Charge dynamics at semiconductor surfaces

investigated by time resolved Scanning Tunneling Microscopy

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The combination of Scanning Tunneling Microscopy (STM) and optical excitation merges two successful experimental techniques in solid-state physics [1]. The combination of optical pump-probe techniques with Scanning Tunneling Microscopy (STM) enables us to get atomic resolution of an STM with time resolution on the ns time scale, i.e. well beyond the bandwidth of the current amplifier. This approach provides the prospect to resolve surface dynamics on the atomic scale. More specifically, optical excitation and Scanning Tunneling Microscopy (STM) is discussed to study the carrier dynamics at the GaAs(110) surface. By illuminating the tunnel contact between a tip and an n-doped GaAs crystal we generate electron-hole pairs, which will be separated in the tip-induced space charge region (SCR). A detailed spectroscopic analysis [2] shows that photo-excited charge carriers, trapped in a very local region beneath the STM tip, contribute to the tunneling current. By adjusting the current in a controlled manner we are able to actively access different screening conditions of the electric potential at the surface. Studying the time evolution of the photo-induced tunnel current gives access to the charge dynamics. We discuss different processes determining the relaxation characteristic of the excited system. By using the lateral resolution of the STM, the influence of single dopants on the relaxation dynamics of the system is investigated [3]. We discuss the impact of these defects in terms of their depth dependent binding energy [4].

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[1] Terada et al., Nature Photonics, 4(12), 2010.

[2] Kloth et al., Nat. Comm. **7** 10108 (2016)

[3] Kloth et al., Science Advances **3** e1601552 (2017)

[4] Teichmann et al., Phys. Rev. Lett. **102** 166101 (2009)