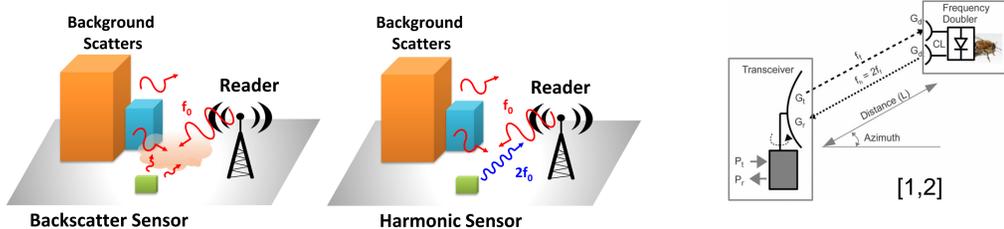


## Introduction: Harmonic IoT Sensors

### ❖ Harmonic Radar/Sensor

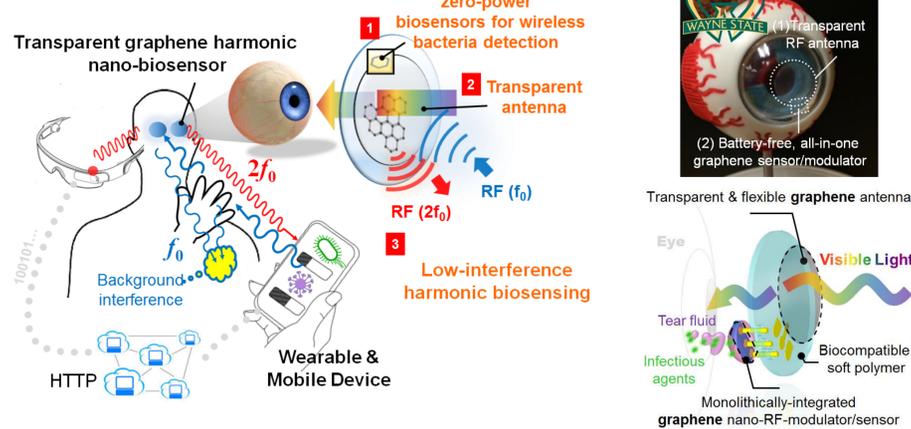


- Higher sensitivity and detectivity: free from unwanted clutter echoes, back-scattered noise and background interference
- Allowing miniaturized sensors and RFID tags

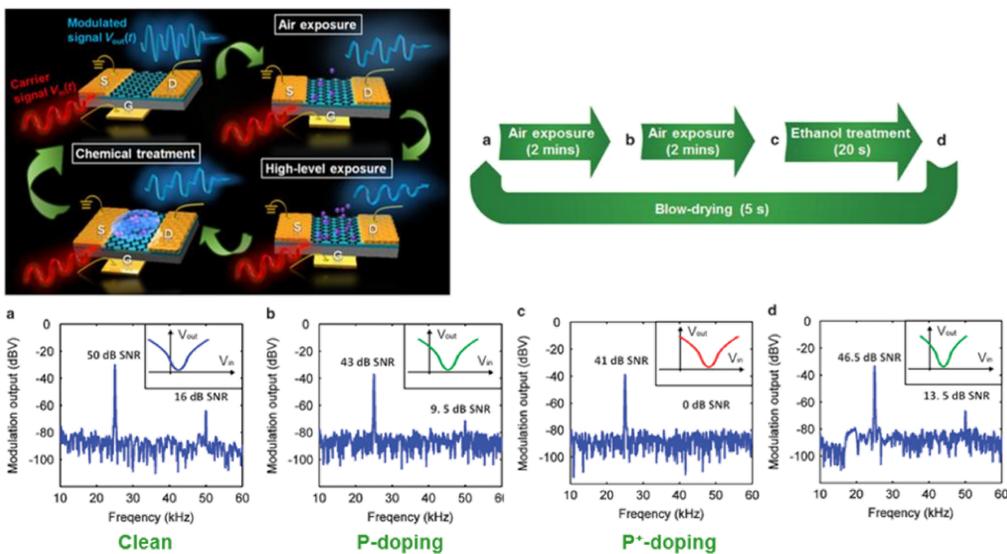
#### Challenges

- Requirement of harmonically-spaced operating frequencies
- Limited information processing due to low-signal dimensionality
- **Integration complexity:** requirement for nonlinear RF element, sensor, and multiple antennas

