Passive RFID Sensing Technology for Supply Chain Traceability

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Agenda

- Introduction
- Project Scope
- Impact of Research
- Value to Industry
- Current Results
- Future Direction
- Project Plan

Introduction: Project Team

INVESTIGATORS

Prem Chahal

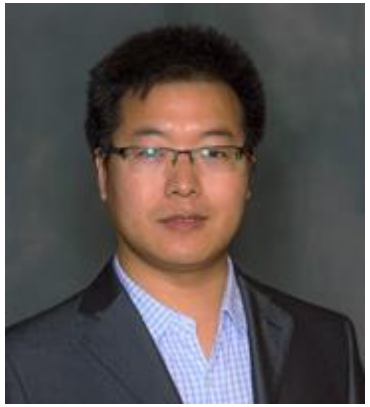
Evangie Alocilja

Amanpreet Kaur

COLLABORATORS

+ 2 Ph.D. Students
+ 1 Undergraduate Student

Bahar Aliakbarian



Changyong Cao

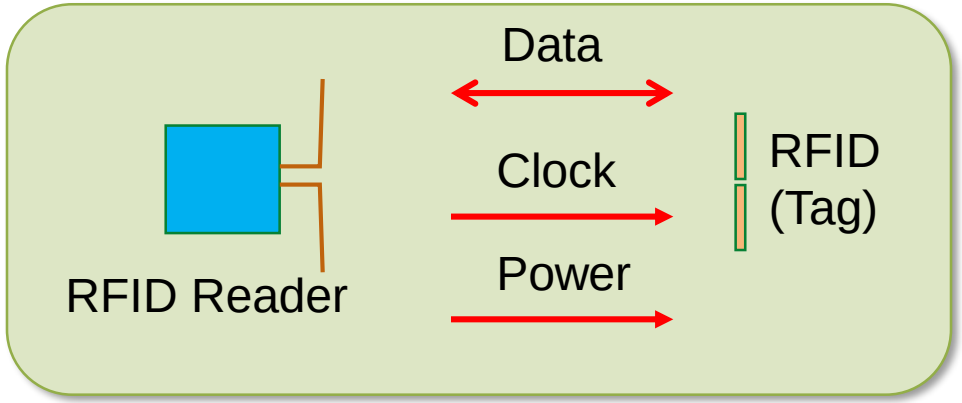
SPONSORS

1. Clark Cummings
2. Jeff Tazelaar

Introduction
Background on Radio Frequency ID

Radio Frequency Identification

- Similar systems: bar-code scanners, magnetic strip readers, etc.
- Use of radio waves to transmit key information over short distances
- Information describes identity, location, and/or condition of physical objects
- Operability is non line of sight and object can be hidden in boxes
- Reader sends commands, clocks, and power to the tag
- Modulation schemes: ASK, PWM, or FSK
- Tag is activated by the RF signal
- Tag sends response (simple ID, or sensor data)
- Modulation scheme: BackScatter Modulation



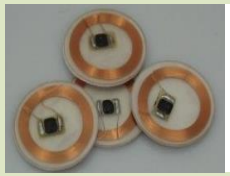
Introduction
Background on RFID

Chipless

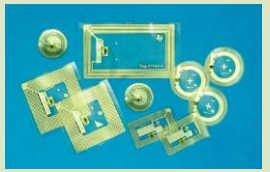
58 KHz

8.2 MHz

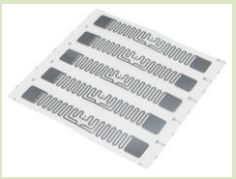
With Chips



Low Freq. (LF)
125 – 134.2 KHz



High Freq. (HF)
13.56 MHz



Ultra-high Freq. (UHF)
125 – 134.2 KHz

- SHF : Super High frequencies (2.45 GHz)

APPLICATIONS:

- Anti-theft Alarm Tags

COMMON APPLICATIONS:

- Medical (e.g., label instruments)
- Logistics/Tracking (e.g., tracking airline baggage)
- Supply Management
- Security/Access Control (e.g., wireless keys)

Introduction
Passive RFID market – 10 year forecast

Passive UHF market data segments – 10 year forecast
Retail apparel and footwear
Retail – other
Logistics, conveyance, roll cages
Asset management/inventory
Medical/heathcare
Air baggage and cargo
Access control/ticketing
Embedded
People
Other

