DTIP 2013

Pyroelectric PZT sensors screen printed on glass

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Outline

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- Screen Printing
- PZT sensor
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  - Pyroelectric characterization
  - Piezo
- Thermal loading
  - Water Jet
  - Microfluidic
- Conclusions

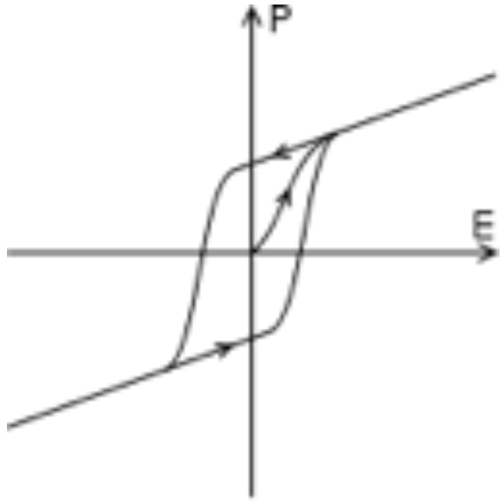
Pyroelectrics

Ferroelectrics : Internal polarization

Piezoelectrics : Polarization changes with stress

Pyroelectrics : Polarization change with temperature variation

$$I_{pyro} = pS_{el}\frac{dT}{dt}$$



! Measure only temperature **variations**

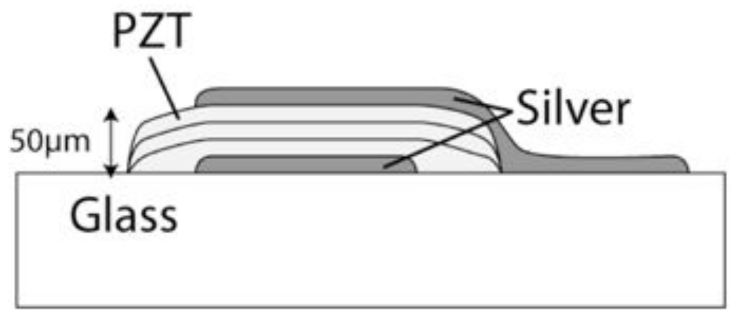
Pyro coef. from 30 to 200 ($\mu C.m^{-2}.K^{-1}$)

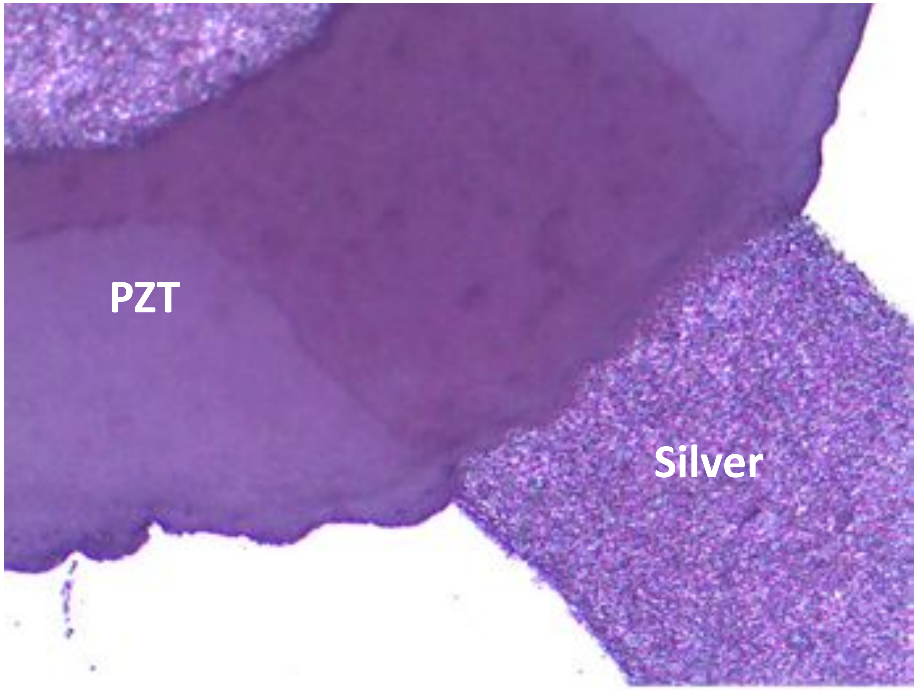
Applications :
Bolometers, IR detector, presence detector, fingerprint sensor
Terahertz detectors

Screen printing

Localised transfer of Ink paste through a stencil on a mesh.

Glass substrate
2x Silver Electrodes
3x PZT (15µm each)
Hardening 10mn 120°C
Firing : 650°C (instead of 850°C)
Passivation : Si_3N_4 PECVD Deposition

