Surface transport properties of metal monolayer films studied by macroscopic and microscopic measurements

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In two dimensional electron systems, a lot of quantum phenomena occur. For example, in two-dimensional superconductor, superconductor-insulator transition is induced by magnetic fields through the breakdown of phase coherence of the superconducting order parameter at T = 0. Moreover, in the vicinity of quantum critical points, an anomalous metallic phase appears. However, most of studies about these properties are performed by macroscopic measurements. Therefore, it is quite important to perform microscopic study using scanning tunneling microscopy.

First, superconductivity of Pb monolayer films formed on Si(111) will be presented. In this system, Our STM study revealed that atomic steps work as disorder and superconducting properties are affected by steps. Especially, we found that superconducting coherence length is suppressed by disorders. Moreover, an anomalous metallic phase is observed in this system. These phenomena are studied by macroscopic surface transport measurements and microscopic scanning tunneling microscopy [1,2].

Second, microscopic study of transport properties of Pb monolayer films formed on Si(111) will be presented. In order to perform microscopic investigation, we have developed scanning tunneling potentiometry (STP) [3,4]. This microscope, which is based on STM, enables us to make images of topograph and electrochemical potential of a sample surface, simultaneously with atomic scale spatial resolution and uV level high potential sensitivity under the current flowing parallel to the sample surface. Although most of STP measurements are performed at room temperature, we have currently developed low temperature STP. I would like to present some results revealed by STP [5].

References:

[1] Oguro, M. Haze et al., Phys. Rev. B 103, 085416 (2021).
[2] Y. Sato, M. Haze et al., Phys. Rev. Lett. 130, 106002 (2023).
[3] M. Hamada and Y. Hasegawa, Jpn. J. Appl. Phys. **51** 125202 (2012).
[4] M. Hamada and Y. Hasegawa, Phys. Rev. B 99, 125402 (2019).
[5] M. Haze, M. Hamada et al., in preparation.