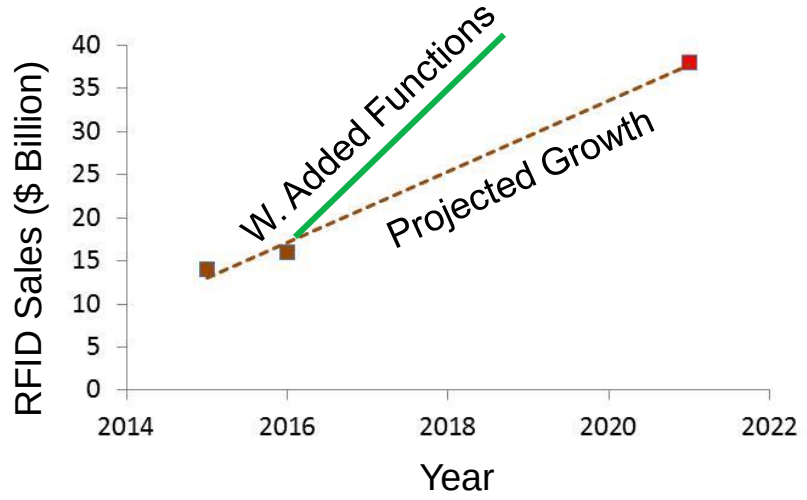
Passive HF RFID market data segments – 10 year forecast
Contactless cards/fobs
Smart tickets
Books
Medical
Assets/tools
Passports
People
NFC applications
Other

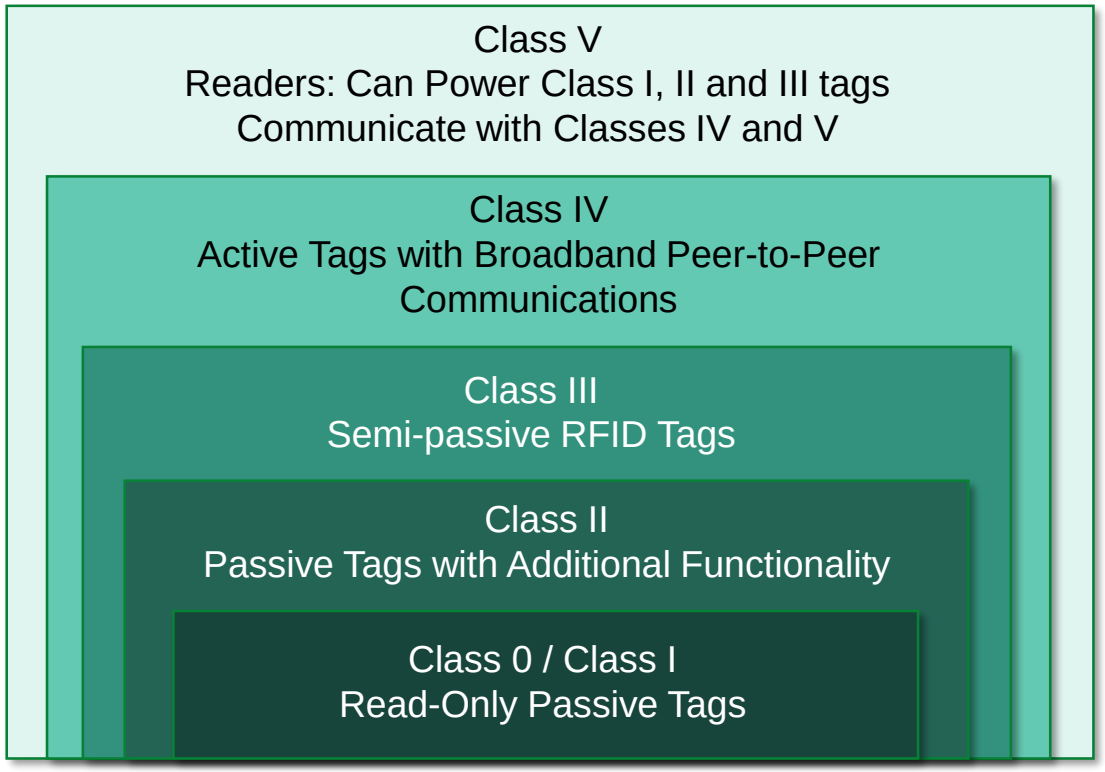
Passive LF market data segments – 10 year forecast
Livestock and pets
Access control
Vehicle immobilizers
Medical
People
Other

