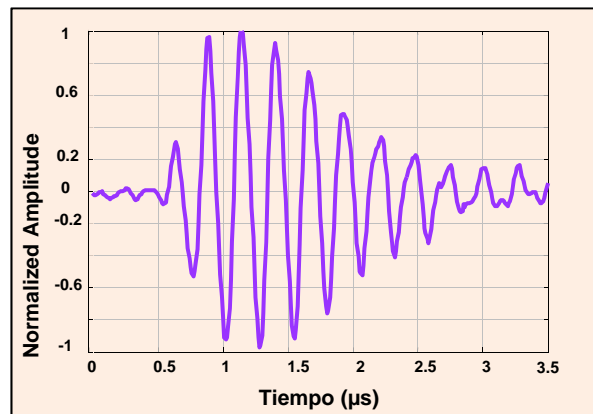
## PZT Microstructure

- Porosity
- $\rho$  (PG) 20% <  $\rho$  (solid)

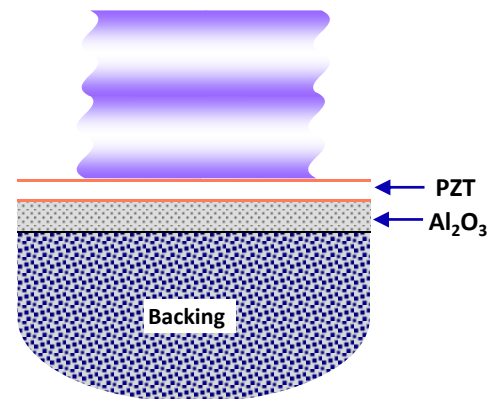


Micrografía obtenida con MEB (2400x)

# Pulsed Response and Fourier Spectrum I



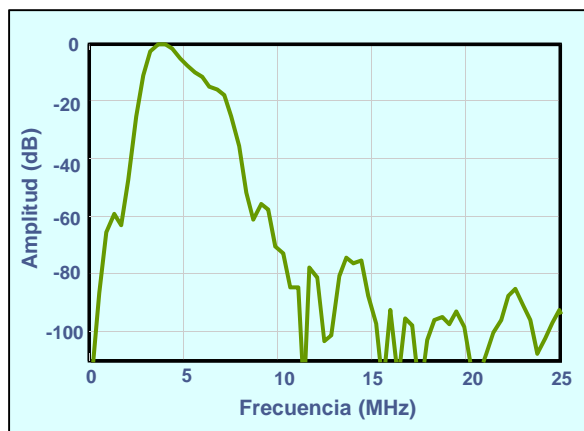
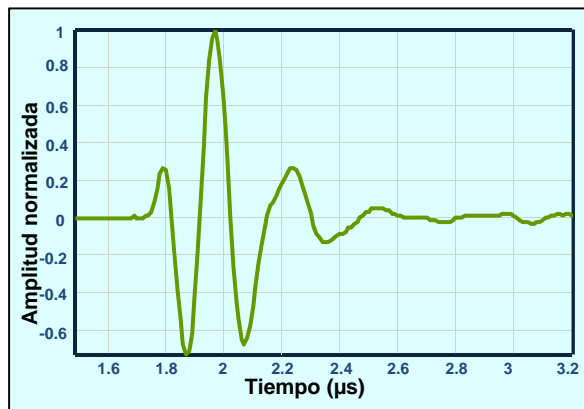
Without Backing



