Optical pump-probe scanning tunneling microscopy -present and future-

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Since the invention of scanning tunneling microscopy (STM) in 1982. the addition of high time-resolution to STM has been one of the most challenging issues, and various time-resolved STMs have been considered [1, 2]. The most successful approach among them is to combine STM with electric and optical pump-probe techniques [2-4]. In the optical pump-probe STM (OPP-STM) which we have been developing [3], the sample surface below STM tip is excited by a train of pulse pairs, similarly to the case of the original OPP method, however, instead of measuring, for example, the change in the reflectivity of probe pulses, tunneling current is measured as a function of delay time. There are two ways to probe dynamics. One is the use of absorption bleaching mechanism like the original OPP method. When tunneling current induced by the probe pulse depends on the delay time due to absorption bleaching, the change in the total tunneling current measured by OPP-STM provides the information on the carrier dynamics. With the use of circularly polarized light for excitation and probing, spin dynamics can be detected [5,6]. When tunnel current depends on the change in the material conductivity, like photo-stimulated phase transition, its dynamics also can be probed. A new technique is to use THz pulses. Although it is difficult to apply a high bias voltage between the STM tip and sample in general, the tip-enhanced electric field obtained by ultrashort THz pulse enables it, and taking a snapshot of ultrafast dynamics becomes possible [7-9]. Control of the carrier envelope phases in pump and probe pulses paves the way for the development of new time-resolved analyses. Details will be discussed at the conference with recent results and the prospects for future researches.

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