Magnetooptic Studies of Spin Dynamics and Spin Torque in High Spin-Orbit Materials

Roland Kawakami, *The Ohio State University*

Magnetooptics provides a powerful method for imaging spin and magnetization dynamics. Recently, we have employed magnetooptic techniques to investigate the static and dynamic properties of novel materials with high spin-orbit coupling. In our first study, we utilize time-resolved Kerr rotation microscopy to investigate spin dynamics in monolayer WS_2. We observe nanosecond spin lifetimes and a complex spatial dependence of the spin density. Magnetic field and temperature dependence reveals spin dynamics in a spin-orbit stabilized regime, where the large spin-orbit coupling stabilizes spins against external fields and thermal fluctuations. Optical methods are also ideal for investigating spin/valley Hall effect in such materials, which should be rather strong due to utilize magnetooptic Kerr effect (MOKE) to investigate spin-orbit torque in heavy metal/ferromagnet (HM/FM) bilayers. Running a charge current along the HM/FM bilayer produces a transverse spin current and spin-orbit torque on the FM layer. This torque is quantified using MOKE to measure the magnetization as a function of charge current. The interface and bulk contributions to the spin torque are investigated in epitaxially grown structures. Future studies will include time-resolved studies of spin-torque-induced magnetization dynamics.

BIO: Dr. Kawakami is a Professor of Physics at The Ohio State University (OSU) and a Research Physicist at University of California, Riverside (UCR). He was an assistant professor from 2002-2009, associate professor from 2009-2011, and full professor from 2011-2013 at UCR. He moved to OSU in 2013 as a full professor and supervises research at both OSU and UCR. He did post-doctoral research at University of California, Santa Barbara from 1999-2002. His post-doctoral advisors were D. Awschalom and A. Gossard. He received his Ph.D. degree in Physics from University of California, Berkeley in 1999 under advisory of Z. Qiu. Dr. Kawakami is the lead PI of NRI-NSF Nanoelectronics Beyond 2020 project "Developing a graphene spin computer: materials, nano-devices, modeling, and circuits."

His pioneering and innovative contributions include the first demonstration of tunneling spin injection into graphene leading to efficient spin injection and long spin lifetimes; forefront experiments on spin relaxation in graphene ; manipulation of pure spin currents in graphene via scattering by magnetic moments; optical pump-probe spectroscopy of spin dynamics in semiconductors; first demonstration of electric field control of Verwey transition in magnetite films; development of a unique MBE system with in situ magnetotransport measurements to investigate doping effects on spin and charge transport in 2D materials.