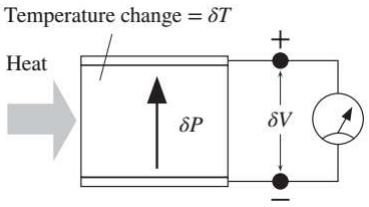
PYROELECTRICITY

Pyroelectricity

- **Pyroelectricity:** When a temperature change δT induces a change δP in the polarization of the crystal.
- **Example:** $BaTiO_3$



- **Pyroelectric coefficient:** $p = \frac{dP}{dT}$

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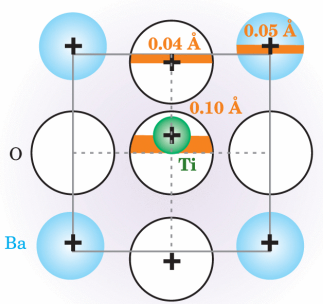
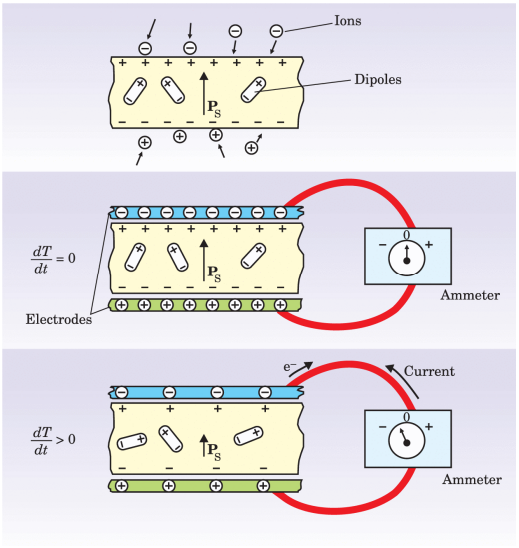
Microscopic Picture



- Spontaneous polarization depends on temperature.
- Current sign depends whether temperature increases or decreases.
- Pyroelectric effect is observed only when temperature changes.



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Pyroelectric Crystals

Material	Pyroelectric Coefficient ($\times 10^{-6}$ C m^{-2} K^{-1})	Curie Temperature (°C)
$BaTiO_3$, barium titanate	20	130
$LiTaO_3$, lithium tantalate	230	610
PZT, lead zirconate titanate	380	230

- Very small temperature changes, even in thousandths of degrees, can develop voltages that can be readily measured.
- If $\delta T = 10^{-3}$ K for a PZT material, we find $\delta P = 3.8 \times 10^{-7}$ C m^{-2}.

$$\delta P = \varepsilon_0(\varepsilon_r - 1)\,\delta E$$

- with $\varepsilon_r = 290$, we find: δE = 148 V m^{-1}
- If the distance between the faces of the ceramic where the charges are developed is 0.1 mm, then $\delta V = 0.0148$ V or 15 mV

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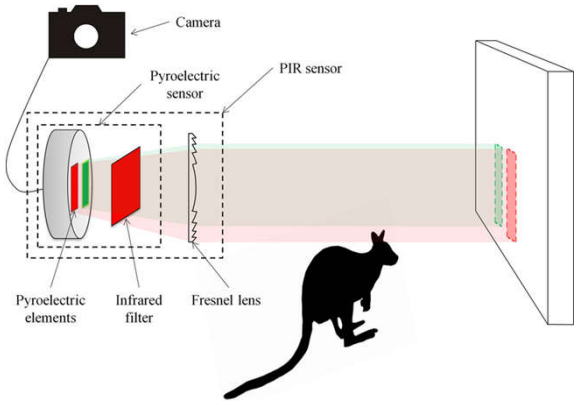
Pyroelectric Radiation Detector

- Pyroelectric crystals are widely used as infrared detectors (**PID**). Any infrared radiation that can raise the temperature of the crystal even by a thousandth of a degree can be detected.



