Ultrafast generation and decay of a surface metal

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Band bending at semiconductor surfaces or interfaces plays a pivotal role in technology, ranging from p-n junctions in solar cells to field effect transistors. Remarkably, the control of band bending via chemical doping or electric fields can create metallic two-dimensional electron gases (2DEGs) with properties not found in the bulk semiconductor, such as high electron mobility, magnetism or superconductivity. The creation of such surface metal on femtosecond timescales would be a fertile ground for the development of ultrafast electronics. Here[1], we demonstrate the ultrafast (20 fs) generation of a metal at the (10-10) surface of ZnO, a widely used semiconductor in optoelectronics due to its transparency for visible light and its ease of nanostructuring. Compared to hitherto known ultrafast photoinduced semiconductor-to-metal transitions (SMT) in inorganic semiconductors, this SMT can be launched by three to four orders of magnitude lower photon fluxes; also, the back-transition to the semiconducting state is at least one order of magnitude faster than in previous studies. Using time- and angle-resolved photoelectron spectroscopy, we unveil that the mechanism is based on downward surface band bending by photodepletion of deep surface defects. This charges the surface positively and leads to an electron population of the conduction band, in close analogy to chemical doping of ZnO surfaces. We confirm the generation of the surface metal up to near room temperature. The discovered mechanism is not material-specific and could also be realized in other semiconductors.

[1] Lukas Gierster, Sesha Vempati, and Julia Stähler, *Ultrafast generation and decay of a surface metal*, submitted (2020)

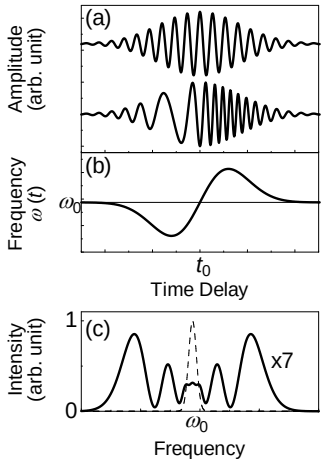

Figure 1: (a) Electric field of a funda mental pulse (upper) and a chirped pulse (lower), **(b)** Temporal change in the frequency of the chirped pulse, **(c)** Spectrum of the chirped pulse.

References:

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