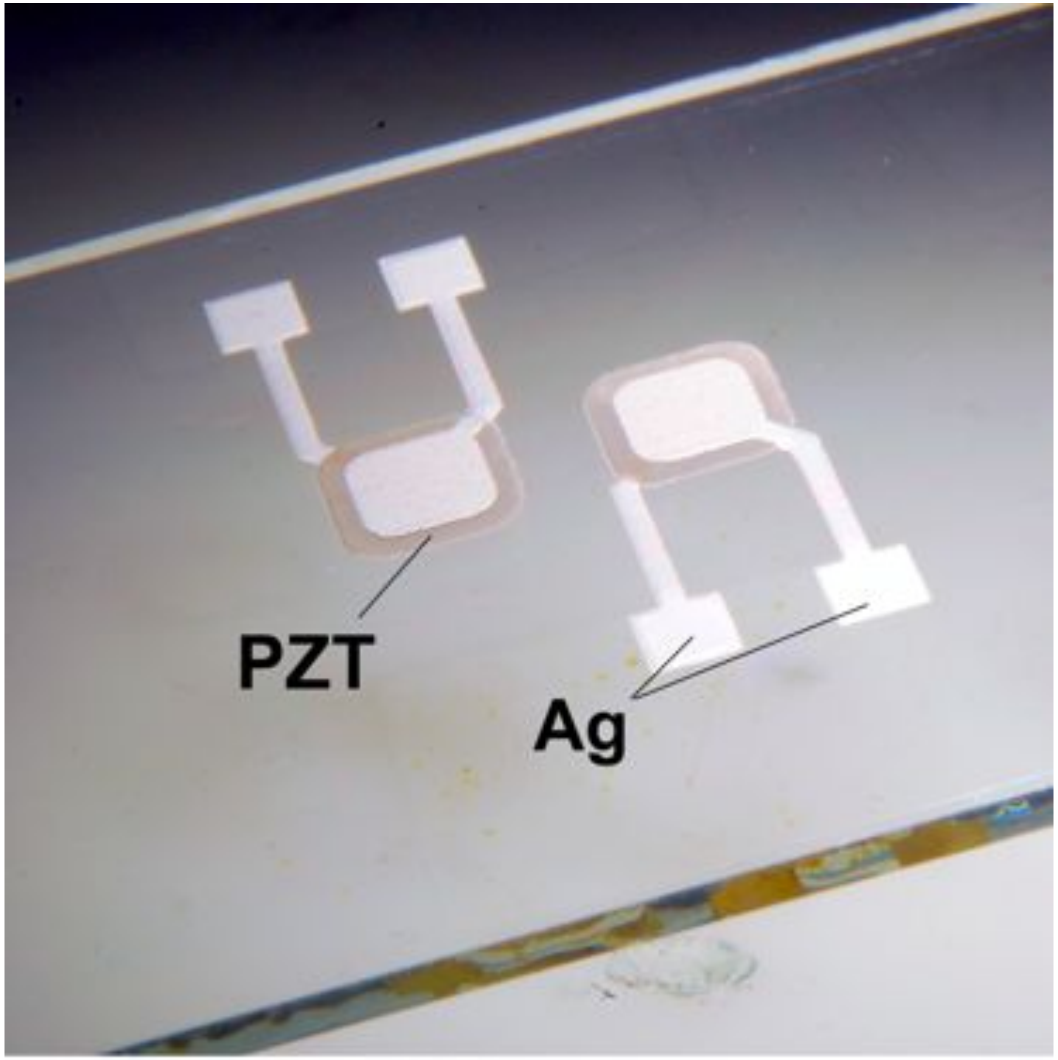




DEK 248

PZT paste from Smart Fabrics Inks

Screen printing

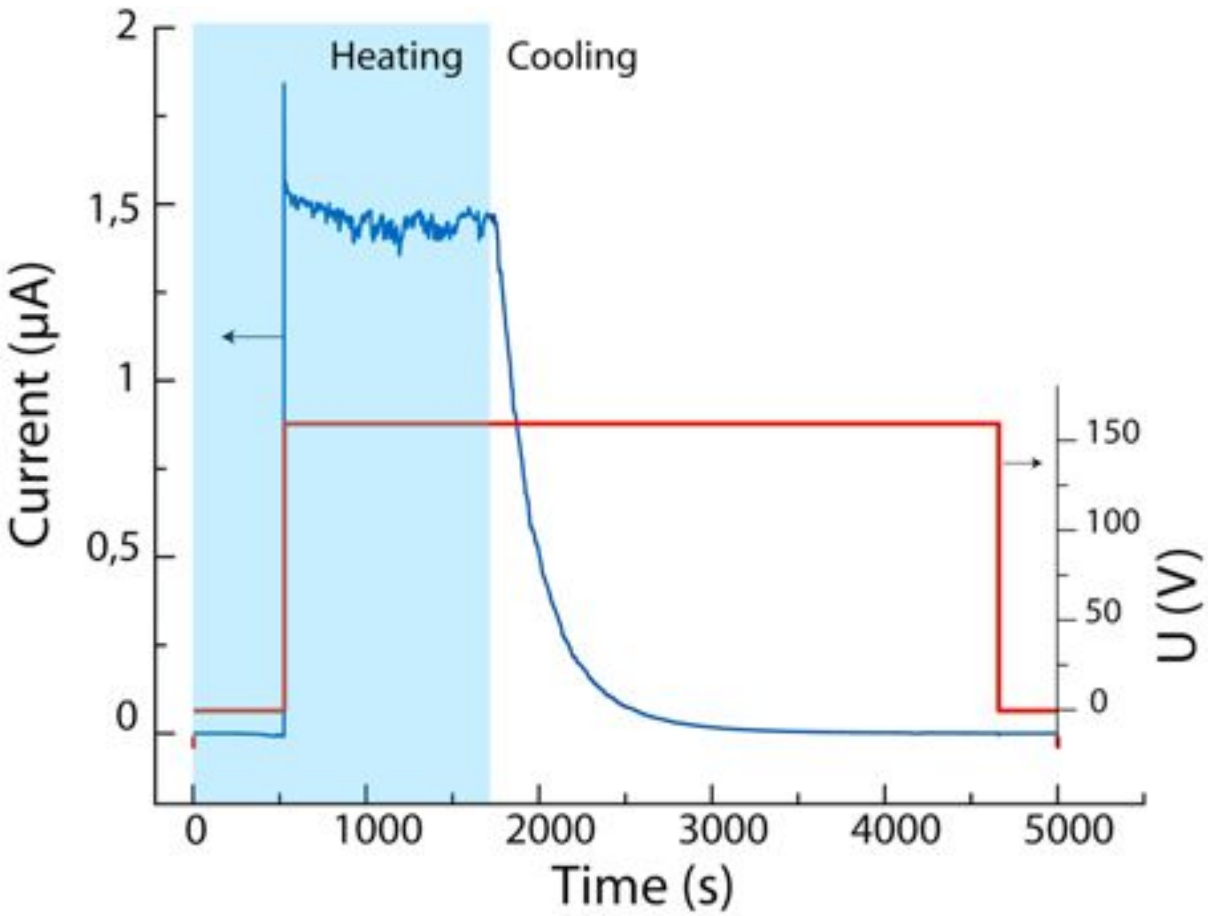


Surface $8mm^2$

Poling

Ferroelectric materials needs to be polled in order to align