Sensing Infrared Without Power

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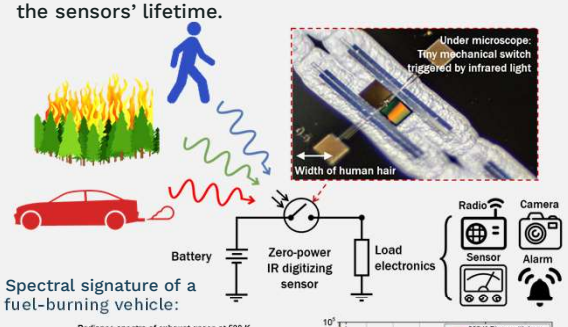
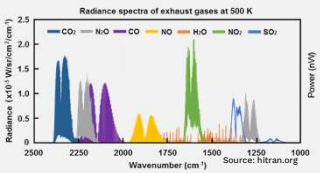
Driving Applications: Near Zero Power RF and Sensor Operations (N-ZERO)

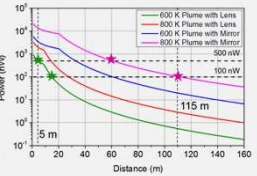
Motivation

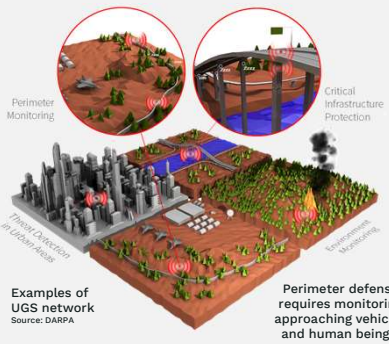
Due to the fast development of the Internet of Things, there is a growing need for unattended ground sensors that can remain dormant, with near-zero power consumption, until awakened by an external trigger or stimulus. State-of-the-art sensors based on active electronics consume power constantly, regardless of the presence of the useful data, which severely limits the sensors' lifetime.



Spectral signature of a fuel-burning vehicle:





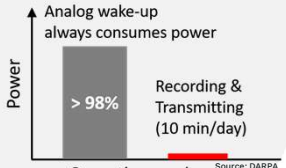


Examples of UGS network
Source: DARPA

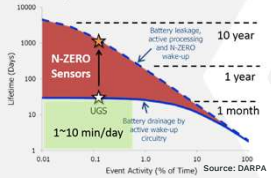
Perimeter defense requires monitoring approaching vehicles and human beings.

A typical low duty cycle sensor node:

Most power is consumed in the idle mode!

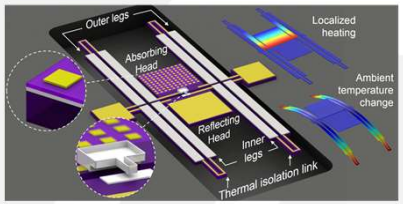


We propose a device concept that fundamentally breaks the paradigm of using active power for sensing.



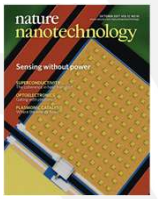
Technical Approach

Plasmonically-enhanced Micromechanical Photoswitch

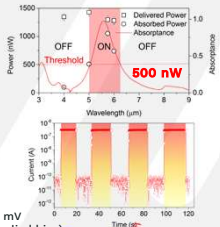


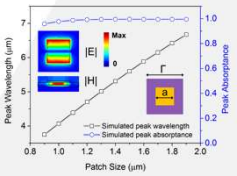
- **Ultra-low detection threshold down to 75 nW**
- **immune to ambient temperature change**
- **High probability of detection**
- **Low false alarm rate**

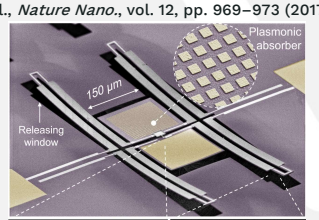
ON/OFF conductance ratio ~ 1.5 ×10¹²
Subthreshold slope > 12 dec/nW



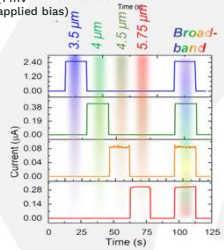
Z. Qian et al., *Nature Nano.*, vol. 12, pp. 969–973 (2017)

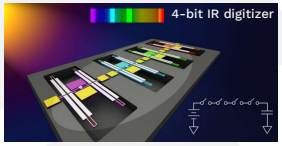




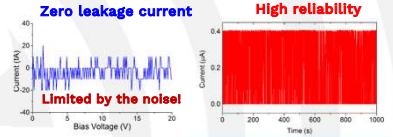


(1 mV applied bias)



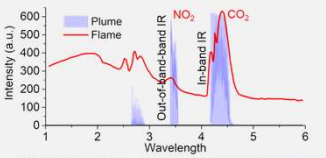


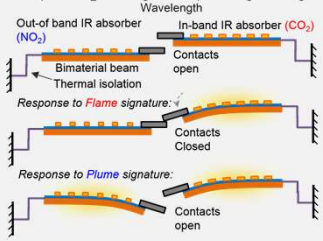
Device	Infrared Spectral State				
	3.5μm Band	4.0μm Band	4.5μm Band	5.75μm Band	Broad-band
3.4μm PMP	1	0	0	0	1
4.1μm PMP	0	1	0	0	1
4.5μm PMP	0	0	1	0	1
5.6μm PMP	0	0	0	1	1

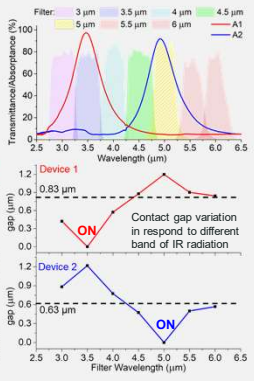


System Level Development

Hardware Logic for Zero False Alarm

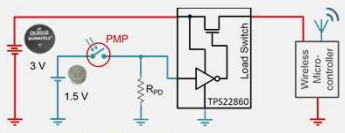


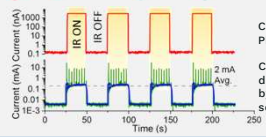




Wireless Sensor Node

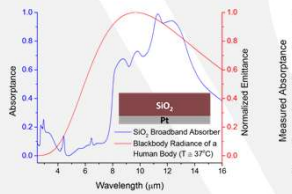
Standby power consumption: ~ 2.6 nW



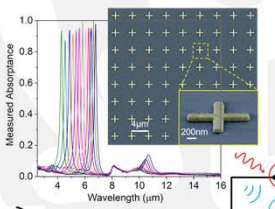


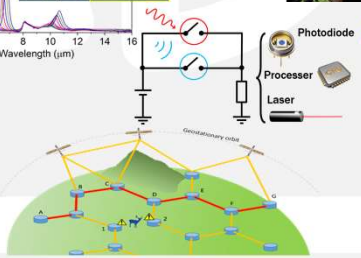
Current in Photoswitch

Current drawn by the entire sensor node



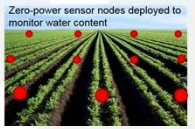
Occupancy Sensing

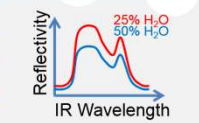


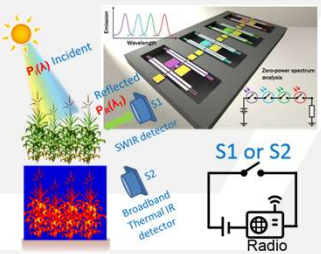


Optical Communication

Envisioned Applications







Smart Farming

Northeastern
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