# MULTIFUNCTIONAL THIN FILMS OBTAINED BY MAPLE AND PLD TECHNIQUES


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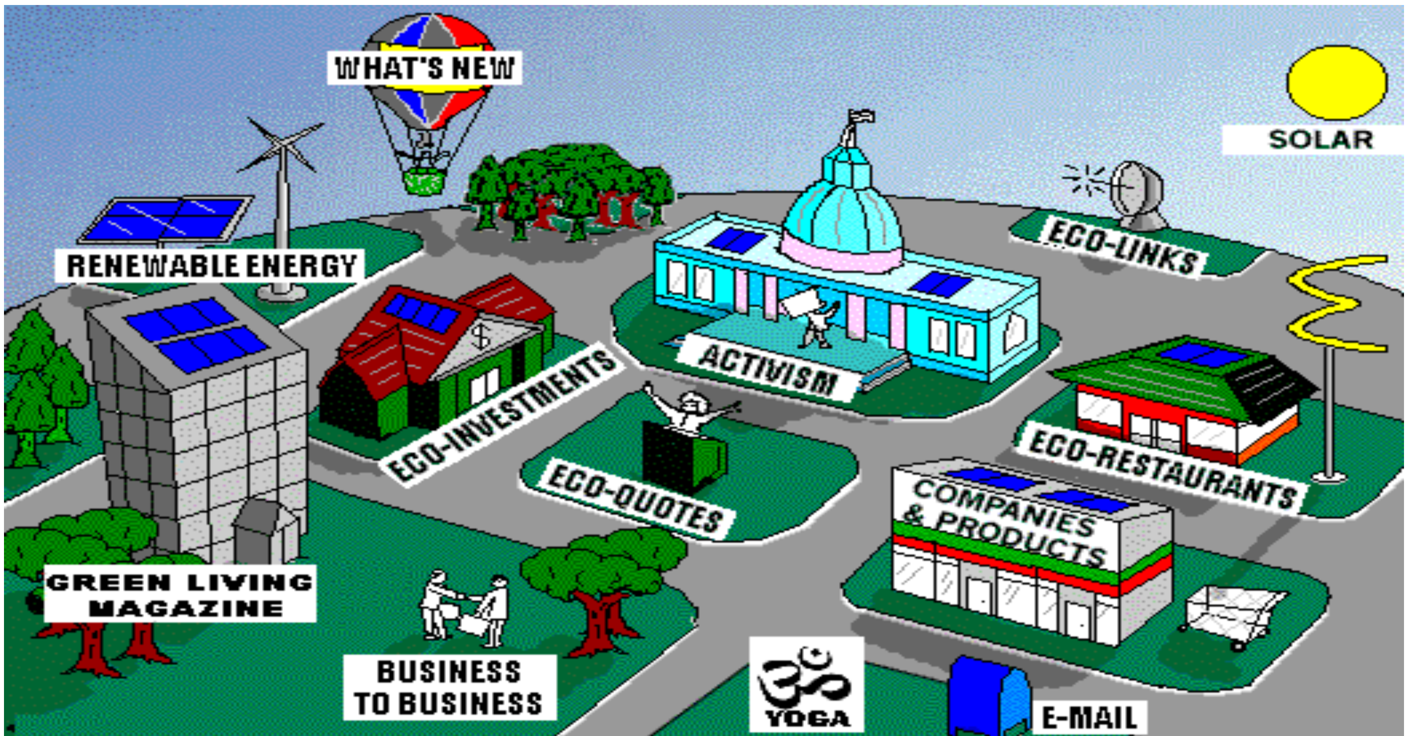
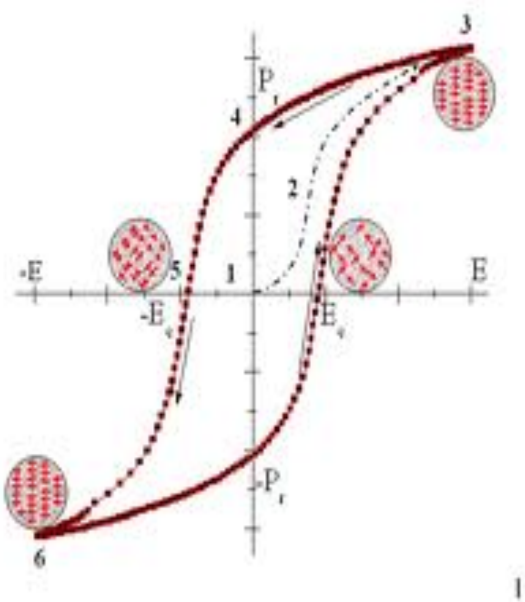
# Motivation: replacing piezoelectric and ferroelectric lead-based materials



