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Institute of Solid-State Electronics

User-specific pyroelectric infrared detectors

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Content

1. Introduction

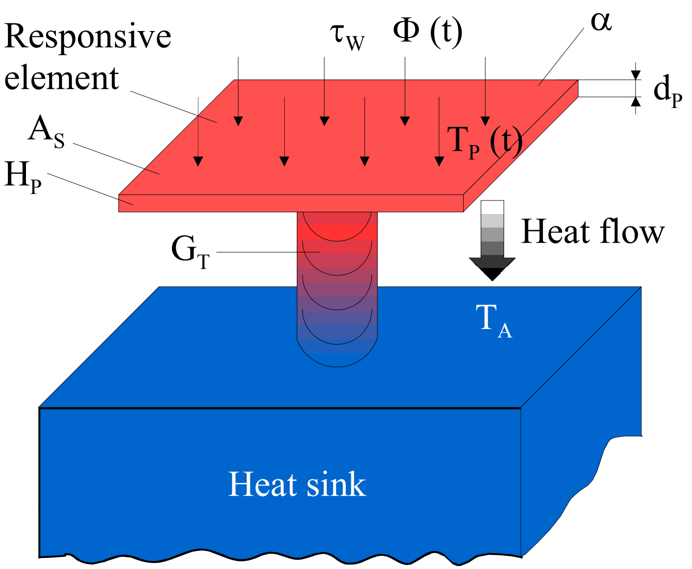
- Single-element detectors and linear arrays based on $LiTaO_3$
- Applications in pyrometry, analytics, spectrometry and security techniques
- Our aims:

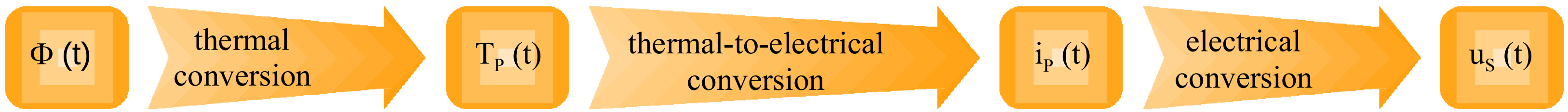
  - High flexibility in the detector layout

  - An as great as possible signal-to-noise ratio

  - Low microphonics

Principal functioning of a pyroelectric detector





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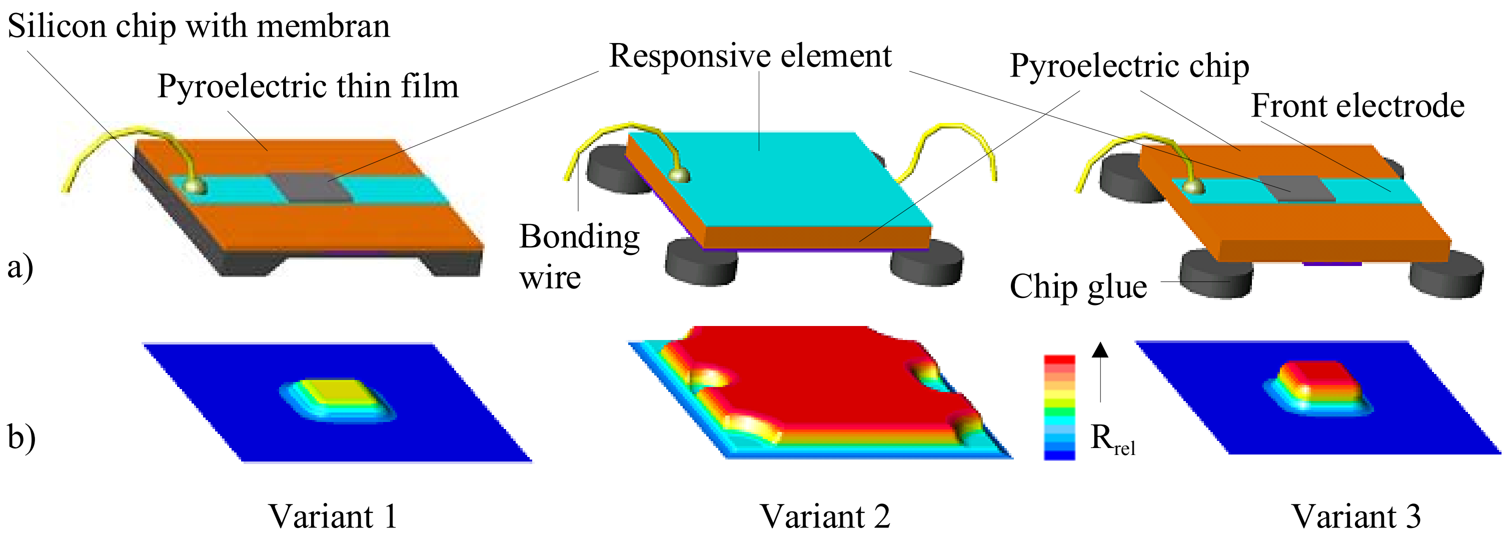
Principal assembly methods of the responsive element

