sub-ps Snapshot of Electron Dynamics in an Organic Thin Film Captured by THz-STM

S. Yoshida[1], Y. Arashida[1], H. Hirori[2], T. Tachizaki[3], H. Ueno[1], I. Igarashi[1], Y. Shinomiya[1], O.Takeuchi, and H. Shigekawa

[1] Division of Applied Physics, Faculty of Pure and Applied Sciences, University of Tsukuba.

[2]Institute for Chemical Research, Kyoto University

[3]Department of Optical and Imaging Science and Technology, Tokai University

http://dora.bk.tsukuba.ac.jp/

Atomic scale surface local structure such as steps, dangling bonds, and defects often act as electron traps due to their localized electronic state. However, electron trapping dynamics in an individual electron trap has never been observed due to a lack of time resolution in atomic resolution microscopy. Recently, THz-STM has attracted much attention as a novel technique to probe ultrafast dynamics of photo-induced phenomena with atomic scale spatial resolution[1-3]. Free space coupling of THz pulses to STM tunneling junction induces sub-ps transient voltage (V_{THz}) across the junction, which drives ultrafast tunneling current. In this study, we have utilized THz driven ultrafast tunneling current (I_{THz}) to capture the sub-ps snapshot of free electrons in C_{60} thin film with atomic spatial resolution. Fig.**a** shows the experimental setup. Excess electrons in C_{60} thin film were optically injected by IR pump pulse from Au(111) surface as illustrated in the band diagram (Fig.**b**.), then we probed spatial distribution of injected electrons in the thin film by mapping I_{THz}. Left top image of Fig.**c** shows topographic STM image of C_{60}/Au(111) surface (average C_{60} thickness ~ 4 ML) and the other shows corresponding I_{THz} map taken with fixed delay time between pump IR pulse and THz pulse. Since the negative charge of injected electrons transiently modulate tunneling conductance, I_{THz} map shown in Fig.c represent of excess electron snapshot of 2 ps ~ 49 ps after optical injection. These snapshots show electron accumulation occurred around the step edge and a defect indicated by the white arrow. The result represents a significant impact of atomic scale local surface structure on electron dynamics.

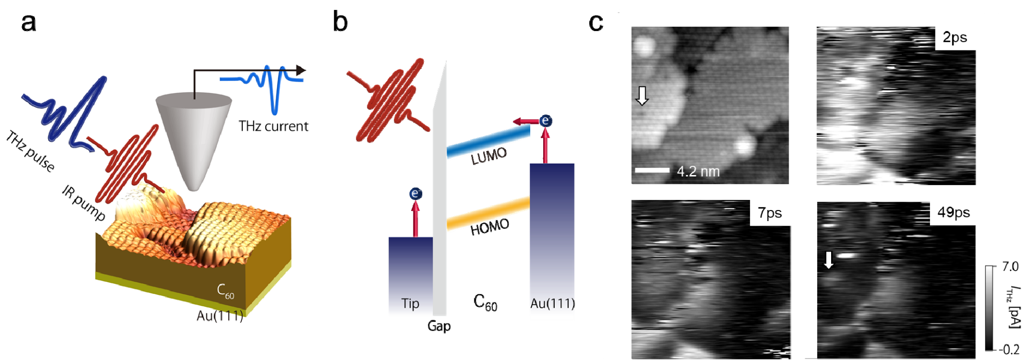

Figure. **a**. Illustration of experimental setup **b**. band diagram of STM tunneling junction under pulse excitation **c**. STM image of C_{60}/Au(111) surface and corresponding I_{THz} map taken with fixed delay time (2 ps, 7 ps, 49 ps)

[1] T. L. Cocker, et al., Nature photonics, 7, 620–625 (2013)

[2] T. L. Cocker, et al., Nature, 539, 263–267 (2016)

[3] S. Yoshida, et al., ACS photon, 6, 1356-1364 (2019)