### ❖ All-graphene harmonic sensor: exceptional sensing & RF mixing functions in a single RF component

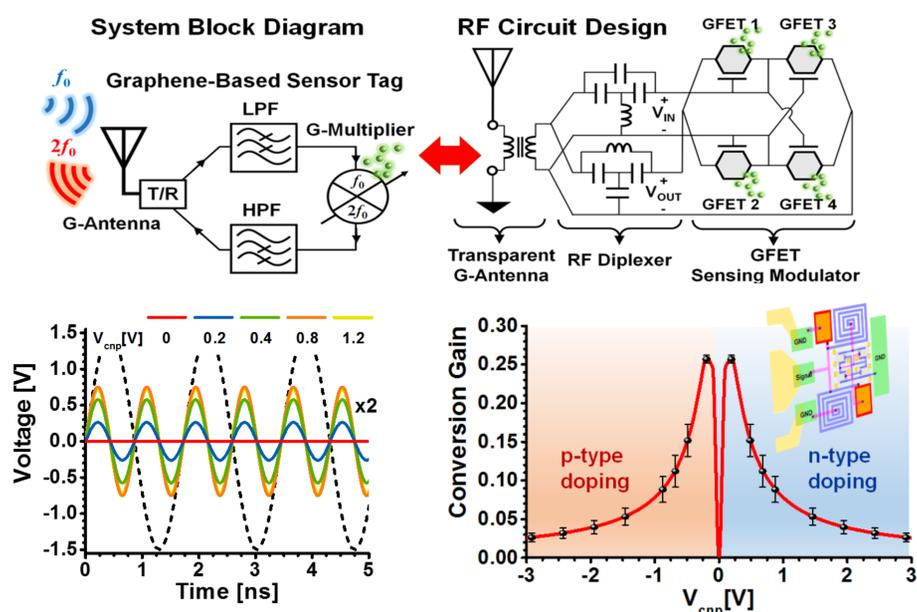


## Graphene-Based Harmonic Sensor

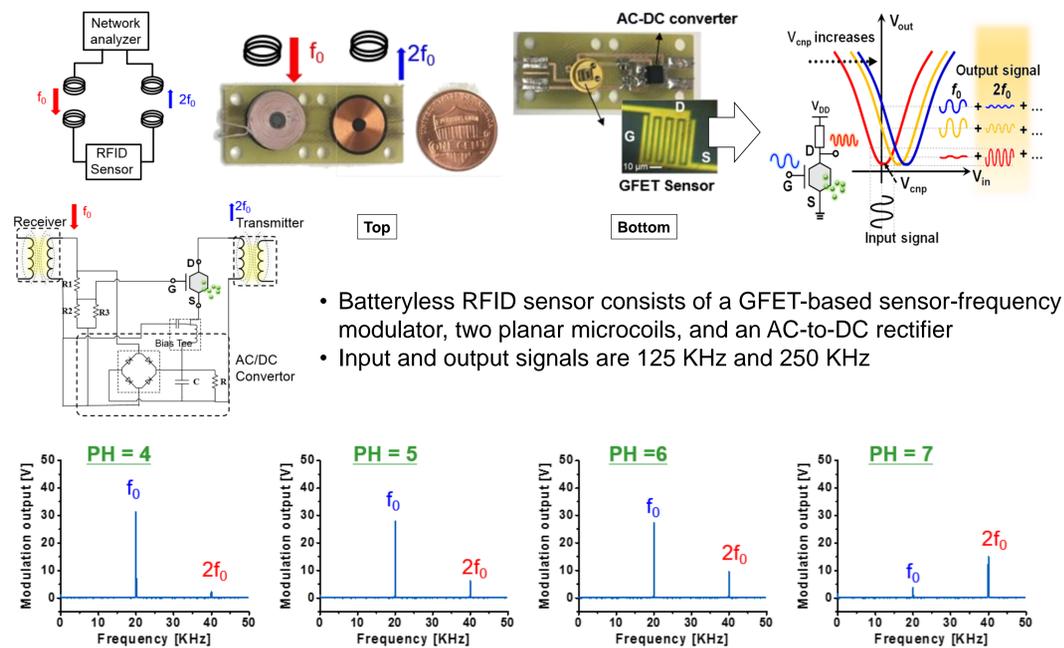


- Unique “V-shape” drain current-gate voltage characteristic (only possible with GFET) [3]
- Cut-off frequency up to 155 GHz [4]
- Molecular-level sensitivity to certain gases, chemical, and bimolecular agents [5-7]

