ATTRACT Academy

Technology card:

h-cube

Micromechanical Bolometers array for Terahertz imaging.

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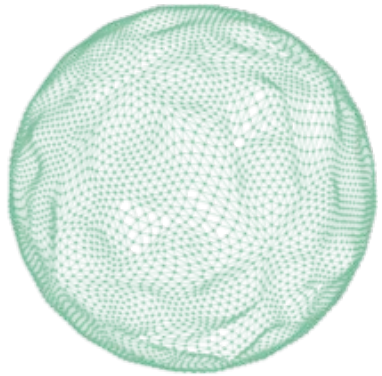
What does it do?

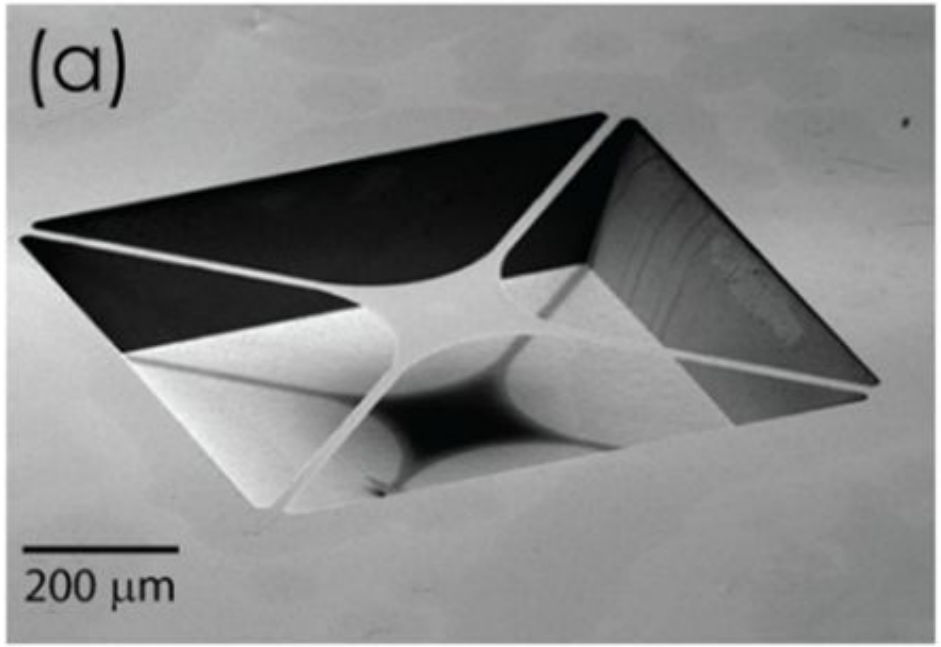
The h-cube technology addresses the emerging need for low-cost, portable solutions for hyperspectral imaging in the terahertz (THz) region of the electromagnetic spectrum. H-cube extends the use of THz imaging from costly, extremely low-volume applications such as large body scanners in airports, expensive in-line machines for production quality control and sophisticated research tools to larger-volume, everyday applications such as crop monitoring, building control and weapon identification in crowded environments.

