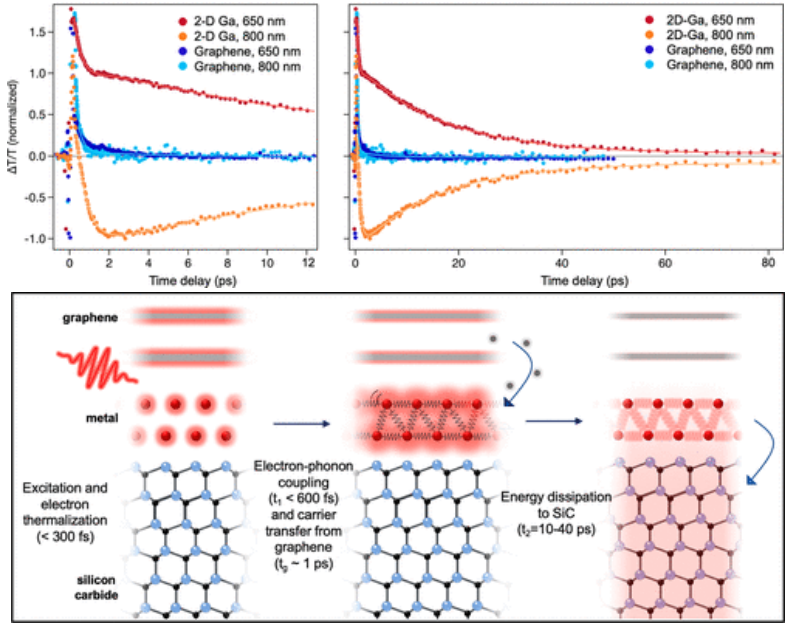
2DCC MIP at Penn State, DMR-1539916
In-House Research - 2022

Atomic-Level Structure Determines Electron–Phonon Scattering Rates in 2-D Polar Metal Heterostructures

Megan A. Steves, Siavash Rajabpour, Ke Wang, Chengye Dong, Wen He, Su Ying Quek, Joshua A. Robinson, and Kenneth L. Knappenberger Jr.

Project Summary: The performance of nanoscale metals in applications such as plasmonics, photodynamic therapy, and photocatalysis is influenced by their ability to absorb and transduce energy to their surroundings. In this study, we measured the non-equilibrium carrier dynamics in an air-stable 2-D polar metal heterostructures. Using transient absorption spectroscopy, the mechanism for energy dissipation was determined to involve contributions from the various components of the heterostructure, including the 2-D metal layer, SiC substrate, and graphene capping layer. The rate of relaxation for these heterostructures is influenced by alloying, with a Ga/In alloy exhibiting an approximately 3-fold increase in electron-phonon coupling rate compared to Ga or In alone. Correlative nonlinear optical microscopy and electron microscopy revealed the presence of atomic-level disorder in alloyed 2-D metals, which influences the energy dissipation rates and excitation of in-plane shear phonon modes. This observation points towards the potential to tune energy transduction through modifications to the metal lattice, which can be monitored through far-field nonlinear optical microscopy. This study was published in *ACS Nano* **15**, 11, 17780 (2021).

2DCC Role: The air-stable 2-D polar metal heterostructures which enabled these studies were synthesized with support from the 2DCC



Wavelength-dependent probing of dynamics with transient absorption spectroscopy (top) reveals contributions of the various components of the 2-D metal heterostructure to the mechanisms of energy dissipation after optical excitation (bottom)