Lateral Engineering of Surface States: Towards Surface State Nanoelectronics

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The search for information carriers that can be manipulated faster, and consequently at smaller scales, is rapidly evolving from electrons and microelectronics towards photons and photonics. The latter can couple to collective excitations on metallic surfaces known as plasmons that are controllable by surface features on the scale of the wavelength, typically in the order of a fraction of the micron. Electronic surface states on metal surfaces share some of the advantages of plasmons, while their in-plane wavelength is of the order of a few nanometers and their expected response time is faster than the femtosecond. Furthermore, by analogy to plasmonics, we can prove the concept of surface-state nanoelectronics, where the flow of signal carriers (surface states) can be molded by structures such as steps and nanostructure arrays.

Our experimental approach utilizes Au(111), Ag(111), and Cu(111) vicinal surfaces with different step size, as well as tunable two-dimensional, hexagonal arrays of misfit dislocations networks on noble metal surfaces. They all exhibit Shockley-type surface states with a Fermi wavelength similar to the nanostructure lattice constant. The free-electron like band is thus modified close to the Fermi energy, allowing low energy excitations near superlattice band extrema and gap edges. Therefore, exotic phenomena, such as surface electron focusing and total reflection is possible for long-lived excitations, which are in turn needed to exploit the concept of surface state nanoelectronics.