Dynamics of Surface Plasmon Polaritons Explored Through s-SNOM Fourier Analysis of WS2 Nanophotonic Antennas

Alexander Knight
Xuerong Hu, Alexander Tartakovskii
University of Sheffield, Hicks Building, Hounsfield Road, Sheffield, S3 7RH, United Kingdom
alexander.knight@sheffield.ac.uk

Transition-metal dichalcogenides (TMDs) represent an exciting class of materials with a variety of properties such as high refractive indices, low-dimensionality, and excitonic features that make them highly suitable for research into cutting-edge nanophotonics and twistronics. For example, stacks of TMD material with sub-micron spatial dimensions can act as nanoantennas, interacting with incident light via near-field electromagnetic modes, and presenting a fertile environment for exploring near-field electromagnetism and other nanophotonic effects. Additionally, these TMD nanoantennas are readily able to adhere to many surfaces, allowing for the engineering of hybrid dielectric-gold structures whose properties depend on the TMD material and the geometry of the nanoantennas. Here we study cylindrical WS2 pillars on gold, and show that these nanoantennas can interact with near-field quasiparticles such as surface plasmon polaritons (SPPs) hosted by the gold-air interface. These nanophotonic structures were studied using scattering-type, scanning near-field optical microscopy (s-SNOM) in conjuncture with a tunable laser source, allowing for information to be collected at individual wavelengths across the visible and near-IR spectral ranges. SPP reflection and launching mechanisms were observed from the nanoantennas at these different wavelengths, likely due to the coupling of the Mie modes within the antennas to the SPP modes in the gold-air interface, leading to complicated interference patterns recorded in the s-SNOM data. Utilising a novel Fourier analysis method, we are able to separate out the effects of each individual mechanism from the data, allowing a deeper and more accurate analysis of the polariton properties than commonly achieved. This method has further applications in the s-SNOM study of other polaritons species (such as exciton polaritons and phonon polaritons), and for the research of 2D materials and photonic structures.

Figures

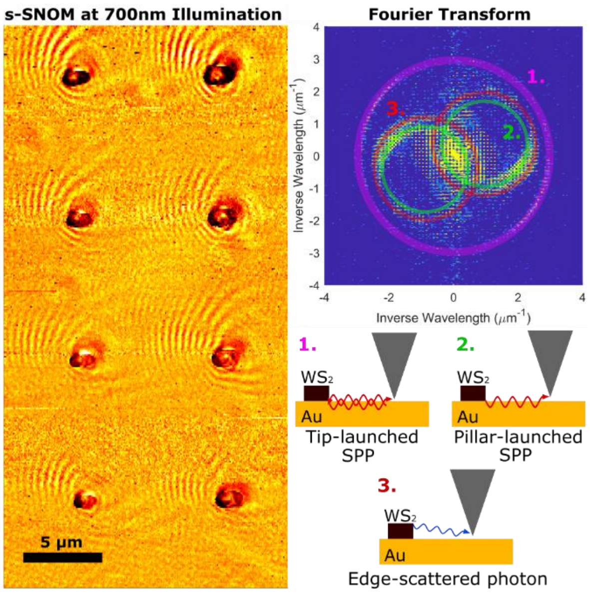

Figure 1: (Left) s-SNOM data taken from WS2 pillars on gold, measured at 700nm illumination. (Top right) 2D Fourier transform of the s-SNOM data, highlighting the different interference patterns observed. (Bottom right) Summary of interference-pattern sources in the data, correlated to the patterns observed in the Fourier transform.