the domains and to maximize the internal polarization.

200°C.
160V
3.2 MV.m^{-1}
10mn



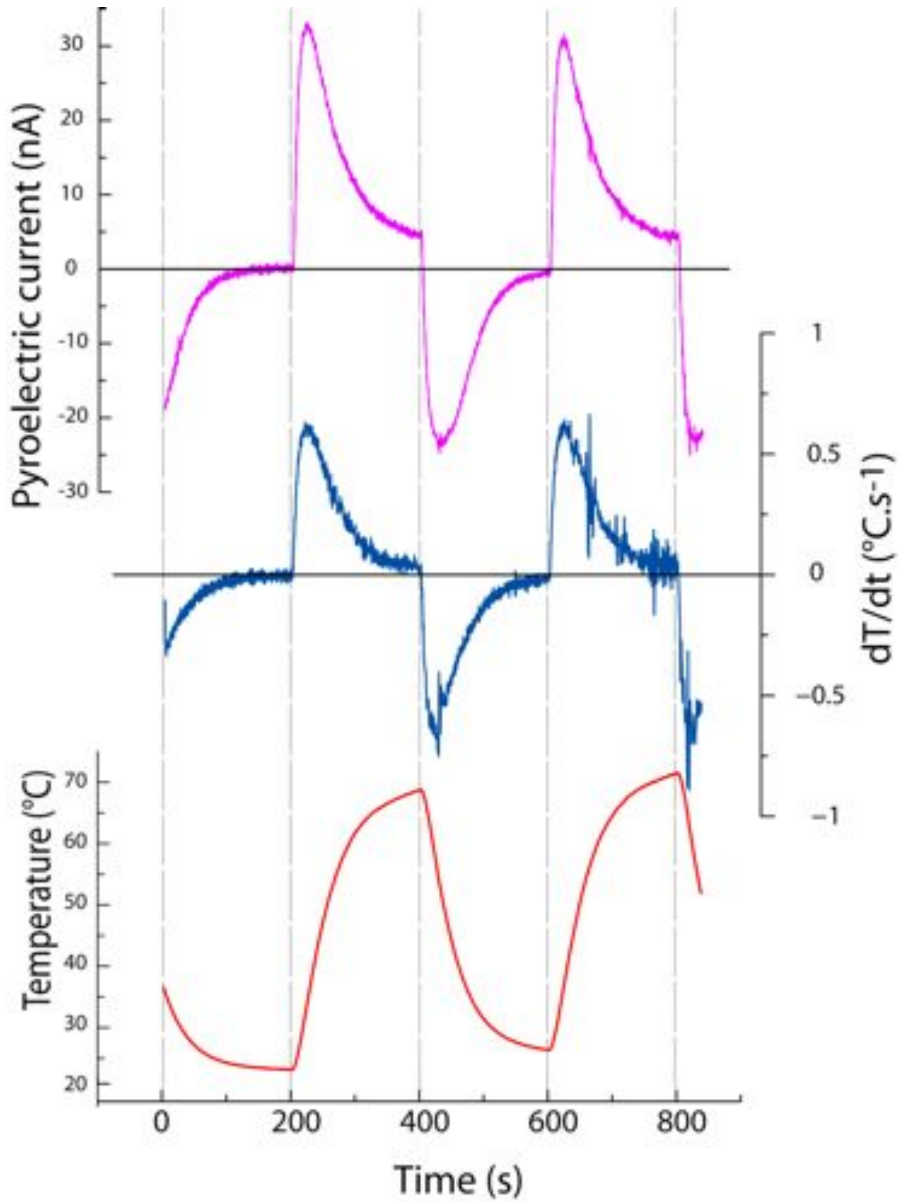
Pyroelectric Characterization

The current is monitored with a shielded Keithley 6514 electrometer.

