THz Detection by Thermopile Antenna

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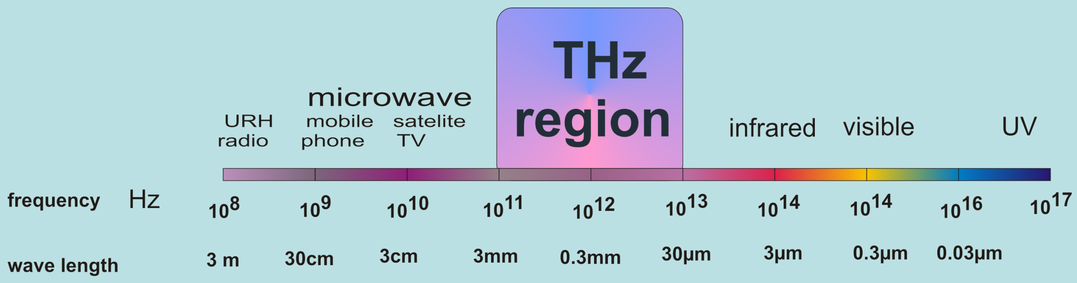
What is the THz?

The terahertz gap is the last unexploited part of the spectrum of the electromagnetic radiations.

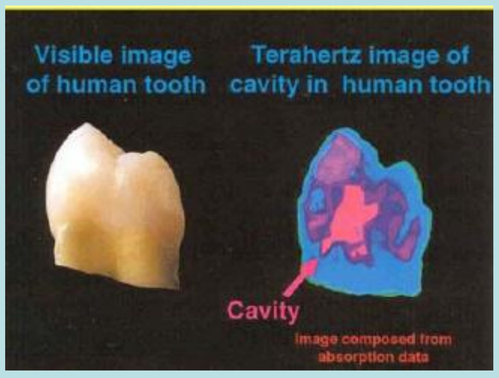


Possible applications:

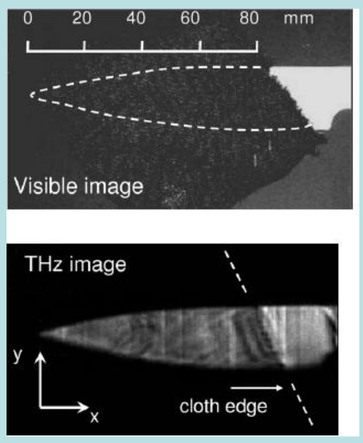
spectroscopy identification of drugs and/or explosives

image medical diagnostics: dental, cancer, etc.
security check: The THz „sees" through the clothing, bags, etc. Also the non-metallic objects are sensed.

Examples:



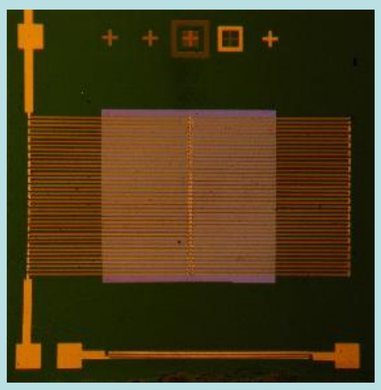
(from the lecture of prof. Nuria Llombart, Optics Department,Universidad Complutense de Madrid, Spain):

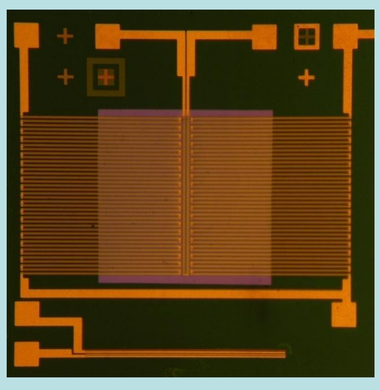


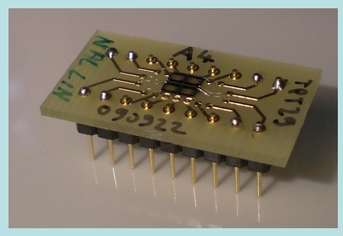
Visible image and THz image of a ceramic blade hidden in cloth (from the catalog of the TOPTICA Photonics AG)