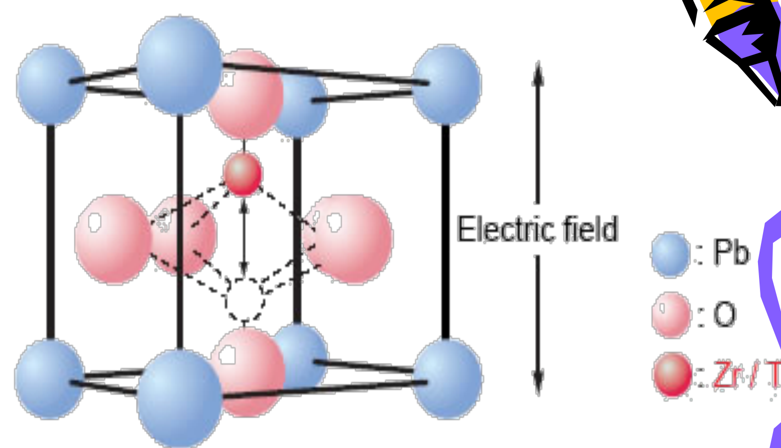
# Motivation of BCTZ lead-free material study: replacing piezoelectric and ferroelectric lead-based materials

# Ferroelectric materials



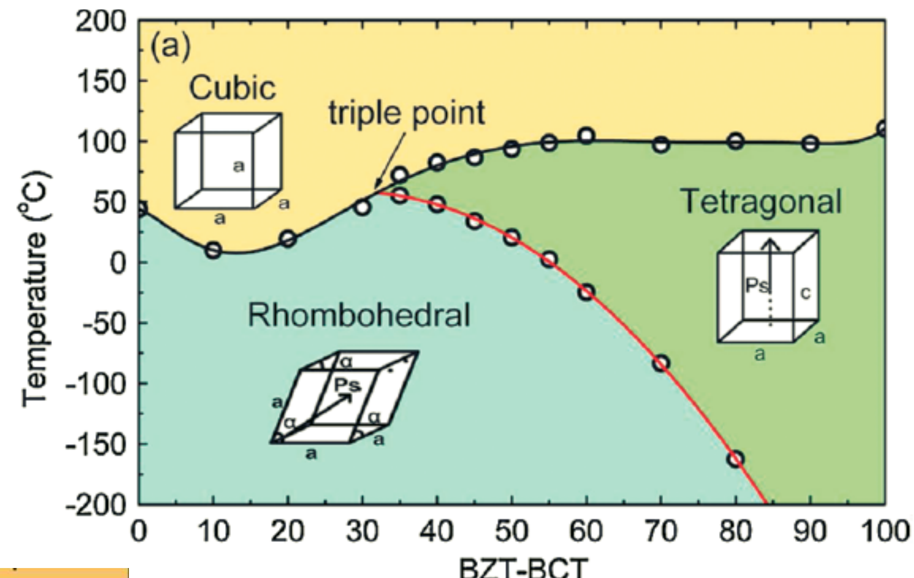

**Properties**

- ✓ Spontaneous polarization in the absence applied electrical field.
- ✓ Extremely high dielectric constant
- ✓ Non-linear dielectric response to an applied electrical field.
- ✓ High strain response to applied electrical field ⇨ piezoelectricity
- ✓ Strong variation in polarization with temperature ⇨ pyroelectricity