Temperature on the sample is measured with a thermocouple placed on the sample surface and its time derivative is computed

P= 67 µC.m^{-2}.K^{-1}

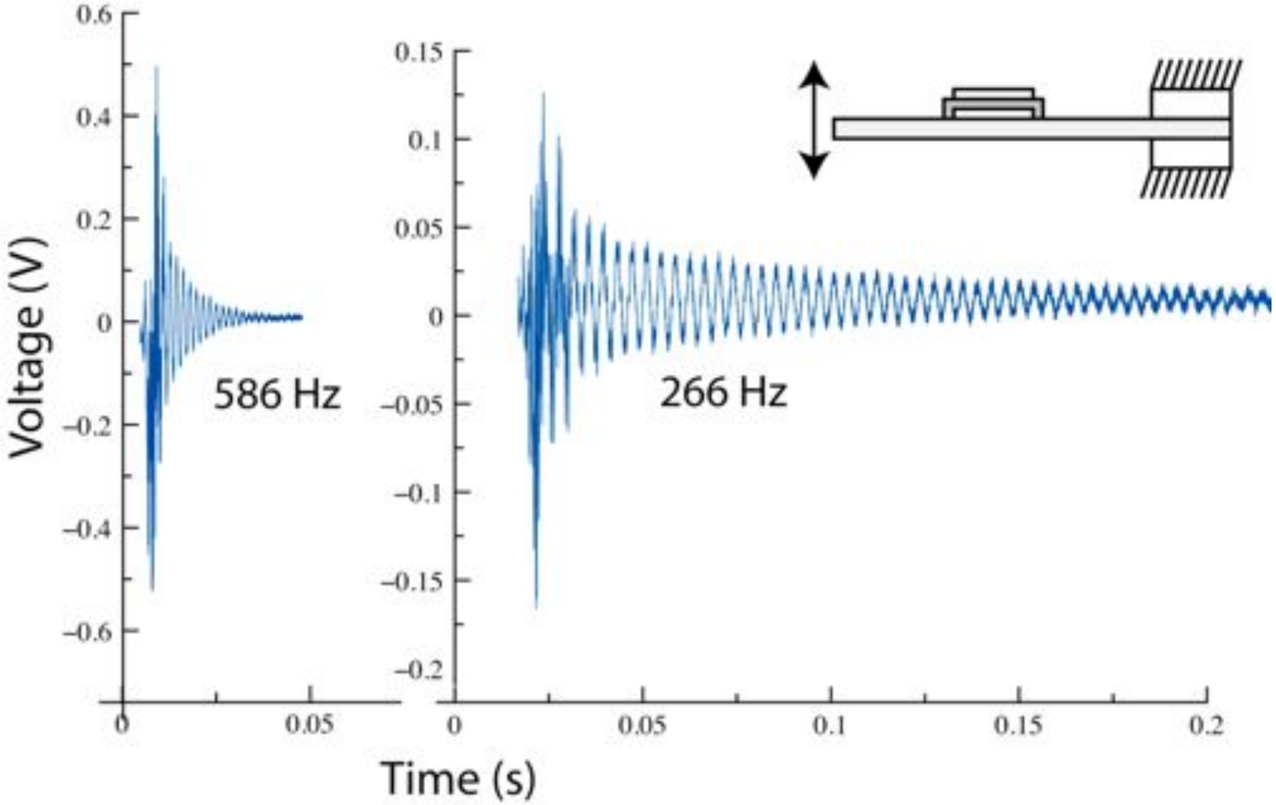
P≈100 on ceramics fired @ 850°C



Piezoelectric

Mechanical oscillations on natural frequency
Measured with the piezo effect
Mechanical escapemement

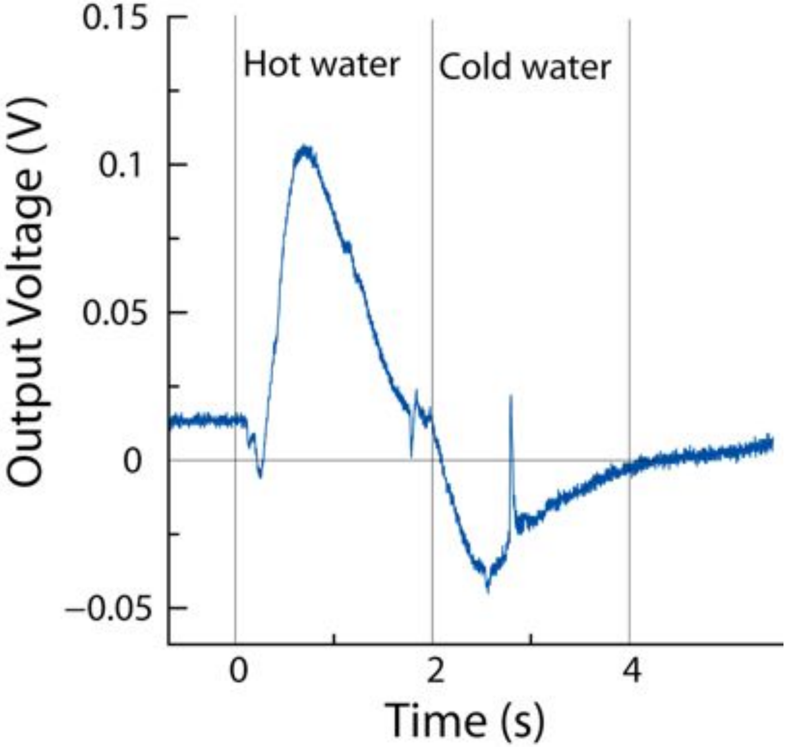
Output plugged on a transimpedance amplifier with a gain of 10^6 .

