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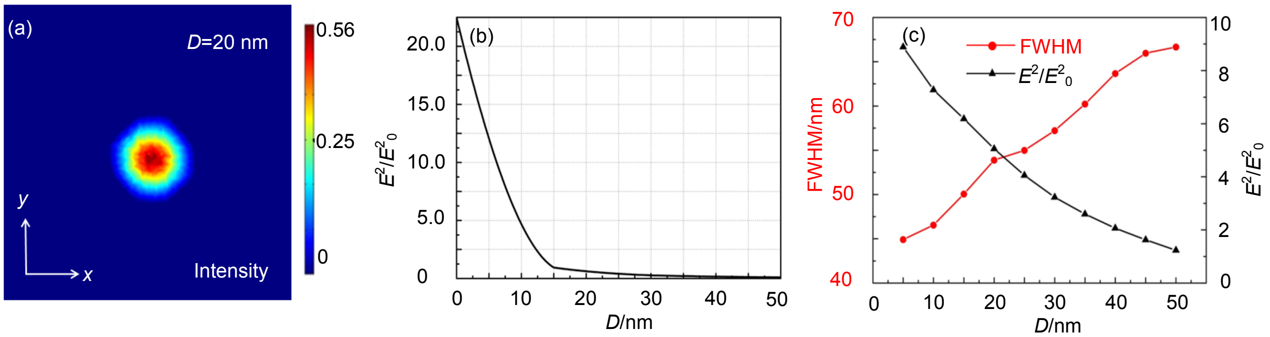
The investigation of focusing characteristic based on double Bowtie nano-lithography structure

Jie Zheng [1], Xianchao Liu [1,2], Yuerong Huang[1], Yunyue Liu[1],
Weidong Chen[1] and Ling Li[1*]

[1]College of Physics and Electronic Engineering, Sichuan Normal University, Chengdu 610101, China;
[2]School of Optoelectronic Information, University of Electronic Science and Technology of China, