Externally triggerable optical pump-probe scanning tunneling microscope with time resolution of approximately 70 ps

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The combination of optical pump-probe (OPP) methods with scanning tunneling microscopy (STM) enables us to investigate carrier dynamics with nanoscale spatial resolution for exploring novel functionalities in advanced materials. Such OPP-STM systems, employing the delay-time modulation technique to suppress thermal expansion of the tip due to the change in light intensity, have been applied for studying atomic-scale carrier dynamics on semiconductor surfaces [1, 2]. However, operating the OPP-STM systems requires considerable skills and experience, hindering widespread use of this technique. To overcome this difficulty, a compact tabletop OPP system, in which the timing of laser pulses is electrically controlled by external triggers using the field-programmable gate array (FPGA), has been recently reported but limited in nano-second temporal resolution [3].

In this study, we newly design and construct a compact OPP-STM, aiming not only to realize highly stable measurements but also for easy system implementation and maintenance. Time resolution determined by the laser pulse width, jitter and the trigger pulse jitter is estimated to be about 70 ps. The OPP-STM measurements are conducted on GaAs(110) surface, revealing local carrier dynamics depending on surface structures such as a step edge and a nanoscale defect. The experimental result clearly represents potential capabilities of this technique for a wide range of materials without complicated optical setup.

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References:

[1] Y. Terada *et al.*, Nat. Photonics **4**, 869 (2010).
[2] S. Yoshida *et al.*, Appl. Phys. Express **6**, 032401 (2013).
[3] H. Mogi *et al.*, Appl. Phys. Express **12**, 025005 (2019).

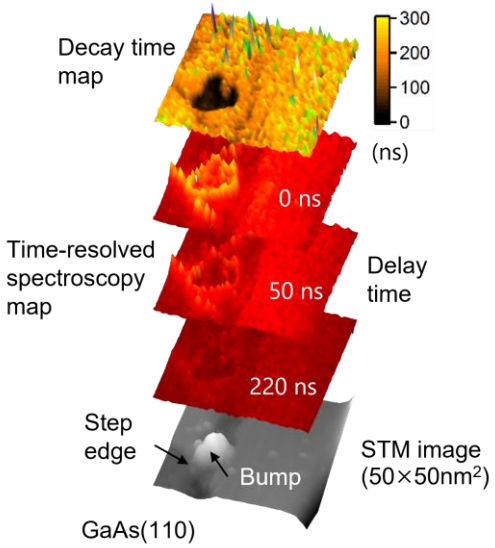

Figure. Time-resolved scanning tunneling spectroscopy of GaAs(110) surface at T= 6 K.