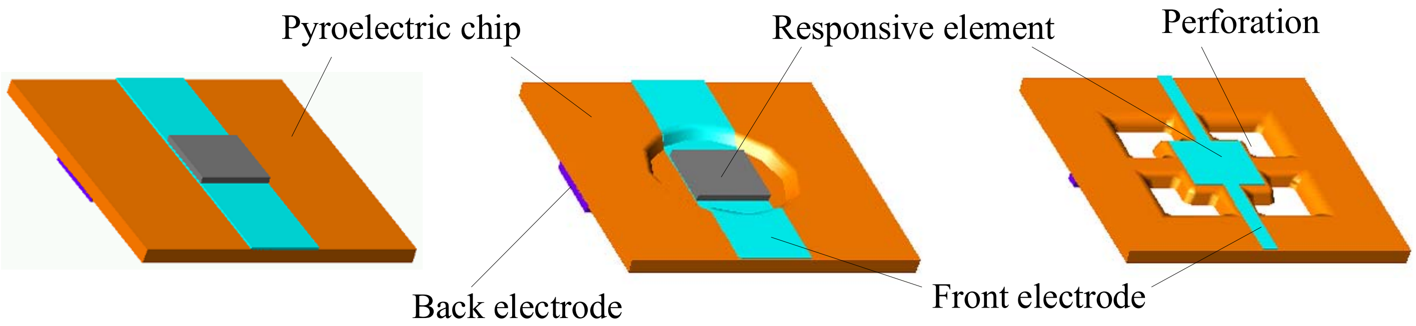


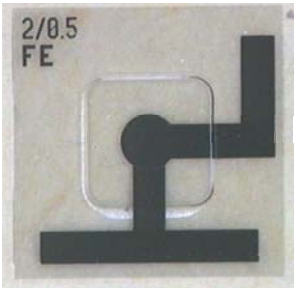
Demands for a high signal-to-noise ratio

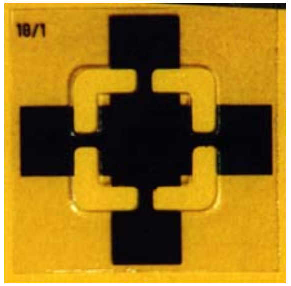
- Very thin responsive elements (50 µm → 20 µm → < 5 µm)
  - CMP of $LiTaO_3$
  - Ion beam etching
- High absorption coefficient of the responsive element
  - Black coatings based on Ag, Au, NiCr
  - Antireflection coatings
- Good thermal isolation of the responsive element
  - Evacuation of the package
  - Three dimensional patterning of the $LiTaO_3$ chips

2. Single-element detectors

➢ $LiTaO_3$ chip layouts

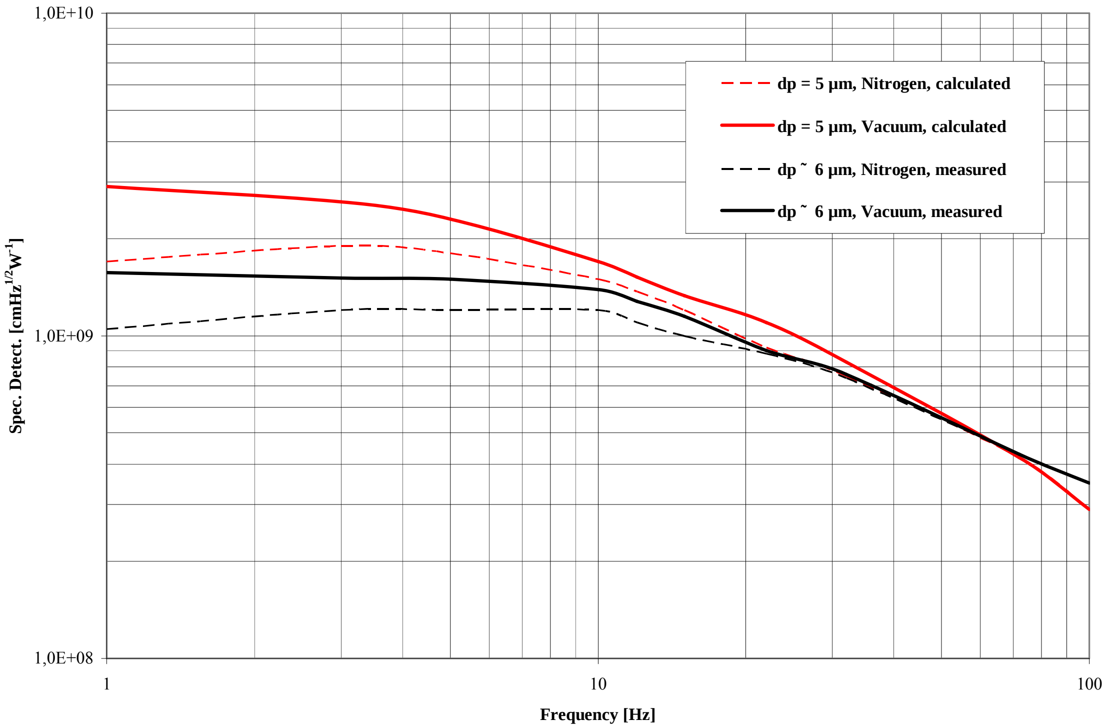






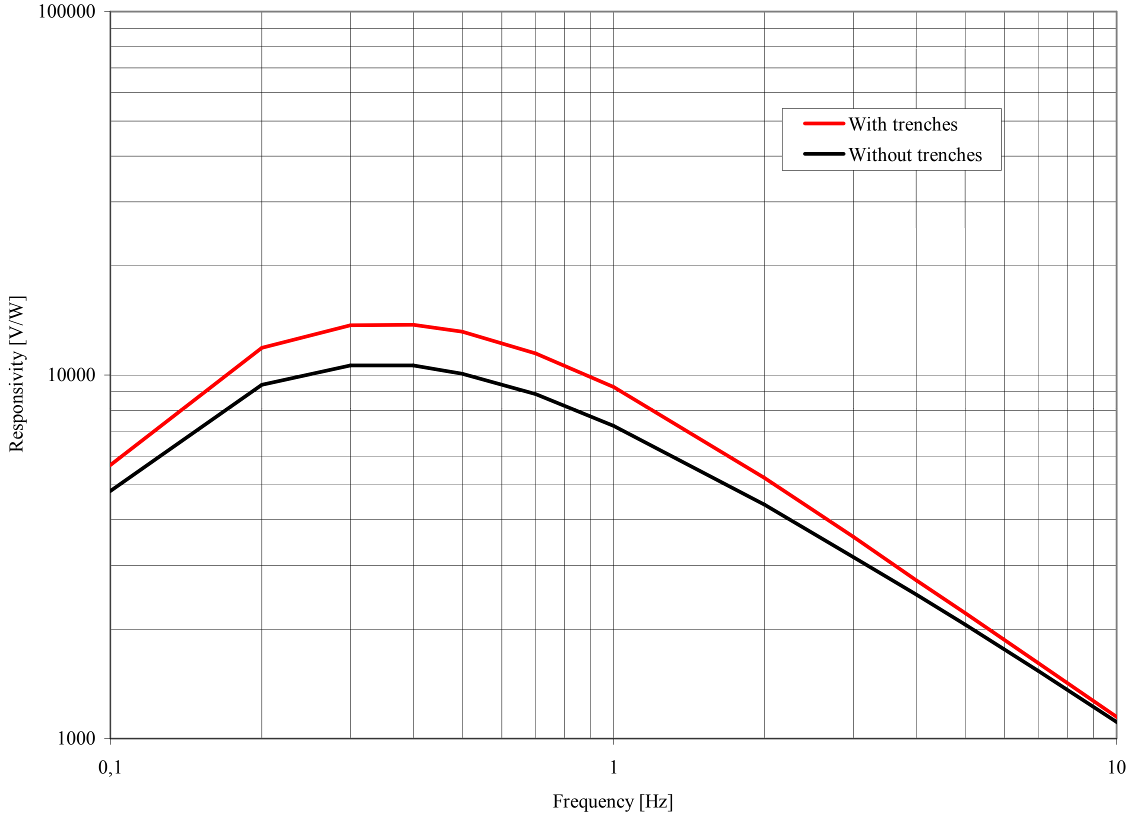
Sensor properties

➢ Heat transfer in the ambient gas, A_S = [3x3] mm^2



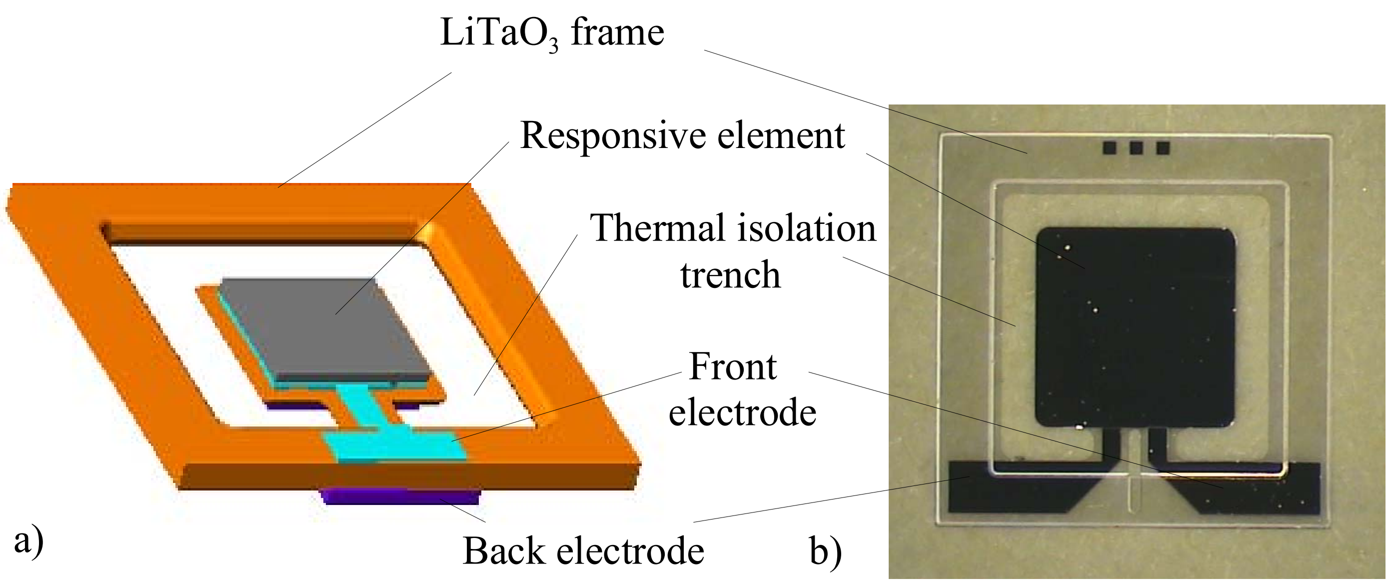
Sensor properties

➢ Heat transfer in the ambient pyroelectric material, A_S = [1x1] mm^2



