Ultrafast electron diffusion in ultrathin crystalline silver films

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Conventional thin film deposition methods, such as sputtering, lead to a polycrystalline structure and need a minimal thickness of several nanometers to achieve a continuous film. Recently, an epitaxial growth method was employed to create few-atomic-layer thin monocrystalline metal layers (<100 atomic layers) [1,2]. These films have quantized electronic energy states [3], which could alter their transport properties.
To understand the influence of the band quantization on the electron transport dynamics, we used a home-made pump-probe spatiotemporal microscopy setup [4,5,6] to track the electronic diffusion in monocrystalline silver films with a thickness ranging from 12 to 30 atomic layers [1]. These measurements revealed an extremely high diffusivity of a few thousand cm^2/s. This is an order of magnitude larger than expected from literature values of the mobility, and approaches diffusivity values found in graphene [7]. We investigate this behavior by comparing thickness-dependent measurements in crystalline films to similar ones performed on polycrystalline silver and density functional theory calculations.
Our results show that atomically thin crystalline metals provide a suitable platform for the investigation of the role of disorder and dimensionality in electron scattering mechanisms, as well as their effect on inelastic optical losses for application in low-loss and tunable plasmonics [1,8].

References

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