QUANTUM TECHNOLOGIES, METAMATERIALS, AND THE FUTURE OF CB SENSING

Tuning Multiferroic van der Waals materials for SWaP Microsensor Applications

Tyler Romig University of Maryland **Efrain Rodriguez** University of Maryland **Ryan Stadel** University of Maryland **Akil Mondie** University of Maryland **Mario Lopez** University of Maryland

Ever since the discovery of graphene, 2D-Van der Waals compounds have been seen by researchers as a family of materials that could allow the feasibility of two-dimensional devices due to the preservation of these materials' bulk properties down to a single layer of atoms. With the utilization of certain properties, such as ferroelectricity and ferromagnetism, a 2D multiferroic device could be made based on magnetoelectric interactions. Furthermore because of the reduction in dimensionality, the size, weight, power requirements for these future devices should be lower than the current state of the art multiferroics that rely on metal oxides, which are 3D materials. Utilizing 2D materials would allow for significant reduction in SWaP enabling chemical and biological microsensors to be realized in the near future. To build this device we have decided to focus on CuInP2S6 and Fe3GaTe2 for the ferroelectric and ferromagnetic components respectively, since these compounds display these attractive properties at room temperature. In this work we have decided to investigate the origins of the ferroelectric behavior in CuInP2S6 and the ferromagnetic property of Fe3GaTe2 for the purpose of tuning these properties for use in multiferroic devices. So far, our preliminary research suggests that the Curie temperature and polarization in CuInP2S6 can be influenced by the displacement and occupancy of the Cu ions as well as through the application of strain on the unit cell. Meanwhile, a delicate change in electron count from Ge to Ga for Fe3GaTe2 increases the Curie temperature when compared to an analogous compound Fe3GeTe2. However, certain substitutions, like in the case of swapping Fe for Ni results in paramagnetic behavior. Additionally, metallic doping is sufficient to influence the coercive field in Fe3GeTe2. Thus, Fe3GeTe2 can be tuned into a harder ferromagnetic. The investigation of 2D materials will enable the shrinking of CB sensors which would otherwise be unobtainable utilizing 3D materials and will serve as a force multiplier for joint CBRN warfighters across the DoD enterprise.

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