Improvement of OPP-STM for coherent phonon measurement in Bi_2Te_2Se

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In today's semiconductor industry, the density and the speed of the devices are increasing. As it has reached the scale of operation speed ~ GHz and processing size ~ nm, a new measurement method with high temporal resolution and spatial resolution is desired. Our group has developed a technique called Optical Pump Probe STM (OPP-STM), which combines optical pump probe method with temporal resolution of sub picoseconds and STM with spatial resolution at nanometer level. In OPP-STM, a sample is irradiated with laser pulse pairs having a delay time Δt, directly under the STM probe. And the tunnel current change ΔI is measured as a function of the delay time Δt. Since the delay time dependence of the tunnel current reflects the ultrafast process occurring on the sample surface from the excitation by the first pulse to the arrival of the second pulse, the ultrafast process occurring locally in the sample can be observed by this method. Among them, in order to further pursue the interaction between phonon and electrons, we decided to try coherent phonon detection in a topological insulator, Bi_2Te_2Se, by OPP-STM. For the detection, as the coherent phonon signal is so weak, we at first needed to improve the measurement system. So, in this study, we reduced the mechanical vibration caused by the delay time modulator of OPP-STM apparatus and the resulting fluctuation of the spot, by adding compensating vibrator to it. In addition, we coated the tungsten STM tip with gold, to drastically decrease absorption of laser beam by the STM tip. It reduces thermal expansion and shrinkage of STM tip due to beam intensity or spot position fluctuation. For evaluating the improvement, the displacement of the laser spot was measured by combining a micrometer and a photodetector. As a result, the fluctuation of the beam position is greatly reduced. As a result, the S/N ratio in a pump-probe reflectance measurement was improved and coherent phonon signal from Bi_2Te_2Se was clearly observed in the transient reflectance change. (Fig.1.2) Together with the gold coating, noise level of the OPP-STM signal is also greatly reduced. We are now trying coherent phonon detection in Bi_2Te_2Se with the improved system. At the presentation, the detail of the measurement system and results will be shown and discussed.

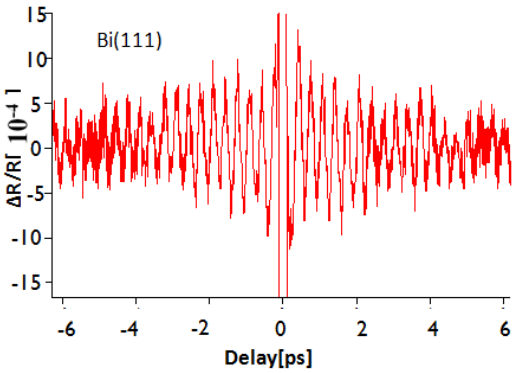

Fig. 1: Pump-probe reflectance of Bi(111)

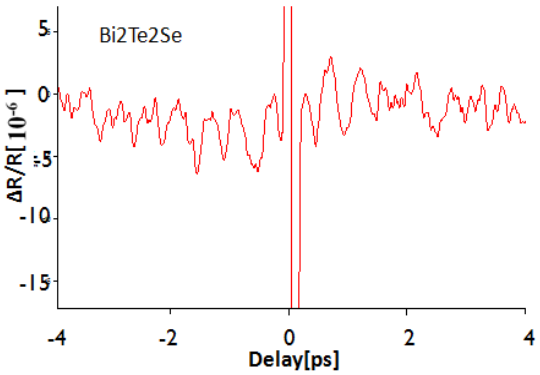

Fig. 2: Pump-probe reflectance of Bi_2Te_2Se