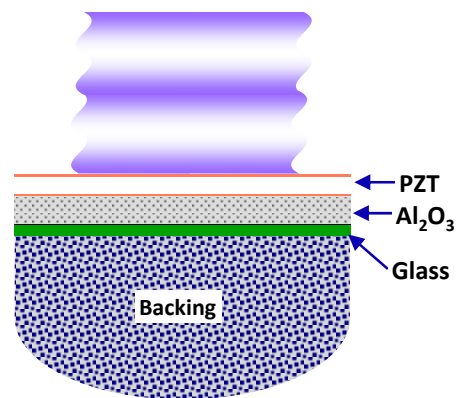
$f_r$ : 3,8 MHz

BW(-6dB): 0,6 MHz

## Pulsed Response and Fourier Spectrum II



With Backing



$f_r$ : 3,5 MHz

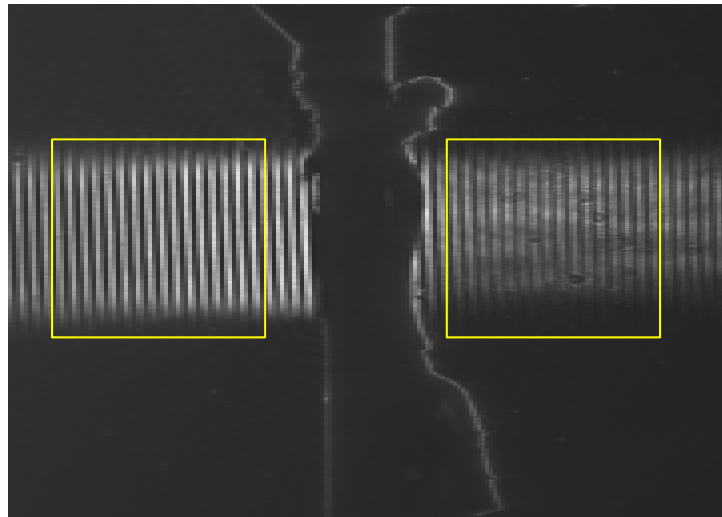
BW(-6dB): 1,9 MHz

# Radiation Field (by schlieren)

Effects of two-layer building

Ratio of transmission coefficients:

$$R_T = \frac{T_{TF-H_2O}}{T_{Al_3O_2-H_2O}} \cong 2.1$$

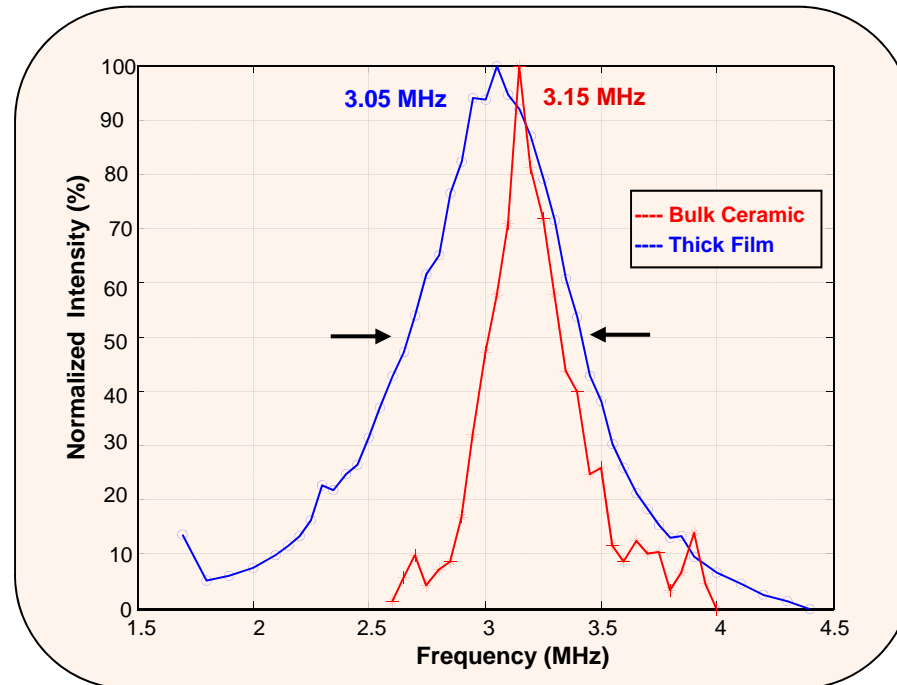


# Radiation Field (by schlieren)

Effects of two-layer building

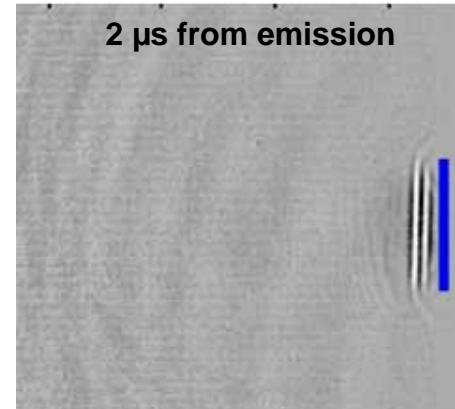
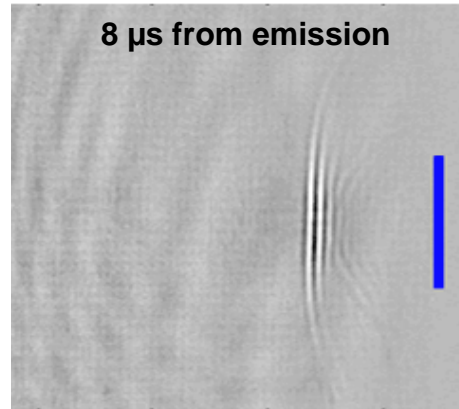
Ratio of transmission coefficients:

$$R_T = \frac{T_{TF-H_2O}}{T_{Al_3O_2-H_2O}} \cong 2.1$$

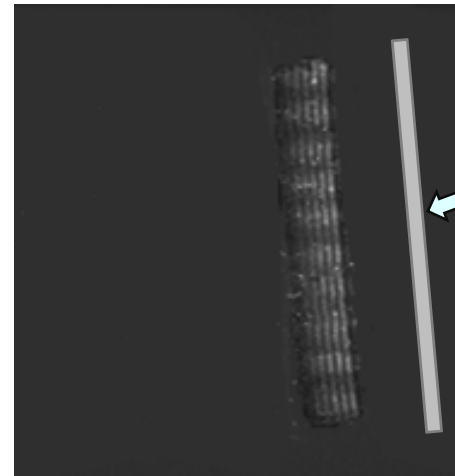
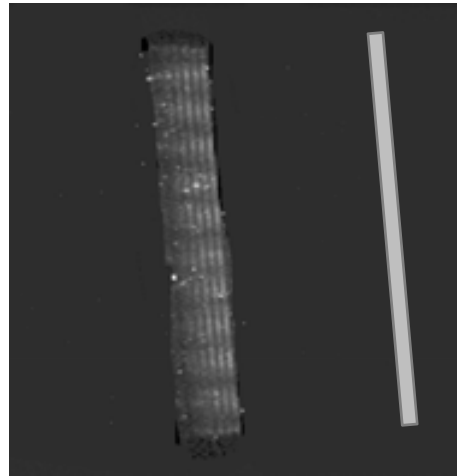