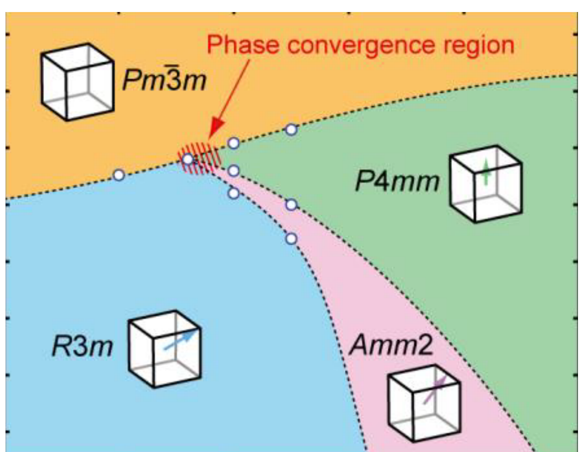


# Solid solution (1-x)$Ba(Ti_{0.8}Zr_{0.2})O_3$ – x$(Ba_{0.7}Ca_{0.3})TiO_3$ BCTZ- complex phase diagram

BCTZ ceramic systems are known to have
high dielectric constant
and high dielectric tunability.
Impressive piezoelectric activity for
composition
$0.5Ba(Zr_{0.2}Ti_{0.8})O_3$–$0.5(Ba_{0.7}Ca_{0.3})TiO_3$ –
higher that for PZT
Beside MPB region, a C-T-R triple point or
tricritical point
has been found.

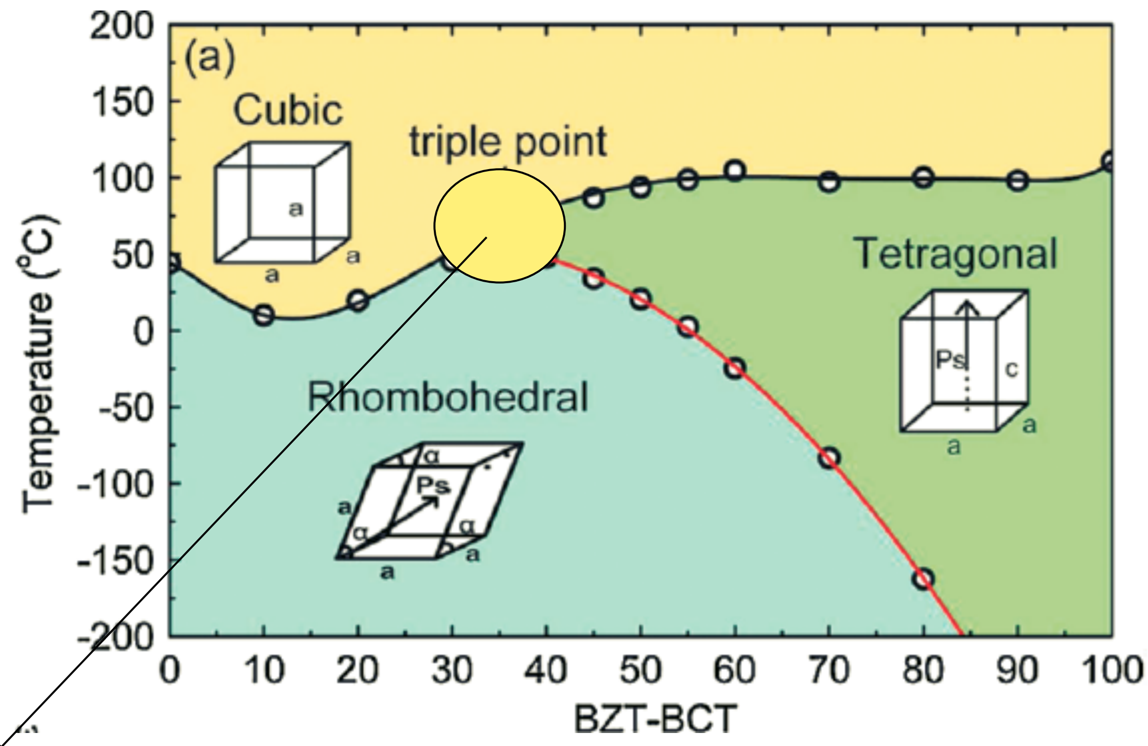



W. Liu and X. Ren, Phys. Rev. Lett. 103, 257602 (2009))




D.S. Keeble et al, Appl. Phys. Lett. 102, 092903 (2013)

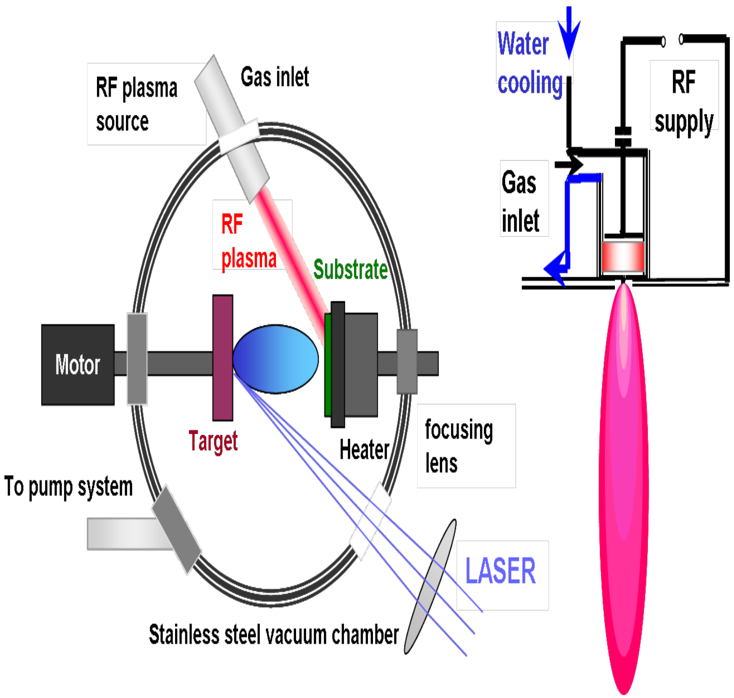
# BCTZ complex phase diagram



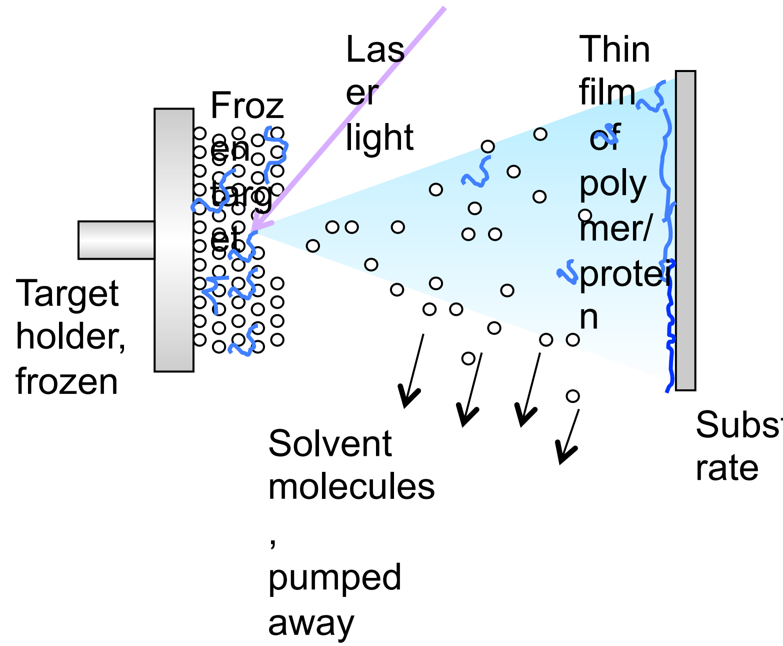

Region of interest

W. Liu and X. Ren, Phys. Rev. Lett. 103, 257602 (2009))

# Laser methods




PLD technique




MAPLE technique

# Deposition methods of piezoelectric active layers

- Pulsed Laser Deposition, PLD, epitaxial thin films can be obtained for maximum piezoelectric activity. High temperatures are required during deposition. Piezoelectric active layers have been obtained on different supports ($MgO$, $Al_2O_3$, $SrTiO_3$ )

- Matrix assisted Pulsed Laser Evaporations, MAPLE, room temperature deposition conditions, high areas can be obtained. Flexible supports have been used for piezoeletric active layers: kapton, Pt/Kapton

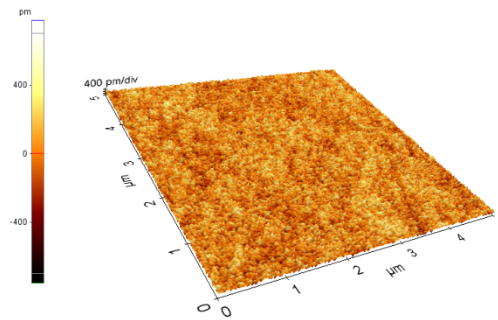
# Piezoelectric epitaxial thin films deposition by Pulsed Laser Deposition

