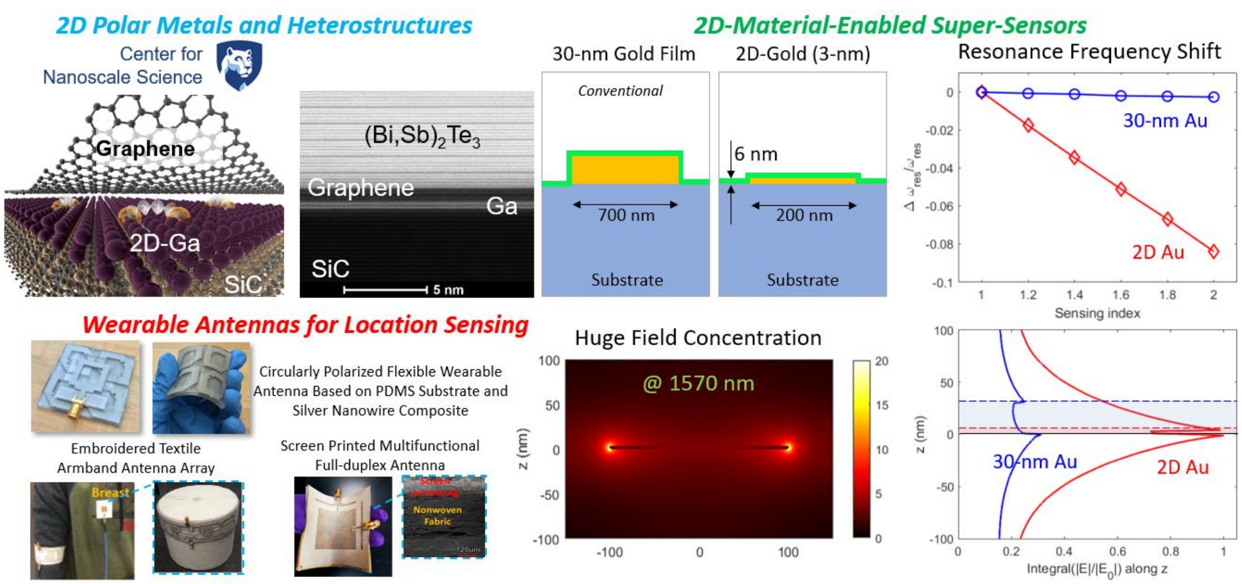
Computational Electromagnetics and Antennas Research Laboratory (CEARL)

The Penn State Computational Electromagnetics and Antennas Research Lab (PSU CEARL: http://cearl.ee.psu.edu) is internationally recognized for pioneering the use of powerful global optimization techniques (many developed in-house) for application-driven antenna, frequency selective surface, and electromagnetic/optical metamaterial-enabled device design. This process is realized by combining our efficient in-house full-wave simulation codes (e.g., Method of Moments (MoM), Finite Element Methods (FEM), Finite Element Boundary Integral (FEBI) methods, Time Domain Integral Equation (TDIE), Finite Difference Time Domain (FDTD) and Discontinuous Galerkin Time Domain (DGTD) techniques) together with robust global optimization procedures (e.g., Genetic Algorithms (GA), Particle Swarm Optimization (PSO), Covariance Matrix Adaptation Evolutionary Strategy (CMA-ES), Ant Colony Optimization (ACO), Wind Driven Optimization (WDO), etc.). Furthermore, PSU-CEARL has a wide range of expertise in the modeling and inverse-design of metamaterial-enabled antennas and sensors (including GPS antennas and location sensors), as well as state-of-the-art computational electromagnetics solver and optimization algorithm development. PSU-CEARL has considerable expertise in RF antenna design for functionalized textiles and on-body networks. We have leveraged custom in-house analytical and numerical electromagnetics solvers, inverse-design and optimization, and deep learning techniques to develop advanced ground-breaking, cutting-edge wearable antenna technologies whose custom designs outperform the available commercial off-the-shelf (COTS) antennas as well as provide new antennas with multifunctional capabilities that currently have no COTS counterparts.



2D-Material-Enabled On-Body Sensors for Garment Integration. The strong plasmons supported by 2D-materials are extremely sensitive to the environment. A combination of wearable antennas and 2D-Polar-Metal based nanostructures can facilitate a smart location/environmental sensing platform with unprecedented sensitivity.

Possessing new quantum optical effects, peculiar dielectric properties, and strong plasmons, two-dimensional (2D) crystals (e.g., 2D Au, Ag, Ga, etc.) are essential for next-generation opto-electronic devices. In particular, photonic metasurfaces based on 2D-metals are extremely sensitive to the environment and represent an excellent platform for a variety of sensing tasks. As an example, we have demonstrated a 2D-Au metasurface refractive index sensor, which shows a sensitivity at least an order of magnitude higher than that observed in conventional plasmonic sensors based on gold films.

Selected Papers Relevant to Proposal

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