### ❖ Self-Powered, All-Graphene Harmonic Sensor



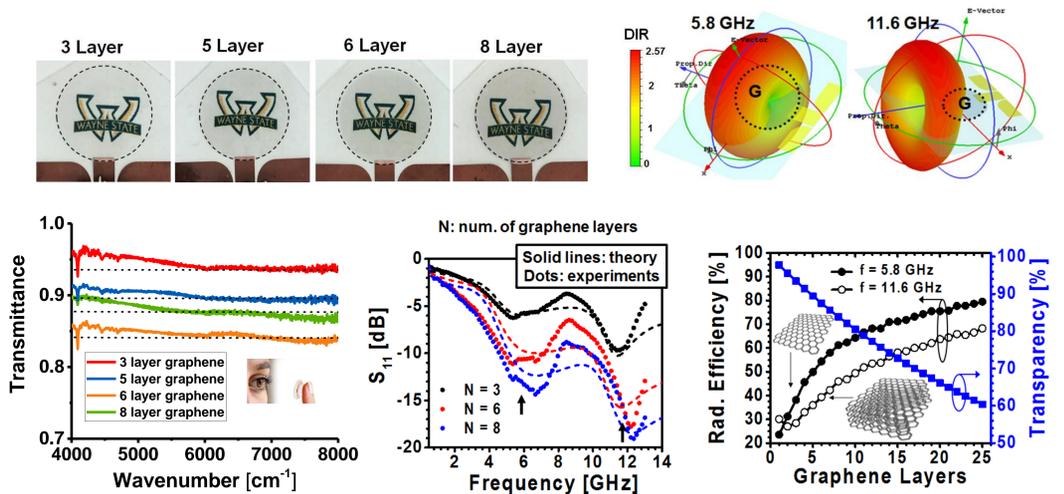
## RFID Sensors for IoT Healthcare



- Batteryless RFID sensor consists of a GFET-based sensor-frequency modulator, two planar microcoils, and an AC-to-DC rectifier
- Input and output signals are 125 KHz and 250 KHz

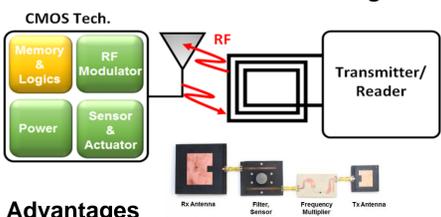
## RFID Sensors for IoT Healthcare

### ❖ Measurement Results



## Conclusions

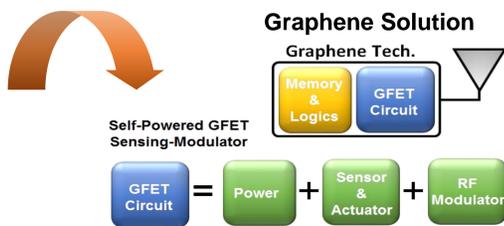
### Conventional Wireless Sensor Tag



#### Advantages

- Battery-free wireless sensing
- Clutter noise free
- Optically transparent
- Flexible
- Light-weight
- High chemical sensitivity
- Integrated on biocompatible PET substrate

### Graphene Solution



### Transparent, flexible, light-weight and self-powered all-graphene IoT sensor

- ❑ Fully-passive, quad-ring frequency multiplier/sensor using graphene field-effect transistors (GFETs)
- ❑ Multilayered graphene makes transparent and broadband monopole antenna
- ❑ Great potential for wireless sensing and non-invasive diagnosis applications, such as smart contact lenses/glasses and microscope slides that require high optical transparency

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