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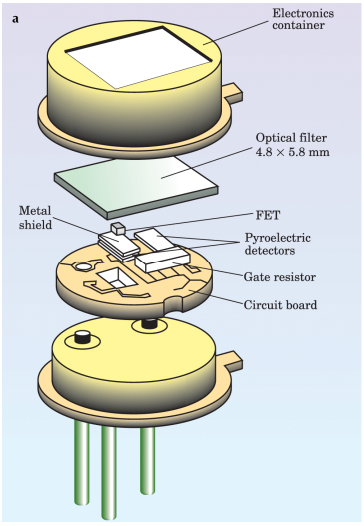
PID Components



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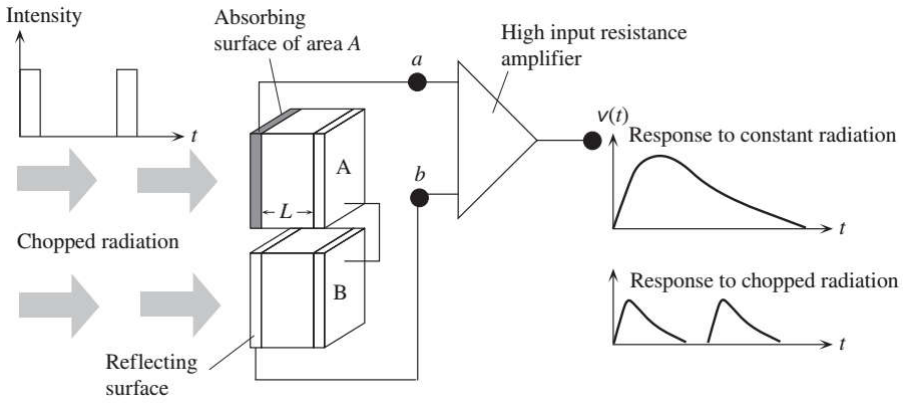
Pyroelectric Infrared Detector

Working Principle:



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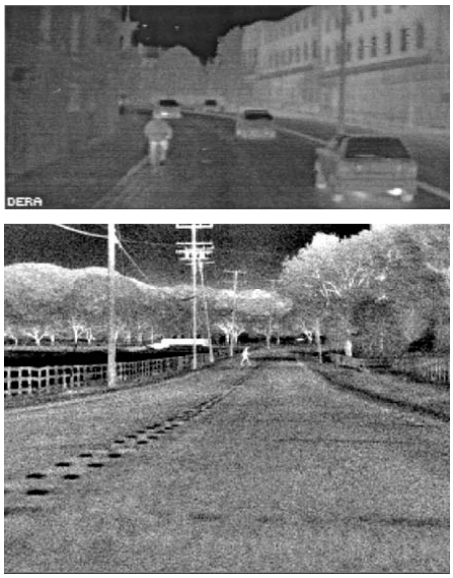
Infrared/Thermal Imaging



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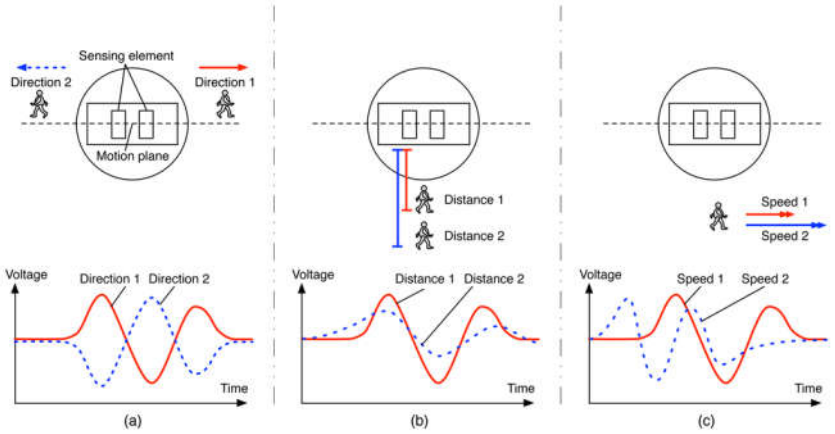
Pyroelectric Sensor



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Pyroelectric Current & Voltage

- Pyroelectric applications use both pyroelectric current and voltage that are generated by the change in temperature.

- **Induced current density:** $J_p = \frac{dP}{dt} = p\frac{dT}{dt}$

- **Current responsivity:** $R_I = \frac{\text{Pyroelectric current generated}}{\text{Input radiation power}} = \frac{J_p}{I}$

- **Voltage responsivity:** $R_V = \frac{\text{Pyroelectric output voltage generated}}{\text{Input radiation power}}$

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