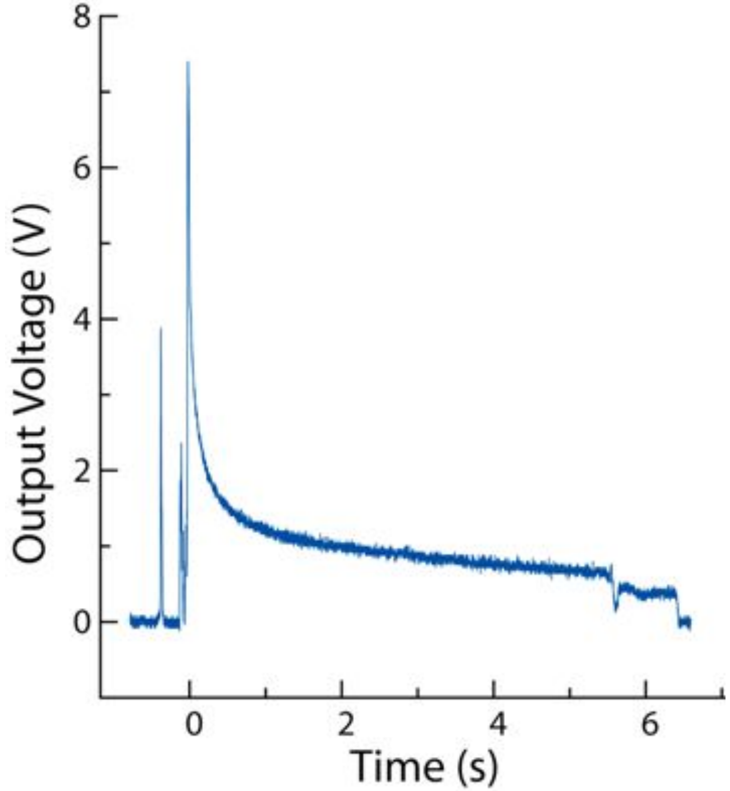


- Different clamping position, different resonant frequency
- Damping

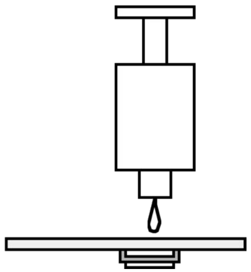
Water Jet

Thermal Stimulation with jet of hot and cold water

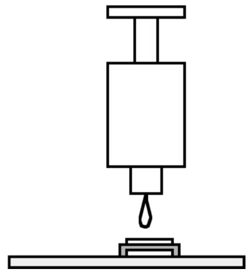




Backside

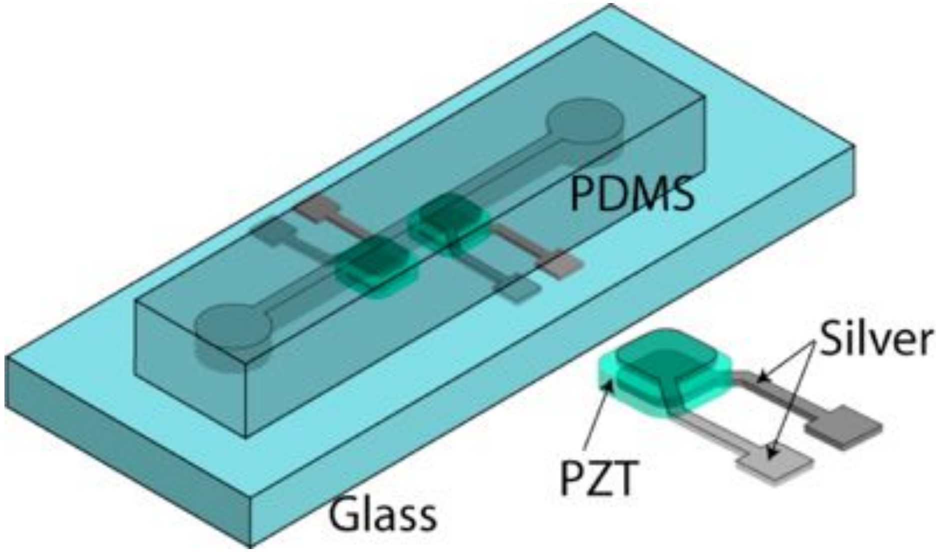


Frontside



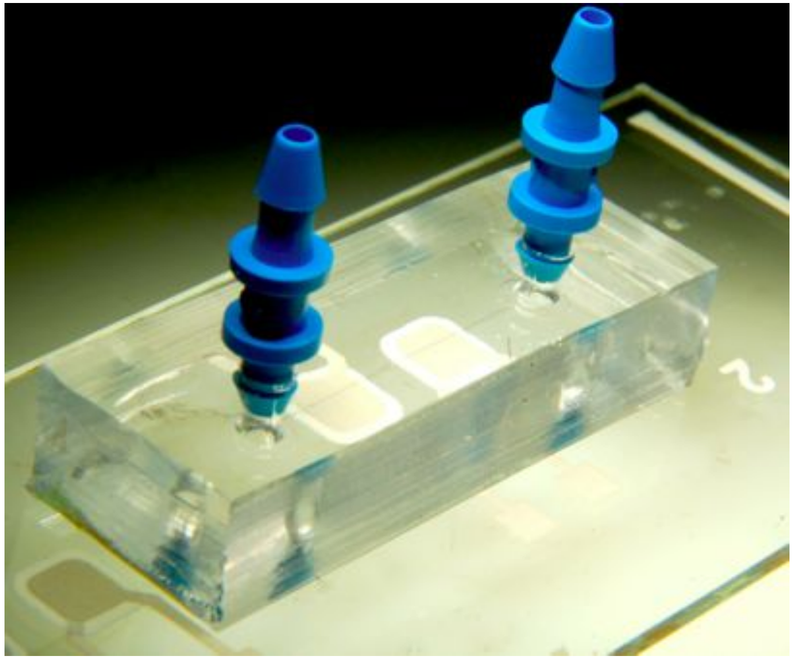
Microfluidic

