Laser-combined STM and probing ultrafast transient dynamics

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"Smaller" and "Faster" are the main concepts in nanoscale science and technology. With the size reduction in structures, the difference in the electronic properties, for example, caused by the structural nonuniformity in each element, has an ever more crucial influence on macroscopic functions. And the direct observation of the characteristics, which provides us with the basis for the macroscopic analysis of the results, is of great importance. Thus, for further advances, a method of exploring the transient dynamics of the local quantum functions in organized small structures is eagerly desired. STM has an excellent spatial resolution on the subangstrom scale. However, since its temporal resolution is limited by the circuit bandwidth (~100 kHz), increasing its potential by, for example, combining its characteristics with those of other techniques has been desired. One of the promising approaches is to control the material conditions, in STM measurement, using the techniques of quantum optics. Ultrashort optical pulse technology has enabled us to observe transient phenomena in the femtosecond range, the optical-monocycle region, which, however, has a drawback of a relatively low spatial resolution due to the electromagnetic wavelength. Therefore, realizing the time-resolved tunneling current measurement in the subpicosecond range by developing STM combined with an ultrashort-pulse laser has been a challenging subject for obtaining the ultimate spatial and temporal resolutions simultaneously. I would like to review our researches and efforts on the laser-combined STM and related techniques we have developed, with some latest results obtained based on them.

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[2] S. Yoshida et al., Phys. Rev. Lett. 98, 026802 (2007).