Two-Dimensional Polar Metals and Heterostructures

IRG 1 of the Center of Nanoscale Science at Penn State, a MRSEC of the National Science Foundation
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Abstract:

The Interdisciplinary Research Group 1 (IRG1) of the Penn State MRSEC comprises 13 faculty members, students, and postdocs from five departments. Our primary research focus is on investigating novel phenomena in atomically thin polar metals and their heterostructures. We employ a range of growth strategies, characterization techniques, property measurements, and theoretical modeling to advance our understanding. Notably, the confinement heteroepitaxy method has enabled the creation of air-stable 2D metals at the micrometer scale, including Ga, In, Au, Ag, Pb, Bi, and Mn. We achieve phase controllability through careful manipulation of growth parameters and substrate selection. This air stability, coupled with a high aspect ratio, allows us to explore remarkable properties of these 2D metals, such as unconventional superconductivity, strong light-matter interactions, exceptional spintronic characteristics, and catalytic applications. Recent findings include a significant in-plane upper critical field in trilayer Ga superconductor devices, enhanced light-matter interactions and unique nonlinear optical properties in Ag, notable spin splitting in Pb, and the catalytic properties of Ga-intercalated heteroepitaxy micron particles.