## Morphology of the surface- Atomic Force Microscopy

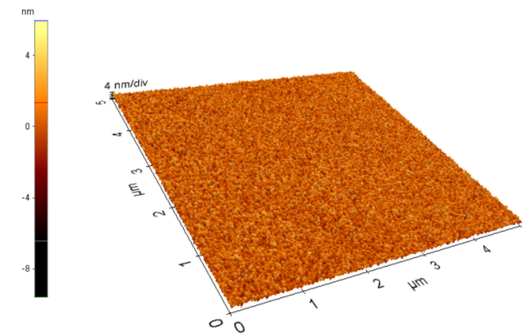
Ceramic target: $Ba_{0.865}Ca_{0.135}Ti_{0.89}Zr_{0.11}O_3$ (1500 $^{0}$C – 4h)

Substrates: Nb:STO

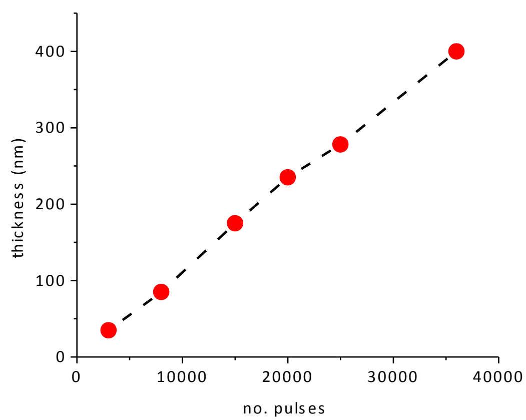
Number of pulses: 3000-36.0000

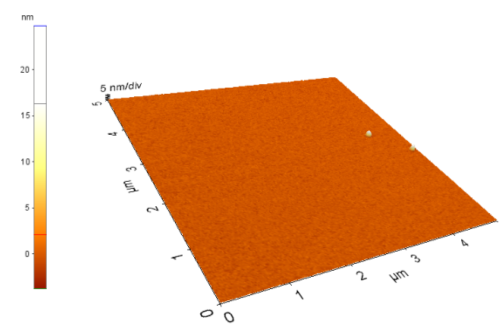



3000 pulses