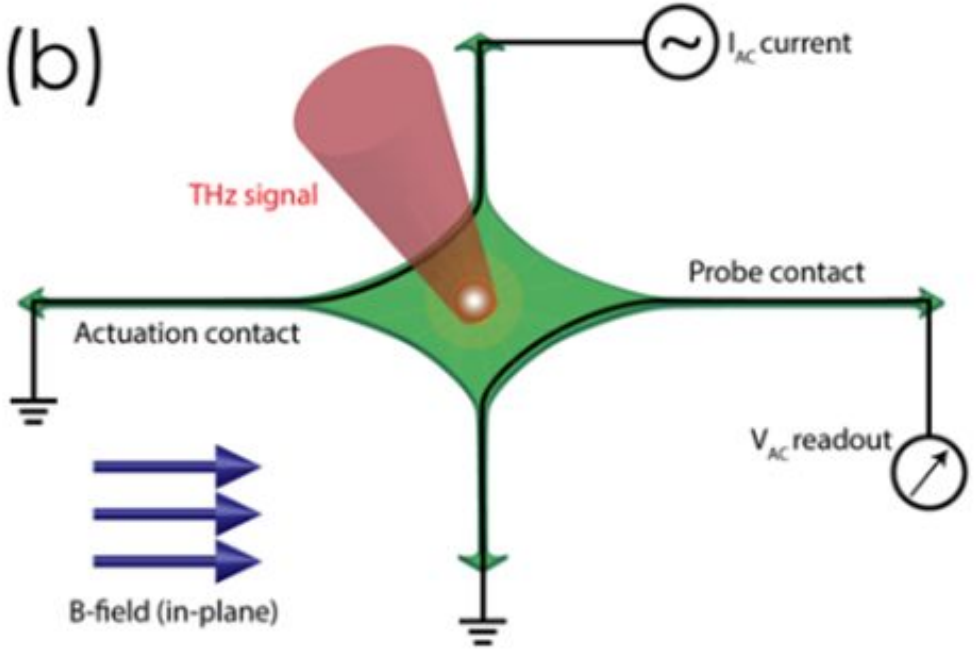


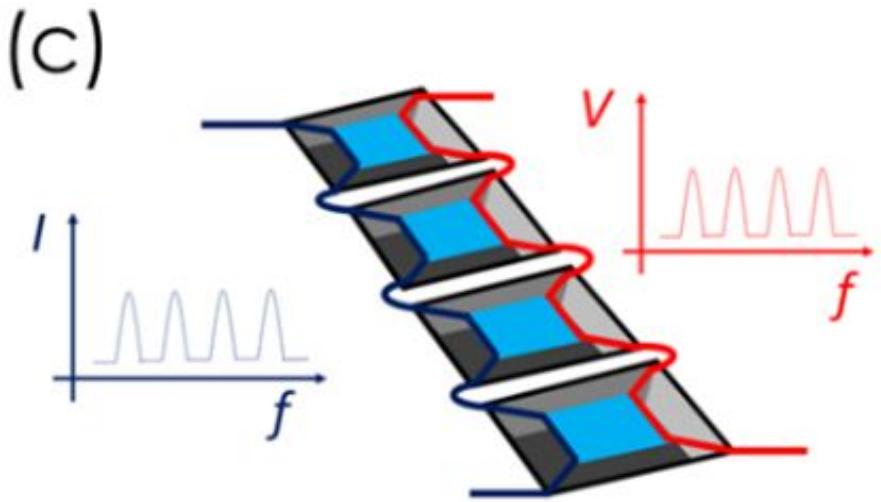
How does it work?

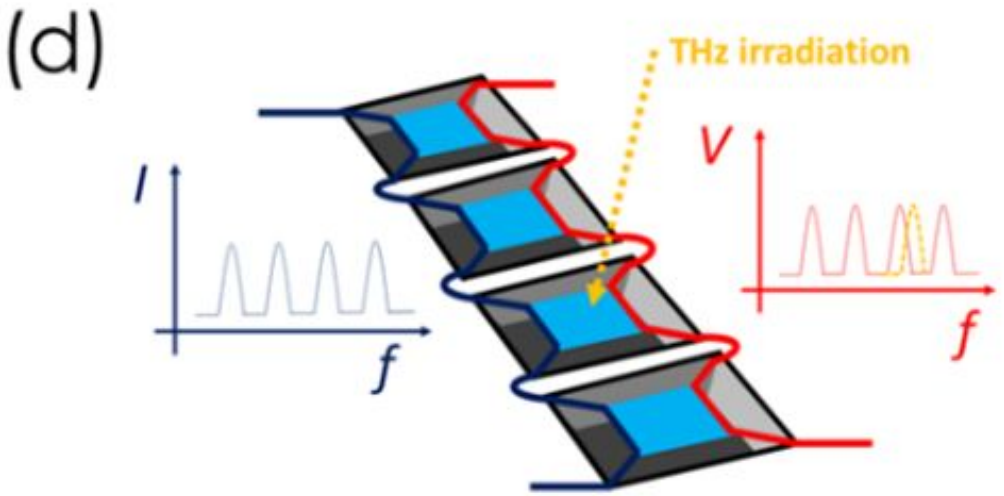
The viable technology for this new generation of commercial THz cameras is thermal detection, such as infrared imaging. The sensor prototype will consist of a 360x240 pixel array of micromechanical oscillators whose resonance frequency will provide a THz irradiation sensitivity equivalent to today's best and cheapest performances. The bolometric detector is based on a micromechanical resonator. In the micromechanical bolometer, a small suspended structure (typical size 10-1000 um) can be forced into large, coherent oscillations using external drives (piezoelectric actuators, electromotive force, etc.) resonant with the device's normal modes. Sweeping the drive frequency and using electrical or optical probes, full spectroscopy of such modes can be performed with a resolution better than one ppm. When illuminated with THz or sub-THz sources, the heat generated by the absorbed radiation induces a thermal expansion of the vibrating structure, thus changing its internal stress and shifting its resonance frequency (ReF). The system can show a temperature coefficient of frequency (TCF) better than 0.1Hz/uW of irradiation power.