Introduction

RFID Market (Source: BCC Research)

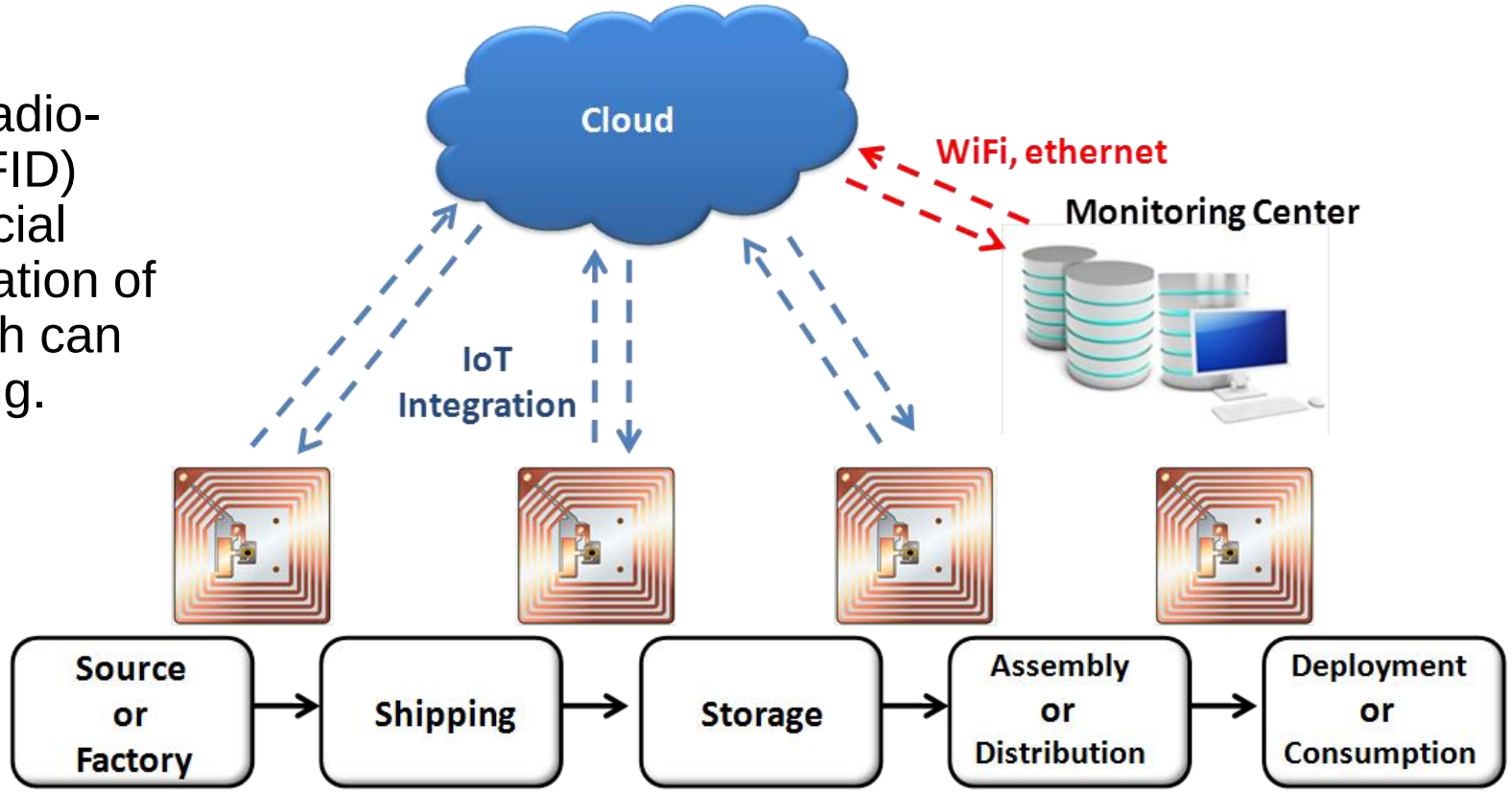
Application	2015	2016	2021	CAGR% 2016-2021
Identification/Security	6.1	7.03	14	15
E-Payment	4.3	5.1	12	19
Materials Handling/ Logistics	1.7	2.2	8	30
Asset Tracking	1	1.1	1.7	11
Military	0.4	0.4	0.5	2
Other	0.4	0.5	1.2	21
Total	**14**	**16**	**38**	**19**





