Excitation of asymmetric surface plasmons based on EIT dark mode coupling

With the support by the National Natural Science Foundation of China, the Terahertz Photonics Team led by Prof. Han Jiaguang (韩家广) and Prof. Zhang Weili (张伟力) at the College of Precision Instrument and Optoelectronics Engineering, and the Key Laboratory of Optoelectronics Information and Technology (Ministry of Education), Tianjin University, proposed a new method to excite asymmetric surface plasmons (SPs) using electromagnetically-induced-transparency (EIT) coupling mechanism, which was published in *Science Advances* (2016, 2: e1501142).

Control over SPs is quite essential in a variety of cutting-edge applications. In recent years, asymmetric excitation of SPs has drawn enormous interest. Various excitation methods have been reported. However, they mainly relied on the far-field SP interference effect. The coupling effects among the excitation units were usually excluded or minimized. In this work, by introducing the classic EIT mode coupling mechanism of free-space metamaterials into SP regime, a new degree of freedom in controlling the SP excitation is achieved, showing that coupling effects could also be very important in exciting SPs.

The proposed excitation unit contains two SP excitation resonators, one bar-shape slit resonator and one split-ring slit resonator, denoted as bright and dark resonators, respectively. The bright resonator is accessible to the incident beam and can excite SPs symmetrically towards $\pm x$ directions; while the dark resonator is not accessible to the incident beam and cannot excite SPs. When putting these two resonators together, the bright resonator will excite the dark resonator which will then excite new SPs towards $\pm y$ directions. In this process, part of the resonating energy of the bright resonator is transferred to the dark resonator, leading to the asymmetric SP excitation behavior. The asymmetric level of the excited SP distribution is strongly related to the coupling strength of the two resonators. By properly designing the distribution of the proposed units, such a method could also be used to control the SP focusing behaviors. This work is well demonstrated at terahertz frequencies with the help of terahertz time-domain near-field scanning technology. The unique property of this controlling strategy delivers a versatile platform for various applications in asymmetric SP excitations plasmonic circuitry and energy harvesting.

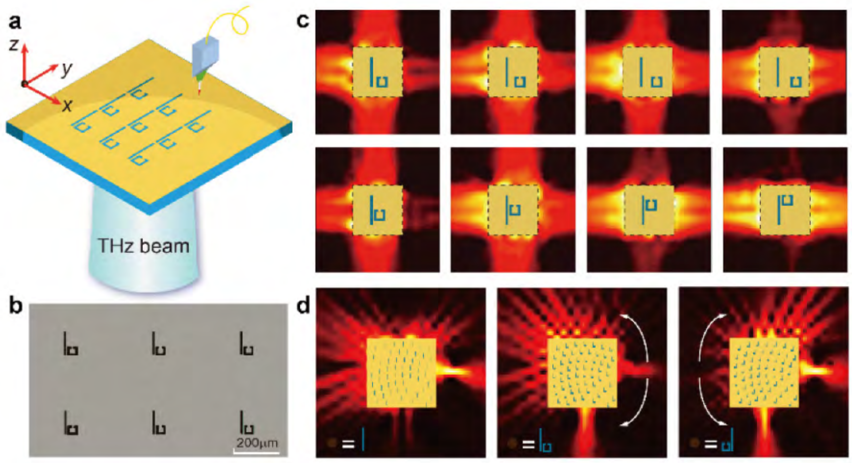

Figure a, Experimental diagram. b, Part of the sample photo. c and d, Measured SP distributions of the samples for controlling the asymmetric level and the focusing, respectively.