Microfluidic channel aligned on top of Pyroelectric element



PDMS bloc with a single channel / inlet / outlet

O_2 plasma bonding permanent bonding
Or mechanical clamping



Syringe pushers connected to inlet with a T junction

3mmx1mm cross section

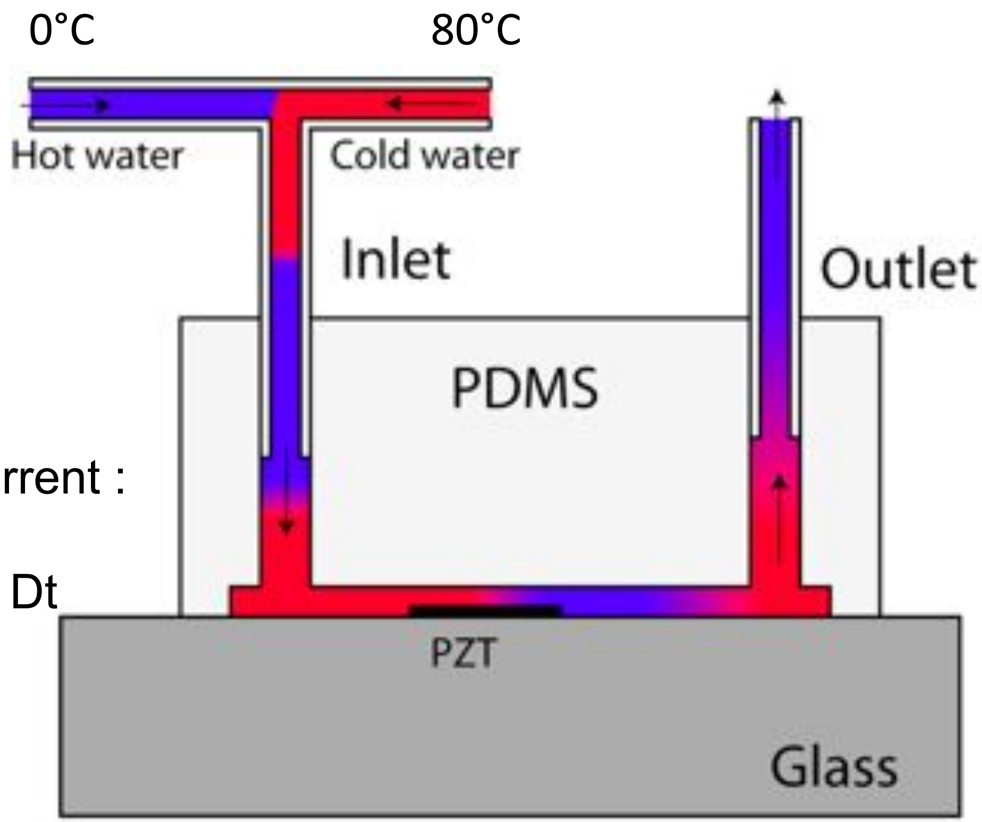
Sequential streams for Temperature gradients

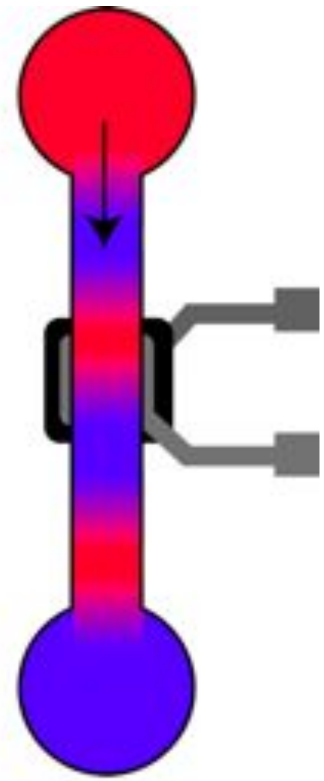
Heat losses :