Project Scope

- Combine passive sensors, packaging materials, and radio-frequency identification (RFID) within the existing commercial infrastructure. Direct integration of sensors on RFID tags which can be integral part of packaging.
- **RFID market to reach $40 billion by 2021.**



Motivation - Sustainable Practices

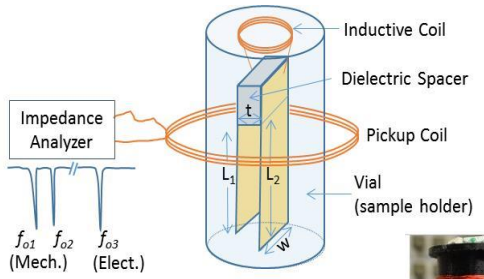
Benefits of sustainable practices in supply chain:

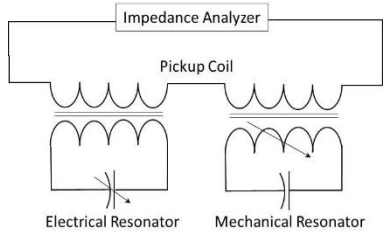
- Promotes global well being and public health.
- Prevents product theft and tampering.
- Prevents adulteration and food fraud.
- Allows real-time monitoring and pricing adjustment
- Prevents product recalls saving billions of $
- Helps reduce food waste
- Compatible with growing area of internet of things (IOT)

Goal: Integration of RFID sensing technology to promote a reliable and tamper-free supply chain with high efficiency and low operational cost.

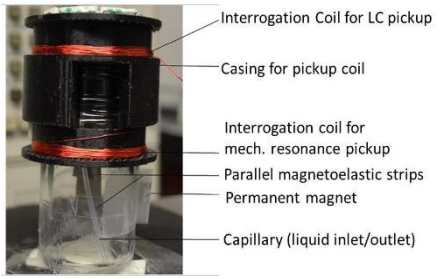
Current Results: A hybrid RFID-compatible magnetoelastic sensor for liquid food adulteration detection (*Example 1*).

- Economically motivated adulteration – direct impact on health
- Supply chain tampering – Lower quality control and loss of reputation