8000 pulses

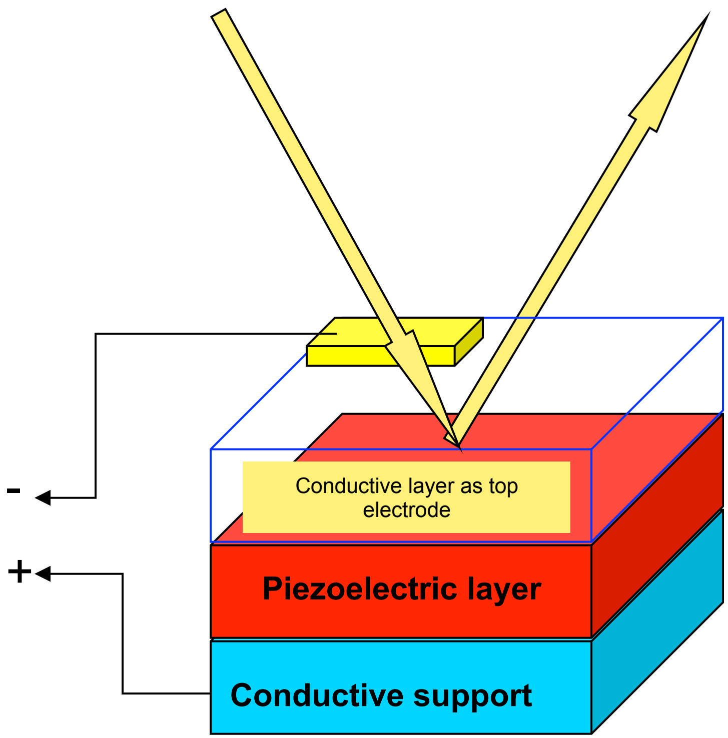


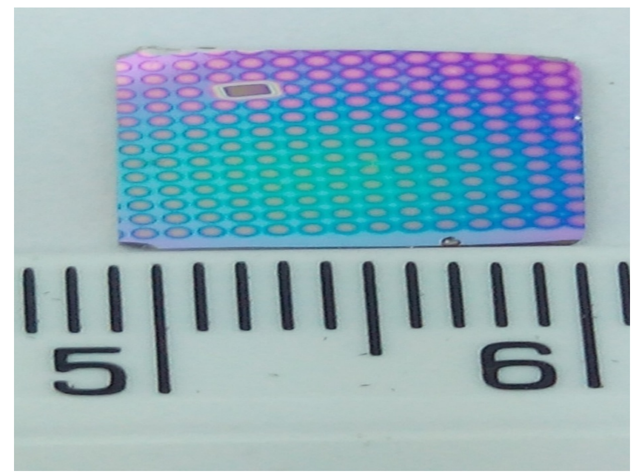




15.000 pulses

Demo sample of epitaxial layer for electrical testing

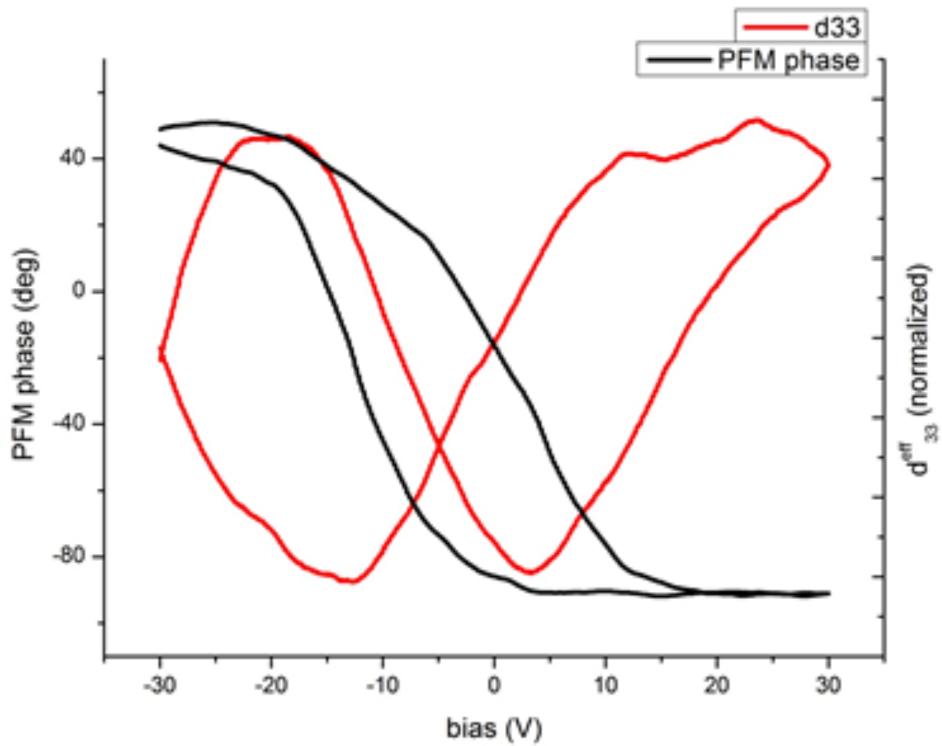
Piezoelectric studies: heterostructure to be obtained for integration of the piezoelectric active layer into a testing device