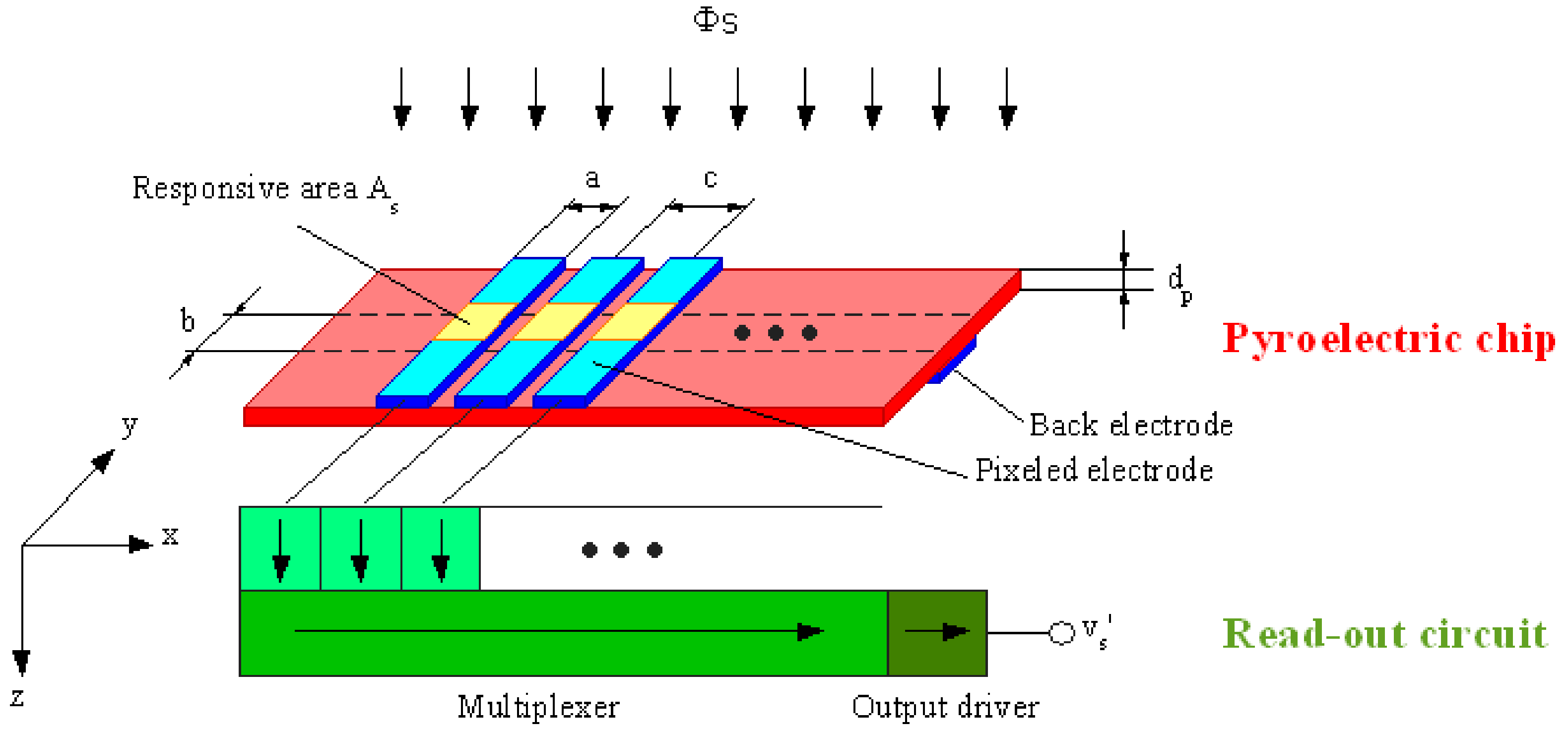
Sensor properties

➢ Optimised chip layout for very thin responsive elements



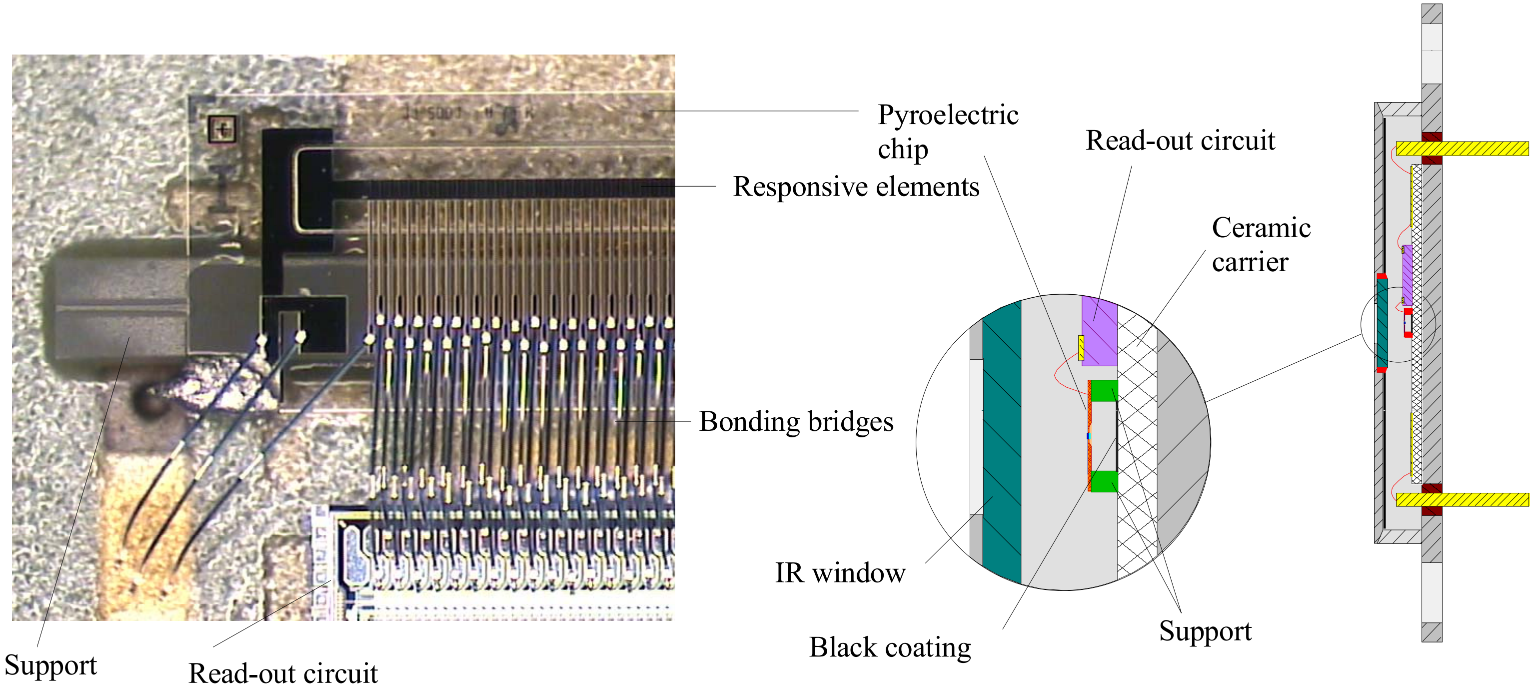
3. Linear Arrays

➢ Fundamental structure of a pyroelectric linear array based on $LiTaO_3$



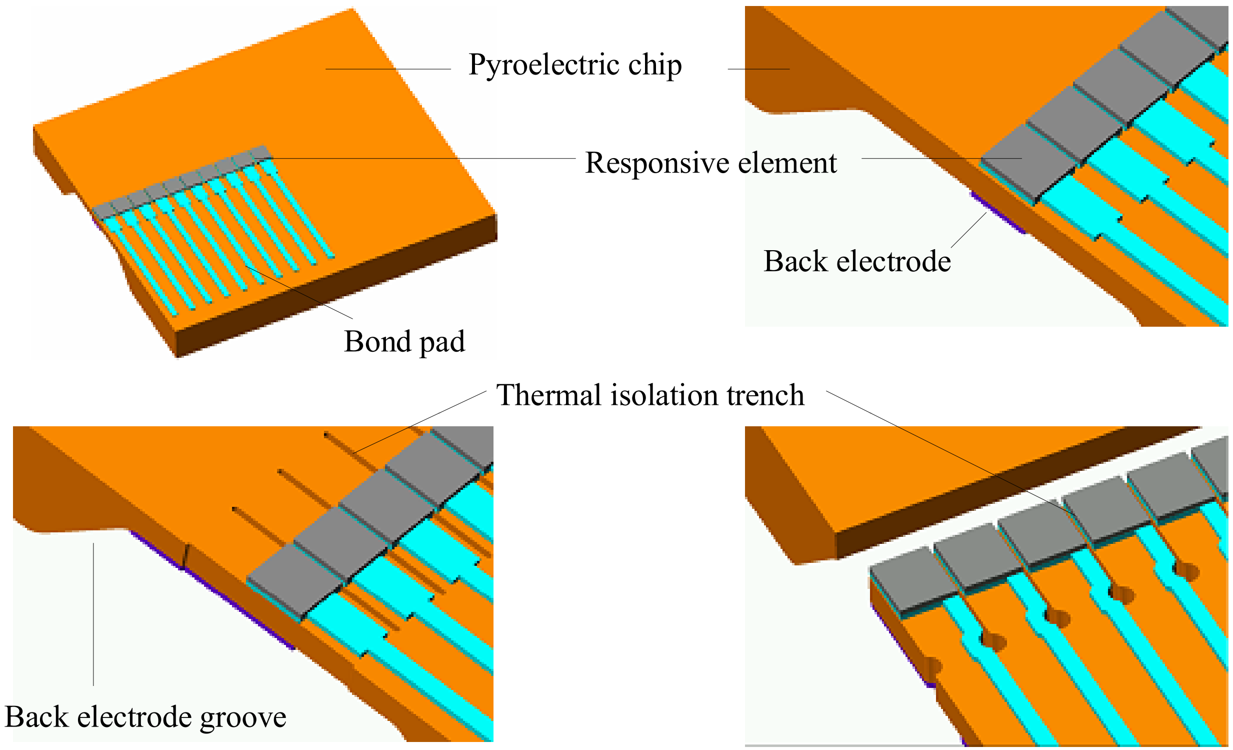
Array design

- ➢ Schematic sectional view and detail of a realized array