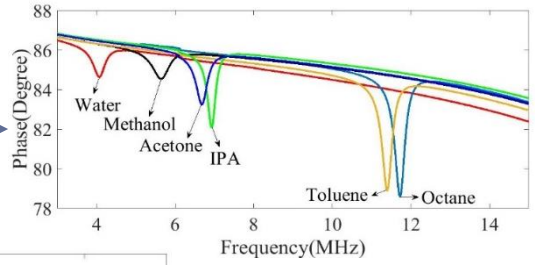


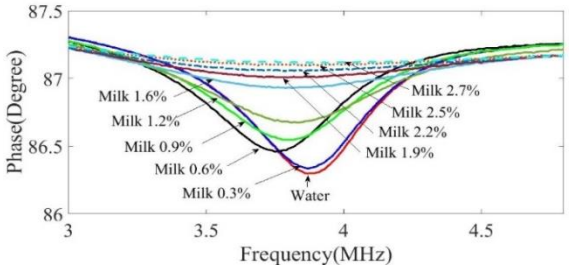


"Smart Cap" sensor

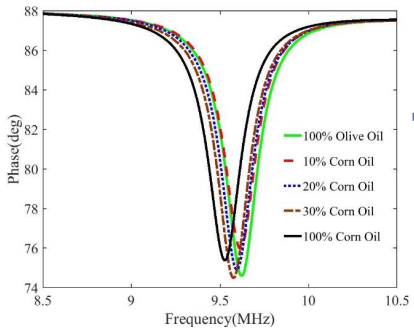


Chemical Sensing



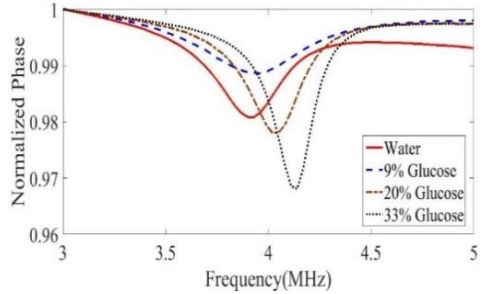


Milk adulteration



Olive oil adulteration

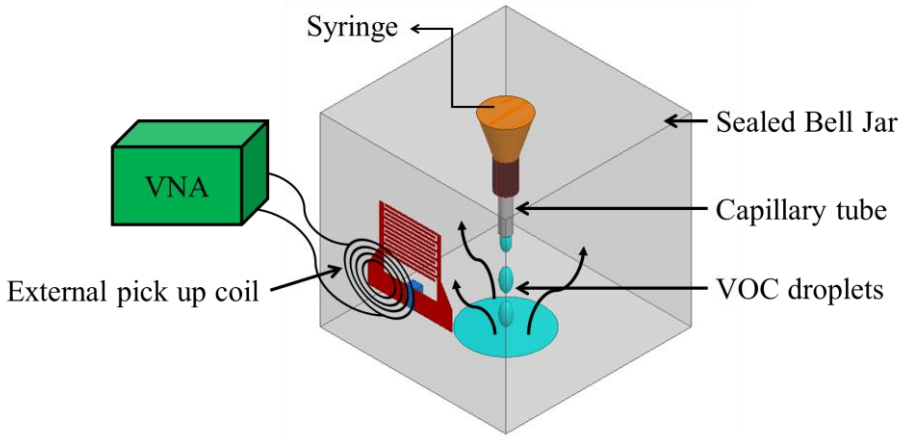
Glucose Sensing

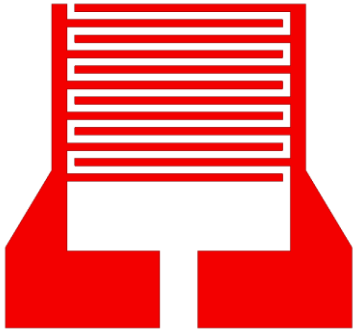


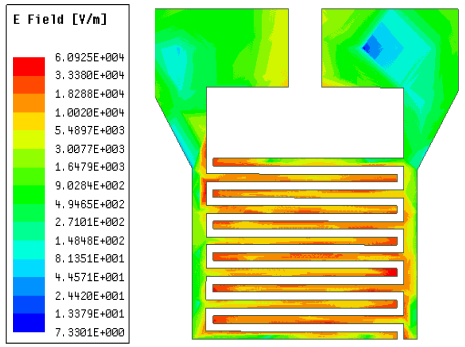
https://thelogicalindian.com/story-feed/awareness/adulterated-milk/
https://www.thedailymeal.com/news/eat/olive-oil-fraud-might-finally-be-regulated-fda-thanks-new-legal-initiative/042616

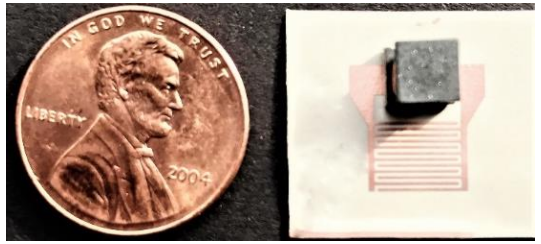
Current Results: Capillary Condensation Based Wireless Volatile Molecular Sensor (*Example 2*)