Device parameters

The structure consist of 10 µm wide and 0.5 µm thick stripes with 10 µm spacing between them. The final doping of the undoped poly-silicon was set by selective ion-implantations of boron and phosphorus ions at 40 keV. The doses were selected to result in similar electrical conductivity after annealing. The poly-silicon structure was encapsulated by 1 µm thick SiO_2 CVD layer for proper electrical isolation. The contacts and wirings were formed by aluminum evaporation. After the contact window-opening the supporting membrane was released by removal of the crystalline silicon from underneath by KOH backside anisotropic alkaline etching at the temperature of 78 °C.
Different geometries were prepared, each composed of 40 thermopairs. One of them principally correspond to the schematic shown above. The second device served as a control, it consisted of two sets of thermopair loops facing each other and a thin resistor of p-type material between the sets. This filament served as a heater and also as thermometer. The chip size is 2 x 2 mm^2.



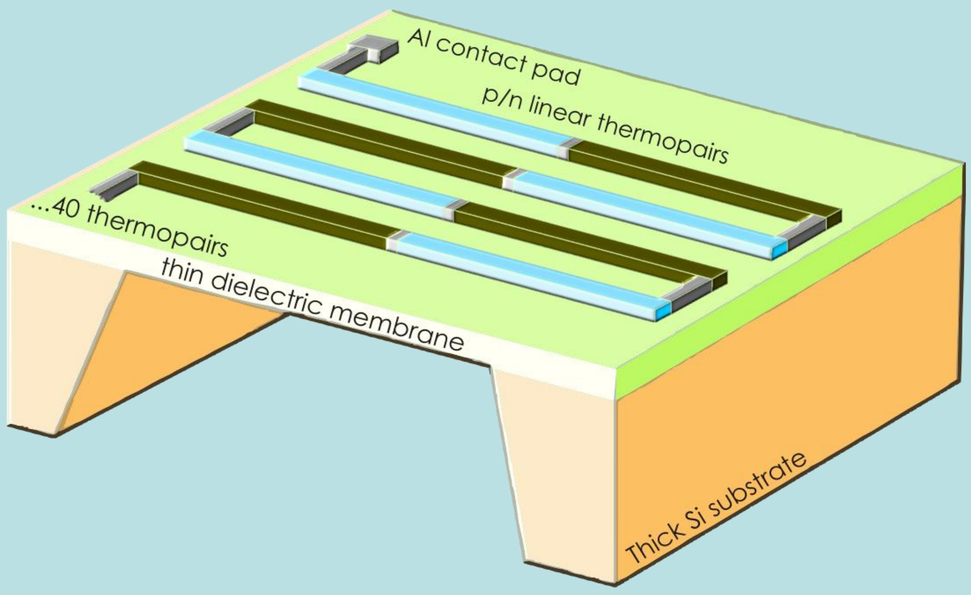




Motivation

To construct a THz detector which is suitable for integration and real-time imaging.

The principle: Linearly arranged micromachined thermopile



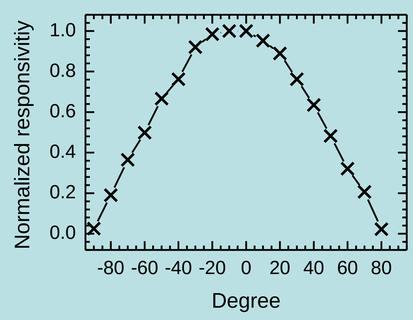
The thermopairs are formed from p- and n-doped polycrystalline Si strips grown on the non-stoichiometric silicon-nitride (SiN_x) film. The substrate is crystalline Si wafer, it is removed from the middle region. The high-frequency electric field parallel to these lines induces currents and due to the finite resistivity Joule heating. The distribution of the current is sinusoidal, having the maximum value at the centre and zero at the ends of the lines. Therefore the heat formation peaks around the middle of the lines, exactly where it generates the highest thermoelectric effect.

Measurements

Method	Responsitivity v/w
Electric heating[1]	90
Infrared[2]	20
13 GHz	0.2
100 GHz	5.6
Broad-band THz[3]	21

[1] measured on the control device (loops + heater)
[2]the two devices (linear and loops) were equivalent
[3]the radiation was generated by a 10^{-12} s broad pulse , the spectrum ranged from about 0.2 THz to 3 THz

The device is sensitive to the polarization, the output has a maximum when the electric field is parallel to the lines.



The response time was estimated by applying square waved heating on the control device.