Array design

- Different layouts of array chips



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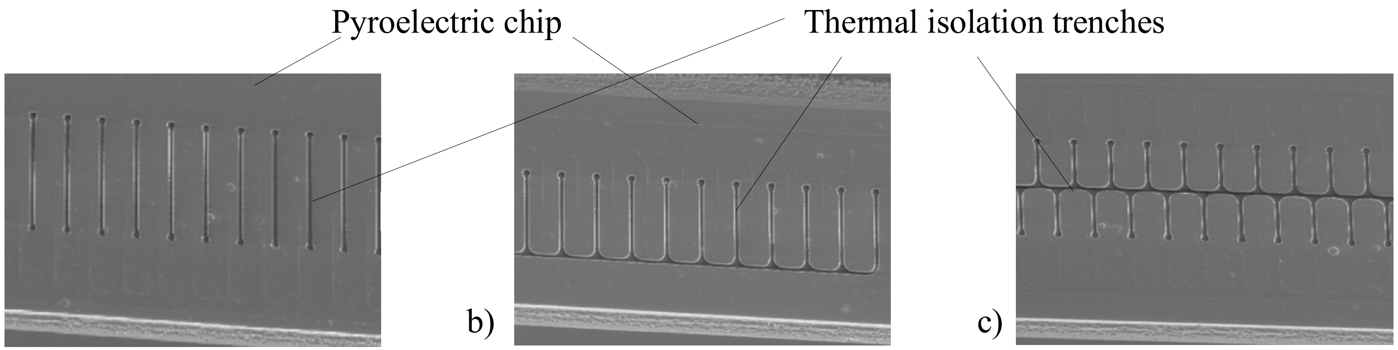
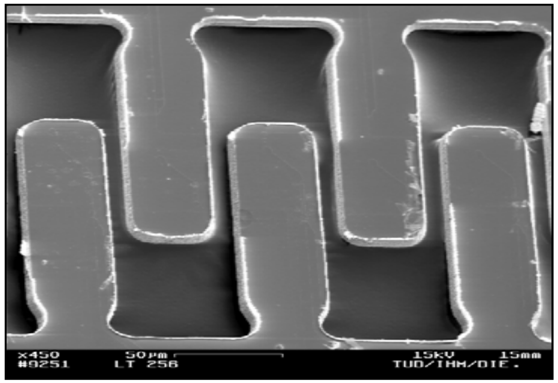
Array design

➢ SEM images of array chips with different isolation trenches



a) b) c)

Detail



Array properties

- Typical properties of different linear arrays (128 Hz, T_A = 25 °C)

Number of elements	**1 x 128**	**1 x 128**	**1 x 128 ***	**1 x 256**
Size of elements [μm^2]	90 x 100	90 x 100	90 x 100	42x100
Pitch [µm]	100	100	100	50
Element thickness [µm]	20	5	5	5
Responsivity R_V [VW^{-1}]	230.000	550.000	550.000	620.000
Variation R_V	1...2 %	2...5 %	2...5 %	2…5 %
NEP [nW]	3	1.5	1.5	1
MTF (R = 3 lp/mm)	0.6	0.6	0.8	0.6