Water to water
Water to glass
Water to PDMS

For high pyroelectric current :
High DT
High flow speed / small Dt

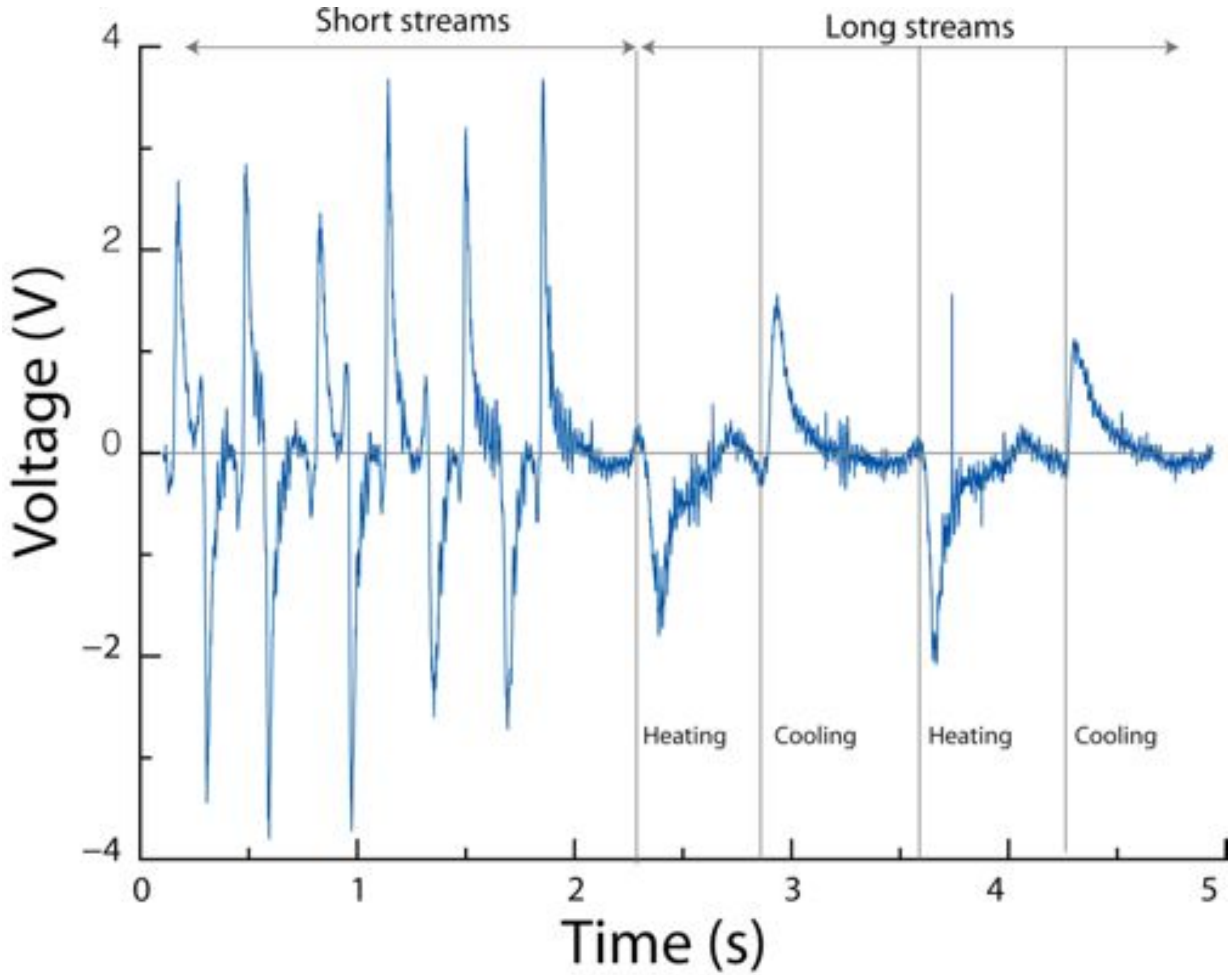
Shortest path



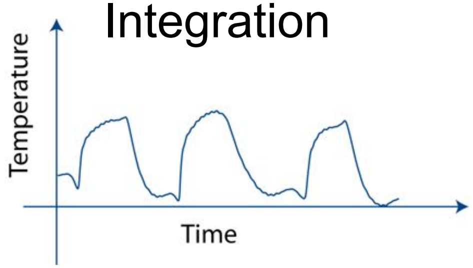


Measurement

Output plugged on a transimpedance amplifier with a gain of 10^6 .



Integration



Toward micro power generation

The device can be used as a micro power generator

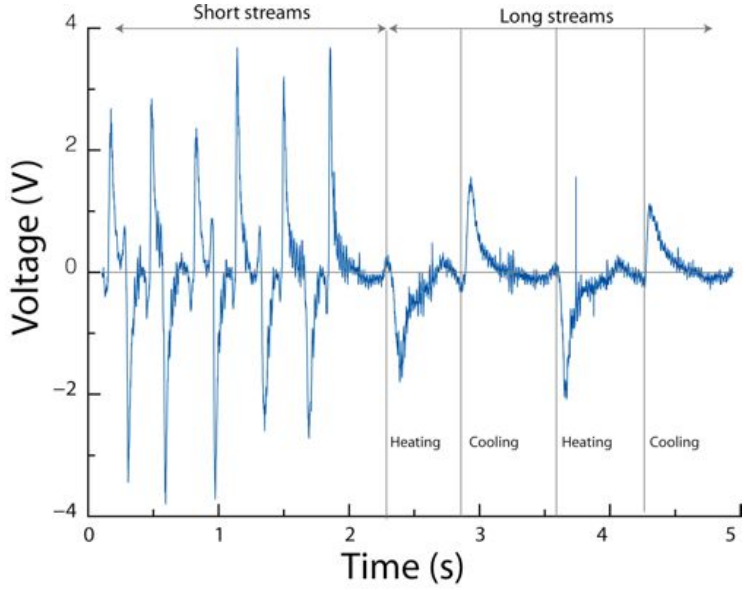
Waste heat collection : Hot and cold water sources
+ pressure (or gravity) to circulate the flow