# Pulse Visualization



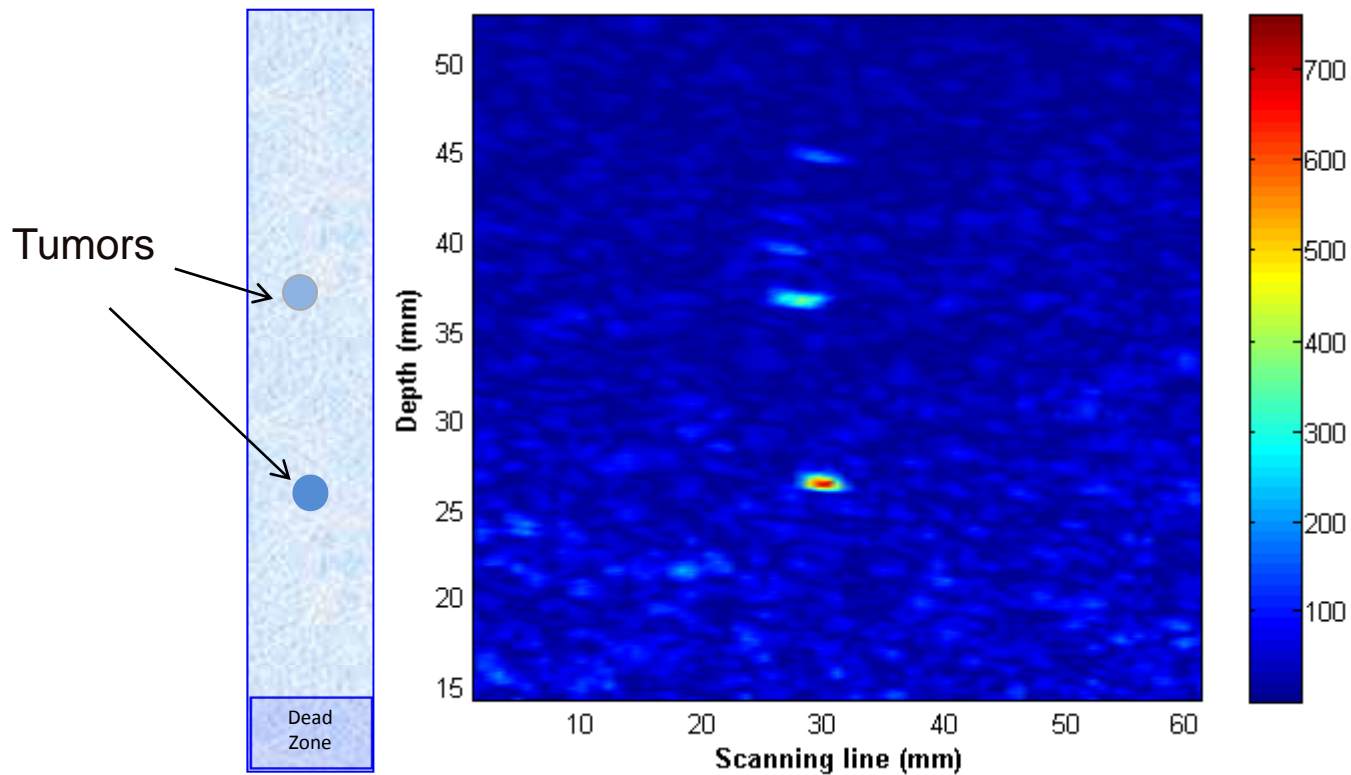
Transducer  
location



Array  
location

# Ultrasound B of a “phantom”

Phantom simulating human tissue with agar.  
Inclusions of 3 mm in diameter: different density.  
Density differences between tumors 30%.

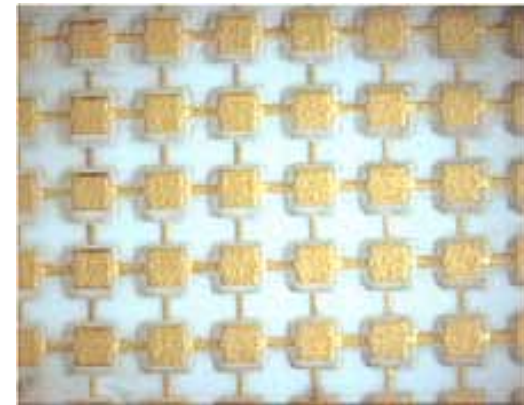
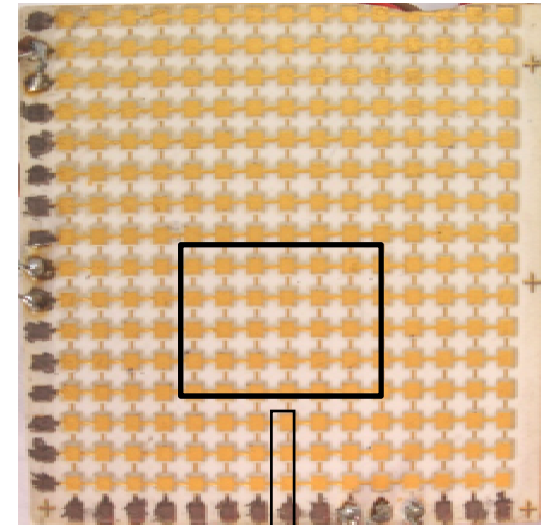


# Thick Film Arrays

- Array: 16 x 15 elements.
- Substrate: 50 x 50 mm.
- Transducers Elements: 1,5 x 1,5 mm.



Mounting of a linear array for testing



# Conclusions

- Good coupling with human tissue
- Easy to make different geometries
- Two resonance frequencies
- Manufacture arrays in a few steps
- Wide bandwidth
- Compatibility with hybrid electronics devices



**Thank you very much**