We report on the recent progress in the theoretical understanding of the optical properties of quasi-2D plasmonic nanostructures (metasurfaces and films) of controlled finite thickness (see Fig.1). While being constant for relatively thick films, the plasma frequency of ultrathin plasmonic films (a) acquires the spatial dispersion typical of 2D materials (b), gradually shifting to the red with the film thickness reduction [1]. This explains recent experiments (c) done on ultrathin TiN films of controlled variable thickness [2]. The confinement induced plasma frequency spatial dispersion and associated dielectric response nonlocality can result in the new features of the magneto-optical response of the film [3]. Specifically, the magnetic permeability exhibits a sharp resonance structure shifting to the red as the film aspect ratio increases. When tuned appropriately, the ultrathin films of finite lateral size can be negatively refractive in the IR frequency range. Compared to the thick film a dipole emitter near the ultrathin film shows a two-order-of-magnitude radiative decay rate enhancement (d) with inelastic electron scattering diminishing the effect, which can be understood in terms of the interacting image dipoles (a). We show that the overall light-matter interaction in close proximity to plasmonic films can be controlled not only by varying the chemical composition and material quality of the film but also by adjusting its thickness and aspect ratio as well as by choosing the deposition substrates and coating layers appropriately. We believe our findings open up entirely new avenues for potential applications of ultrathin plasmonic films in modern optoelectronics.

Figure 1. (a) Confined geometry for thick and ultrathin plasmonic films with oriented point dipole emitters and their images. (b) Film plasma frequency relative to the bulk plasma frequency as a function of in-plane plasmon wave vector $k$, thickness $d$ and permittivity ratio $(\varepsilon_1+\varepsilon_2)/\varepsilon$ as shown in (a). (c) Ellipsometry data for plasma frequency of TiN films (inset) of varied thickness. (d) Orientation averaged dipole spontaneous decay rate ratio as a function of distance from the surface $z_A$ obtained with medium-assisted QED for system in (a). Plasmon relaxation rates $\gamma$ and thicknesses are shown on the graph.

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