Maximum Carnot efficiency $$\eta_{\max} = 1 - \frac{T_c}{T_h}$$

Output power not measured

Electrical charge must be adapted

Problem : sequential flow H+C…

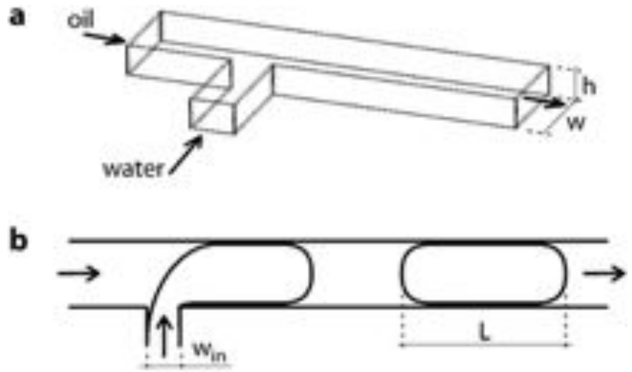


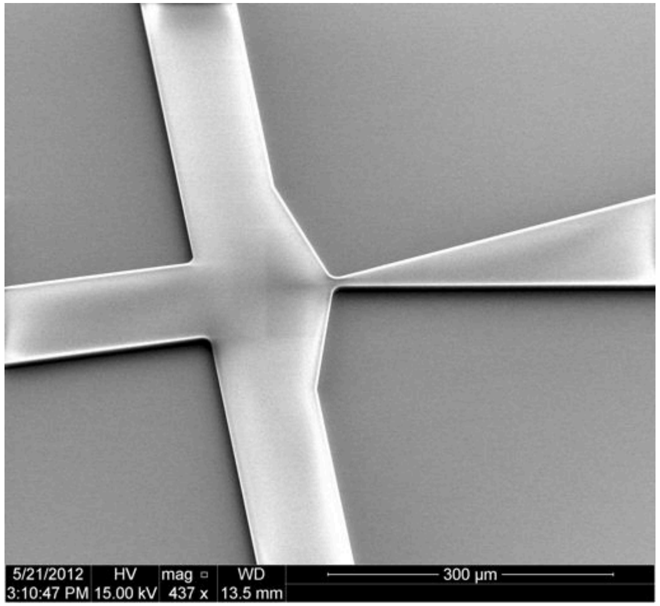
Flow focusing

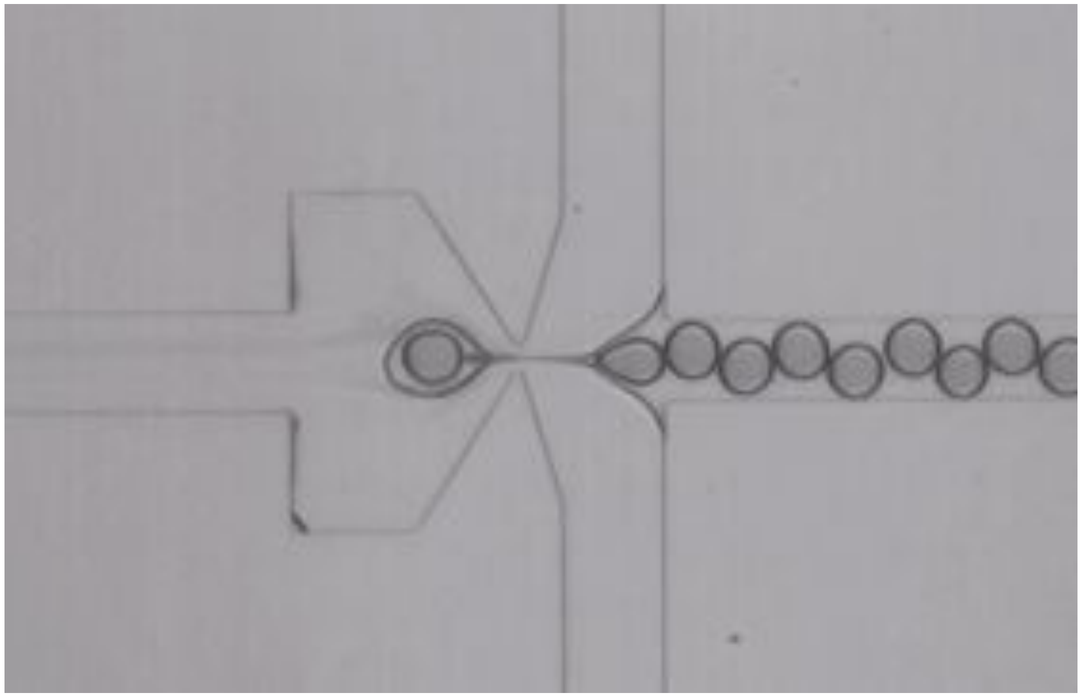
Flow focuring allows the creation of droplets in non miscible fluids

Using two phase non miscible liquids as hot and cold sources :

One pressure input







To be evaluated….

Conclusions

PZT thick film screen printed on glass

Pyroelectric and Piezoelectric behaviour

Streams of consecutive hot and cold water fed through a microfluidic channel

Positive and negative pulses -> pyroelectric current

Potential use in waste heat micro power generation

Optimisation :

- Material coefficient
- Substrate (losses)
- non miscible liquids (one pressure source)