Illustration of the technology









Unique characteristics (1/2)

1) **THz irradiation sensitivity is equivalent to the best performances available today but at ten times cheaper.** H-cube's THz imaging system does not require cooling, complicated time-resolved solution, large and heavy optics, or motors for image reconstruction through scanning. Plasmonic filtering provides spectral sensitivity, and the detector pixilation provides imaging. No macroscopic moving parts are present, only a tiny membrane vibration at the base of the special detection systems proposed. We expect the final prototype to be as light as a GoPro camera or an iPhone7, less than 150grams, including batteries.

2) **The fabrication processes are extremely simple, cost-effective, and suitable for the production of large arrays**. Therefore, H-cube extends THz imaging from costly, highly low-volume applications to larger-volume, everyday applications.

Unique characteristics (2/2)

3) **The measurement of the ReF is not affected by the lead geometry or conductivity. Therefore, there is no need for an ROIC approach**. The readout electronic can be implemented separately. This implies that it is possible to adopt absorbing materials incompatible with the CMOS process if needed, such as 2D multilayers and pyrolytic graphene.

4) The TCF is a consequence of the thermal expansion of the resonator, which is constant within 1% over a ±100K range. Therefore, once calibrated, **the sensor is independent of the operating temperature.**

5) By fabricating resonant structures with distinct resonance frequencies, **a single readout process can collect the data from all the pixels simultaneously**, using the ReF as the pixel index. Moreover, radiation damage, particularly the creation of deep electronic defects in the structure, is not relevant.

Domains of impact?

1) **Coating inspection**: using pulsed terahertz sources to penetrate opaque material and record the reflection delay (similar to pulsed ultrasound techniques), multi-layer coatings are characterised as a non-contact, non-destructive test without the need for coupling fluid.

2) **Semiconductor packaging:** exploiting the transparency of silicon to THz radiation and using THz scanning systems and time of flight information, defects such as the delamination areas and epoxy-rich regions are monitored in packaged silicon chips.

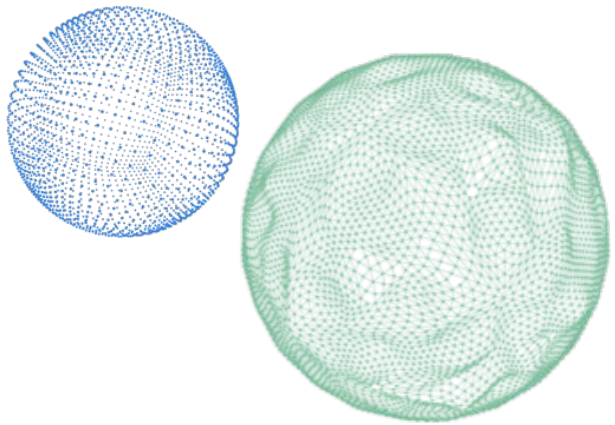
3) **Pharmaceutical applications:** THz absorption and reflection enable the characterisation and optimisation of suspensions, the dissolution of active compounds, and the resistance of tablet coatings.

4) **Food industry:** owing to its non-destructive and non-ionizing characteristics, THz radiation can inspect food packaging, replacing x-ray scanning and its detrimental effects on biological agents.

5) **H-cube's solution can be easily mounted on drone systems and used for remote monitoring and inspection** of **infrastructures and environments**, thus complementing satellite information with 'ground truth' data.

Potential societal issues that your technology can address.

- Owing to its non-destructive and non-ionizing characteristics, THz radiation could be used to replace x-ray scanning and avoid the corresponding detrimental effects on biological agents.



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