Screening excitonic insulator by liquid metal in proximity

Siwon Lee[1,2], Jaeyoung Kim[2], Chang Il Kwon[1,2], Jun Sung Kim[1,2] and Han Woong Yeom[1,2]

[1] Department of Physics, Pohang University of Science and Technology, Pohang 37673, Republic of Korea

[2] Center for Artificial Low Dimensional Electronic Systems, Institute for Basic Science (IBS), Pohang 37673, Republic of Korea

Email: nature1480@postech.ac.kr

Excitons in semiconductors are extensively utilized in optoelectronics and photovoltaics and the control over their binding energy is important for various applications. On the other hand, coherent quantum states of excitons can be formed in artificial electron-hole bilayers and also as a ground state in rare and exotic materials called an excitonic insulator. Here we demonstrate the systematic control over the excitonic order parameter in a unique excitonic insulator Ta_2NiSe_5. We investigate using angle-resolved photoemission spectroscopy (ARPES) the band structure of Ta_2NiSe_5 during the surface doping by alkali adsorbates. Our polarization-dependent ARPES measurements identify that alkali adsorbates form a liquid metallic layer with its 4s band partially-filled without substantial doping into Ta_2NiSe_5. However, the excitonic band gap decreases systematically upon the increase of the alkali coverage (and the 4*s* band occupation). This result indicates that excitons are well screened by the metallic surface layer in proximity. We call this effect proximity screening, which may be utilized widely for the control over the exciton binding energy in various different materials.

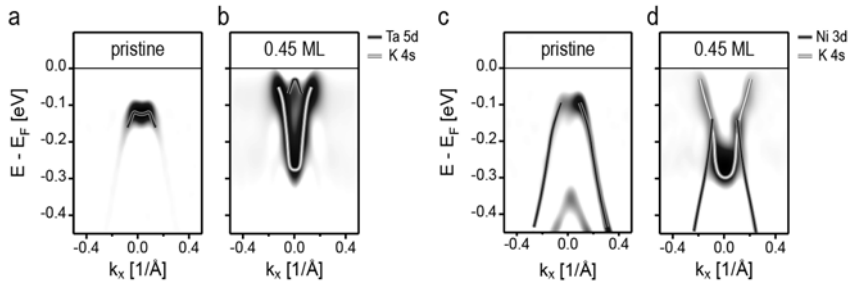

Fig 1. The second derivatives of ARPES data. a-b, vetical polarization data. Ni 3d is invisible. c-d, horizontal polarization data. Ta 5d is invisible. The order parameter is decreased by the liquid K induced proximity screening.