RFID compatible passive tags for volatile gas sensing

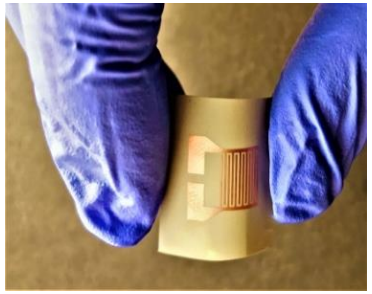


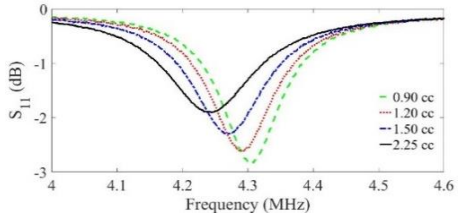


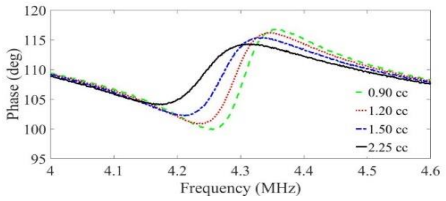


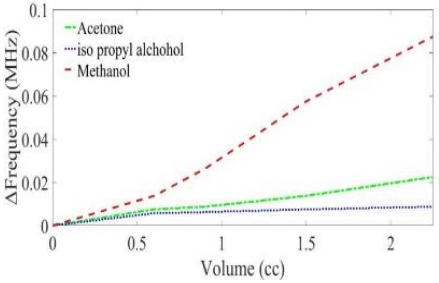


Flexible Gas Sensor



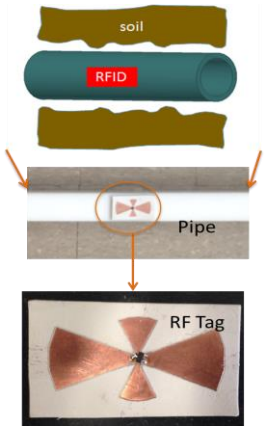


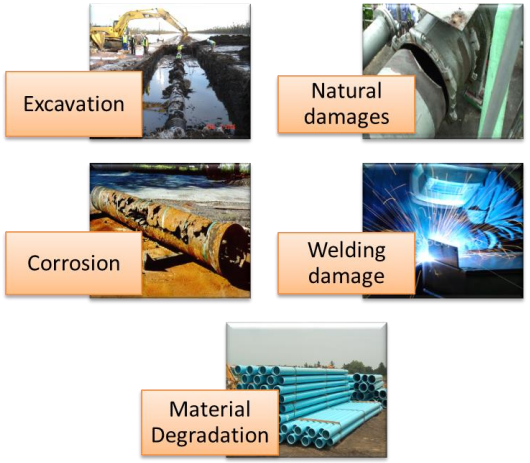




Current Results: RF Tags for Buried Plastic Pipes (*Example 3*).

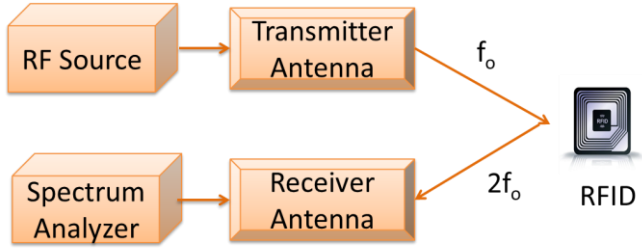
RFID compatible sensor tags as markers for buried pipes (esp. plastic pipes).



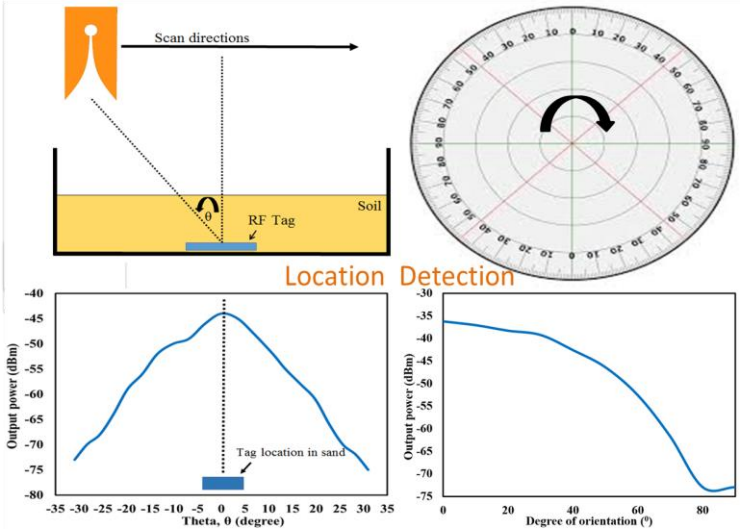


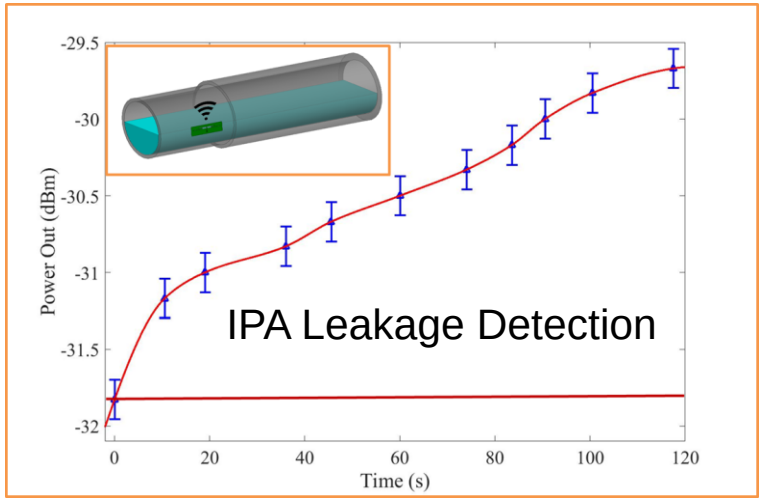
Motivation – Location and Leakage Sensing

