Direct Investigation of the Birefringent Optical Properties of Black Phosphorus with Picosecond Interferometry

Wei Zheng
Department of Mechanical Engineering, University of Minnesota, Minneapolis, MN, U.S.A.

Andrei Nemilentsau
Department of Electrical and Computer Engineering, University of Minnesota, Minneapolis, MN, U.S.A.

Dustin Lattery [S]
Department of Mechanical Engineering, University of Minnesota, Minneapolis, MN, U.S.A.

Peipei Wang
Department of Physics, Southern University of Science and Technology, Shenzhen, Guangdong, China

Tony Low
Department of Electrical and Computer Engineering, University of Minnesota, Minneapolis, MN, U.S.A.

Jie Zhu and Xiaojia Wang [C]
Department of Mechanical Engineering, University of Minnesota, Minneapolis, MN, U.S.A.
wang4940@umn.edu

Black phosphorus (BP) is an emerging two-dimensional semiconducting material with great potential for nanoelectronic and nanophotonic applications, especially owing to its unique anisotropic electrical and optical properties. Many theoretical studies have predicted the anisotropic optical properties of BP, but the direct experimental quantification remains challenging. The difficulties stem from the ease of BP's degradation when exposed to air in ambient conditions, and from the indirect nature of conventional approaches that are subject to large measurement uncertainties. This work reports a direct investigation of the birefringent optical constants of micrometer-thick BP samples with picosecond (ps) interferometry, over the wavelength range from 780 to 890 nm. In this ps-interferometry approach, an ultrathin (5 nm) platinum layer is deposited for launching acoustic waves naturally protects the BP flake from degradation. The birefringent optical constants of BP for light polarization along the two primary crystalline orientations, zigzag and armchair, are directly obtained via fitting the attenuated Brillouin scattering signals. A bi-exponential model is further proposed to analyze the BS signals for a random incident light polarization. The BP experimental results and the associated measurement sensitivity analysis demonstrate the reliability and accuracy of the ps-interferometry approach for capturing the polarization-dependent optical properties of birefringent materials.