“Smart Dust” Tracker

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Introduction

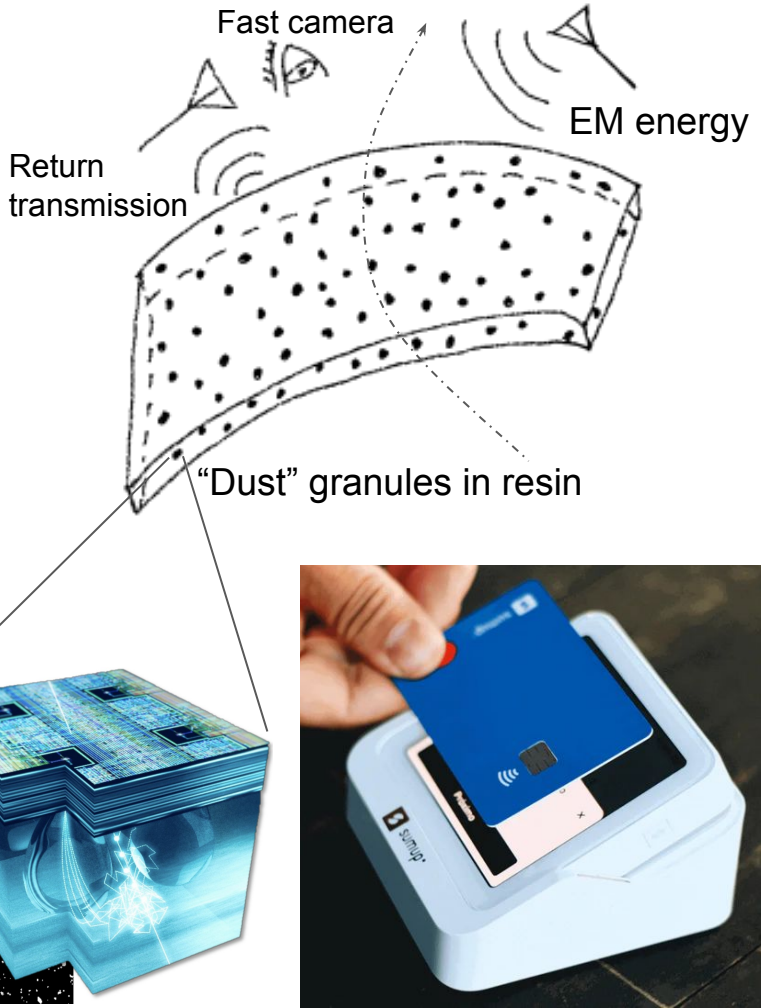
Motivation: make an entirely wireless tracker

Scheme:

1. Dice CMOS pixels (MAPS) into tiny granules (sub-mm^3 volume)
2. Embed granules in a matrix (resin) material
3. Supply power and communicate via RF, akin to RFID tags

- Each “Dust” granule is a MAPS sensor+energy harvesting and data transmission circuits in CMOS
- EM wavelength can be in optical range
- Sensors can include SiPM. The matrix material can be murky scintillator—tracking calorimeter

Effectively a Synthetic Spectrum Shifter with Intelligence



https://ep-news.web.cern.ch/content/pushing-boundaries-monolithic-cmos-sensor-technologies

History and modern approach

SMART DUST

Autonomous sensing and communication in a cubic millimeter

PI: Kris Pister
Co-investigators: Joe Kahn, Bernhard Boser
Subcontract: Steve Morris, MLB Co.

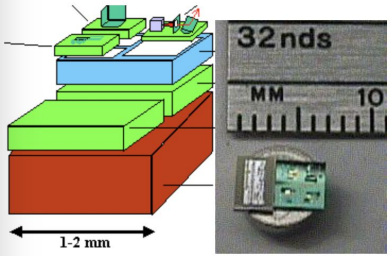
Supported by the DARPA/MTO MEMS program

This project finished in 2001, but many additional projects have grown out of it. Among these are

- Berkeley Webs
- NEST
- Center for Embedded and Networked Sensing at UCLA

If you are interested in commercial applications, you should check out Crossbow Technologies and Dust Networks.

Quick progress update. Another update.
29 Palms demo of air-emplaced 1" scale motes detecting vehicles.
Latest photos and press coverage.
My view of sensor networks in 2010.



The two figures above represent where we are and where we'd like to be.

- "Smart Dust" concept was conceived in the 1990s, aimed for distributed sensor network
- Development led to several-mm-sized assemblies capable of wireless environmental monitoring and mobile deployment

For this proposal:

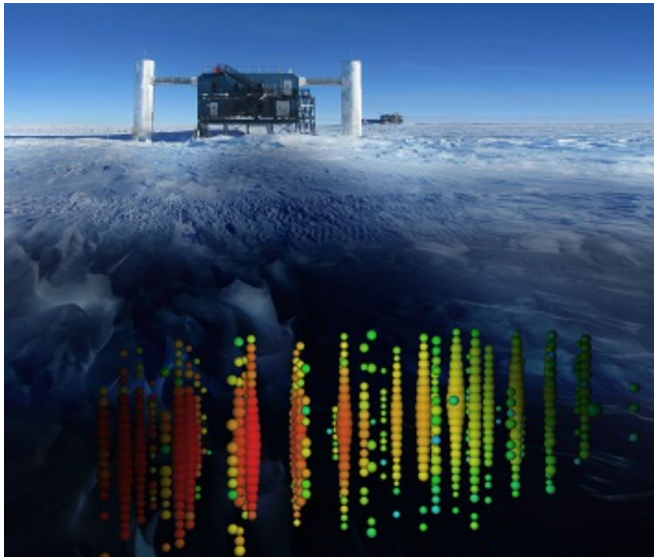
- Dust granules are smaller and immobile. Transceiver-sensor relation (pose) is fixed.
- Dust granules are to be implemented entirely in CMOS IC
  - Sensing elements, front-end, digitizer, processor
  - Energy harvesting, power regulation
  - Communication, transceiver
- Major challenges:
  - Small cross-section. How to best harvest energy?
  - Communication channel crowding. How to transmit data among many neighboring granules?
  - Precise timing. How to keep time during sleep?

Use cases

Tracker

This is a drone show over the Santa Monica Pier.
“Same idea” with MAPS dust in wall-paint instead of LEDs on drones

Tracking calorimeter



This is ICE-CUBE.
“Same idea” with SiPM dust in scintillator instead of giant strings of phototubes in ice

Proposal information

- Team
  - University of Texas at Arlington, Yuan Mei *et. al.*
  - LBNL, Maurice Garcia-Sciveres *et. al.*
  - Others are welcome!
- Overlap with various RDCs
  - Tracker, Calorimeter, photosensor, scintillator, readout, *etc.*
- Timeline
  - Demonstrate **one** autonomous sub-mm^3 granule (1~2 years)
    - Simulation, COTS bench test, CMOS ASIC, validation
  - From 1 to N
    - Addressing vast number of granules
    - Timing resolution (how to do timing?)