* - thermal isolation trenches

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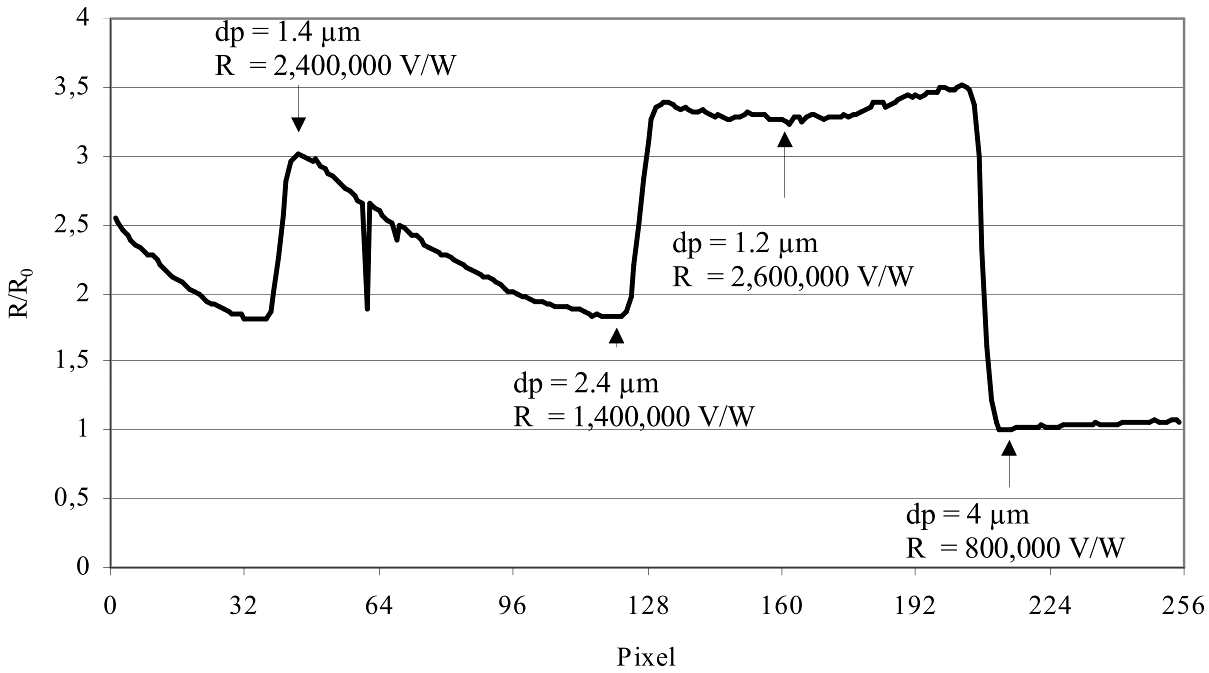
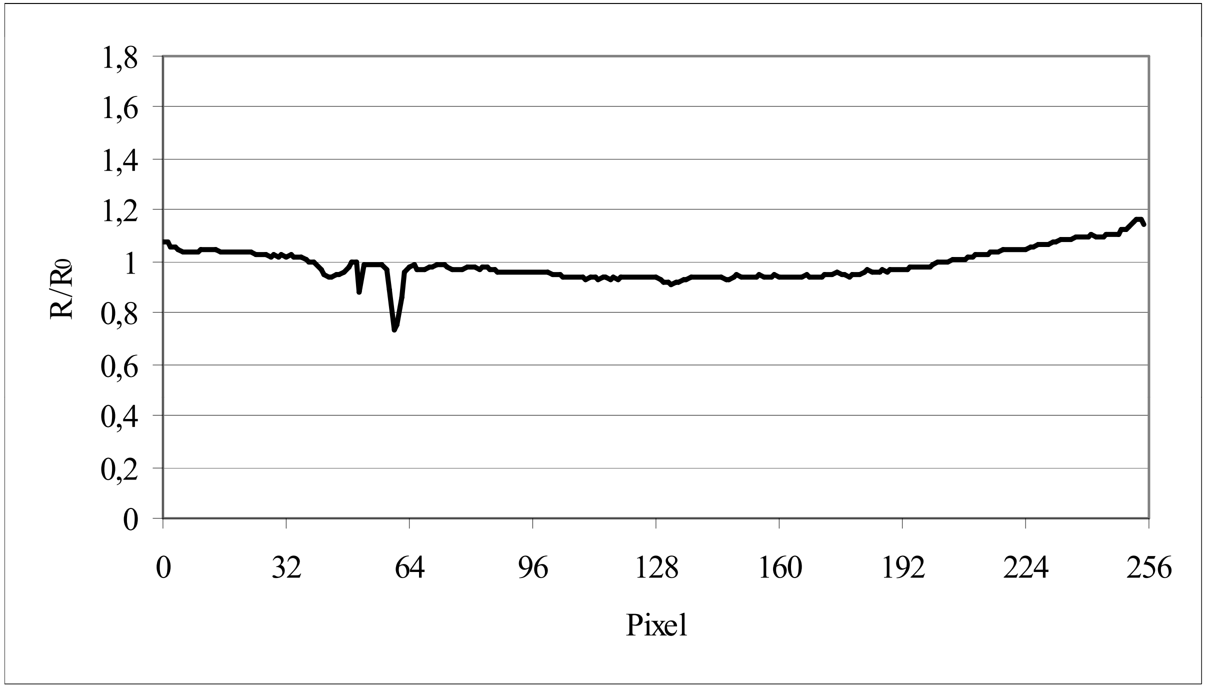
Array properties