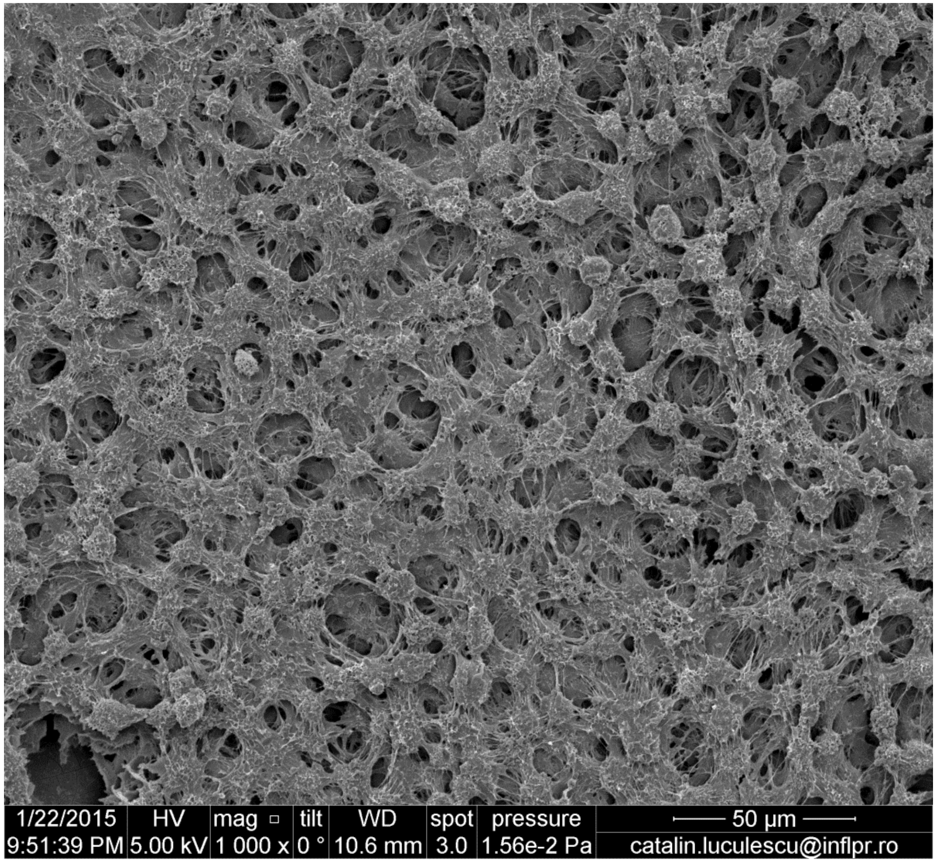
# Piezoelectric studies

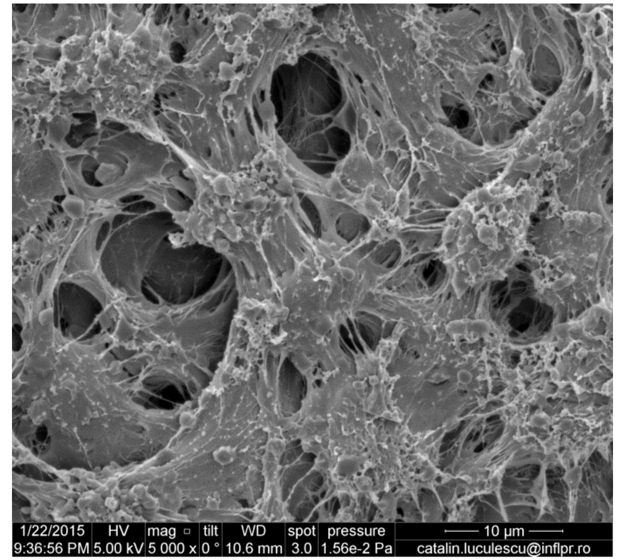
-piezoresponse force microscopy technique has been employed for measuring the piezoelectric $d_{33}$ coefficients of the thin films.



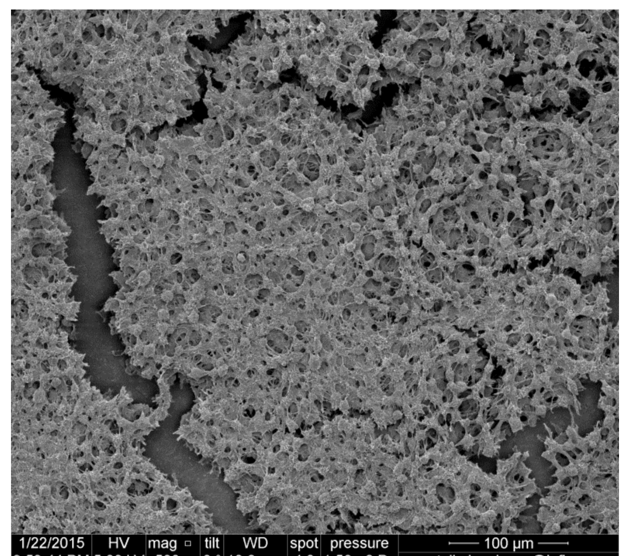

- Slightly lower values for the d33 coefficients for MAPLE thin films, but the major advantage is that the films can be obtained at room temperature from a frozen target.

Biocompatibility studies performed on piezoelectric active layers.




HEK cells culture on piezoelectric layer deposited on Kapton



# CONCLUSIONS:

- Replacing piezoelectric and ferroelectric lead-based materials
- Spontaneous polarization in the absence applied electrical field.
- High strain response to applied electrical field.

# Thank you

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