- ✓ Potential health issues (Flint Water Crisis)
- ✓ Damage/repair cost
- ✓ Disruption in production
- ✓ Loss of lives (Gas pipeline fire)
- ✓ Damages towards infrastructure



http://www.damagepreventionprofessional.com
http://www.lifeline-eng.com/en/project/domestic
http://www.undergroundsolutions.com/pipeline-repair-methods.php





Current Results: Technologies Demonstrated

Technologies Demonstrated

Safety – Food Supply Chain

- ✓ Adulteration detection
- ✓ SPEL vial – Pathogen detection

Smart Packaging – Integrated wireless sensors

- ✓ Volatile molecular sensors
- ✓ Flexible PET harmonic doubler sensor
- ✓ RF barcodes

Environmental / Safety

- ✓ Chemical identification and spill detection
- ✓ Marker for buried pipes

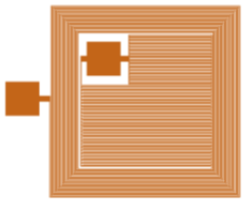
Next: Tags for Smart Packages

Passive RF Tags (batteryless)

- ➢ Near Field (short range)
  - HF: 13.56 MHz
  - W/Chip (IP address)
  - Wo/Chip

Sensors:

- Moisture
- Ammonia
- CO_2
- Ethanol



Planar Structure on Flex Substrate

Future Direction

Large area low-cost manufacturing compatible

- Roll-to-roll process

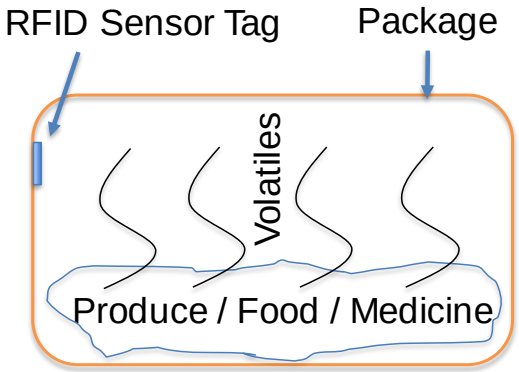
Different size 0

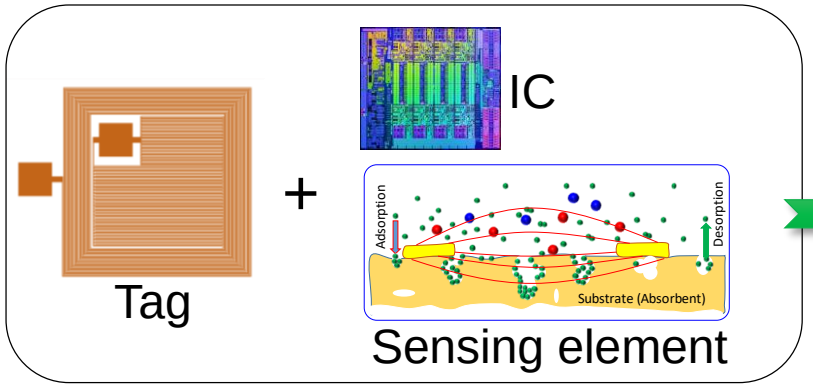
- Small (pharmaceutical and anti-counterfeit)
- Large (food packaging)

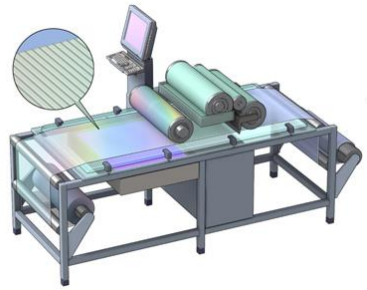
With and without added functions (chip and chipless)

Detect different gases/molecules:

- Ammonia, CO_2, Ethanol, Moisture in packages





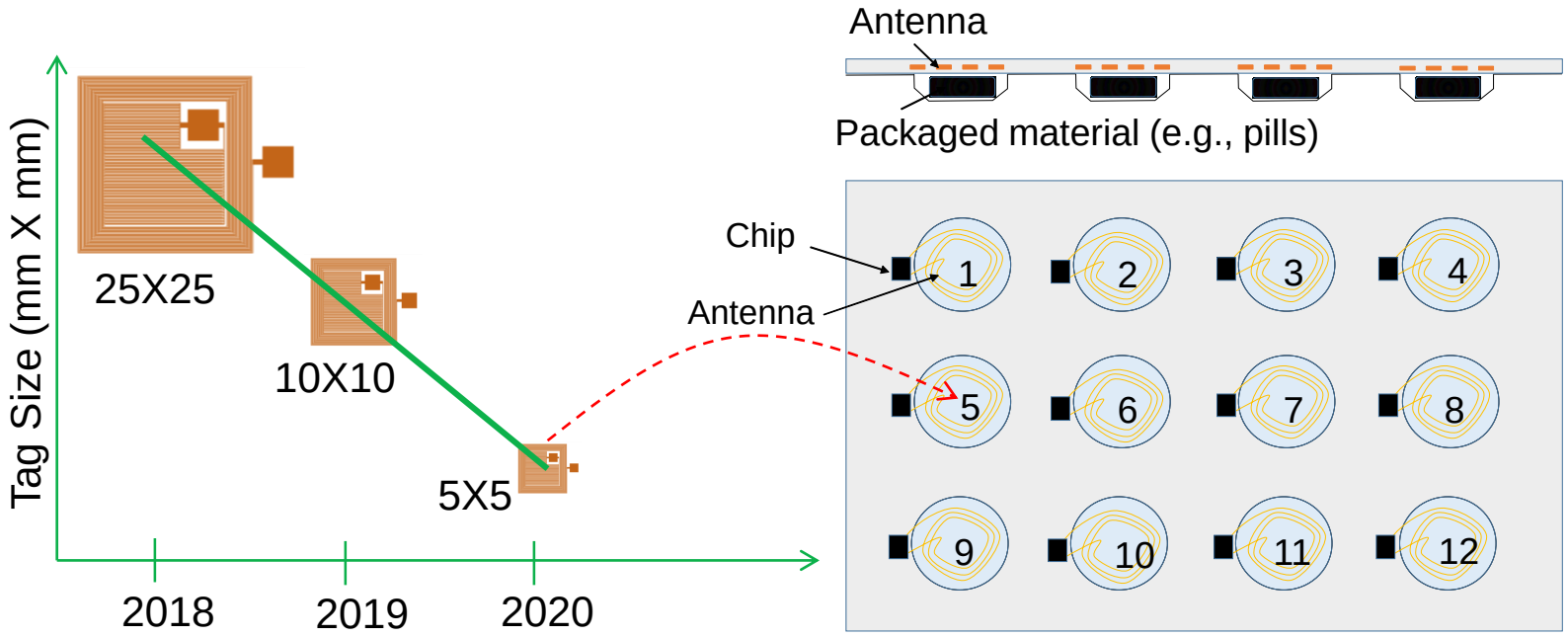


http://www.luminitrd.com/Nanotechnology.html

http://www.dow.com/en-us/packaging

Future Direction

Compact RFID sensors



Integrate RFID sensors directly in packaging materials

- Food and pharmaceuticals

Project Plan

Quarter	Tasks
Q1	• Assess current technologies – a comprehensive review • Demonstrate design and fabrication of different size low-cost RF tags on flex substrates for food and pharmaceutical applications
Q2 – Q3	• Demonstrate coatings to detect different gases/vapors (improve specificity)
Q4	• Optimize sensor designs to detect different gases wirelessly
Q5	• Integrate chip along with sensing elements (provide IP address and memory)
Q6	• Demonstrate integration in food/pharmaceutical packages • Carry out tests using food packages (e.g., detection of fruit spoilage)
Q7	• Optimize design to make it compatible with roll-to-roll manufacturing process (work closely with Co-PI A. Kaur)
Q8	• Redesign readout circuitry • File patent disclosures • Deliver test coupons for demonstration to industry partners • Submit final report

In parallel: 1) Develop an RFID course to be offered at the Center
2) A comprehensive review report on the use of RFIDs for pharmaceuticals

Thank you