- ➢ Measured responsivity distribution of an array with stepped profil



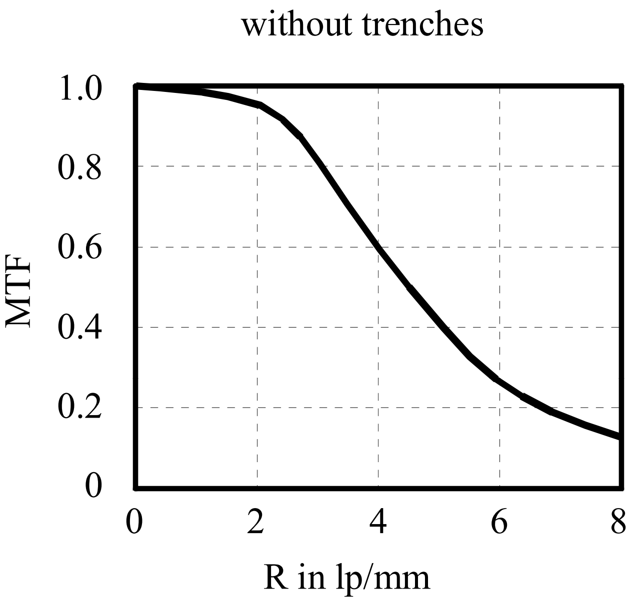
Array properties

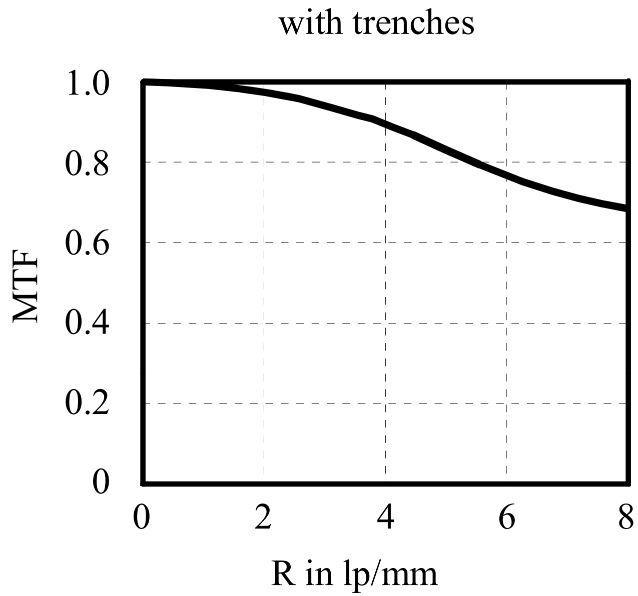
➢ Responsivity distribution of a array with a thickness of about 3 µm



Array properties

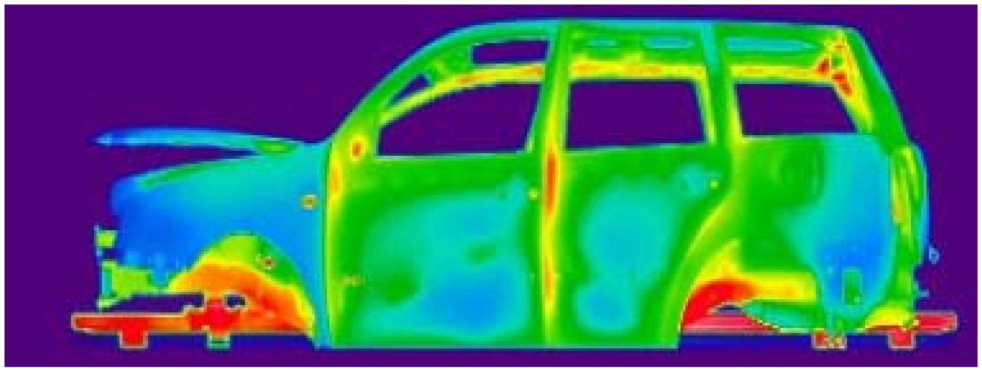
- Measured MTF of two $LiTaO_3$ arrays with 256 pixels





Array application

- Infrared line camera system PYROLINE 256



4. Summery

- Single-element detectors with a specific detectivity
  D* (500 K; 10 Hz, 1 Hz) > 10^9 cm $Hz^{1/2}$ W^{-1}
- Sensors with very low microphonics
- Linear arrays with up to 512 responsive elements
- Minimum NEP for a 256 pixel array < 0.5 nW (128 Hz)
- MTF improvement by using thermal isolation trenches

→ Customized detectors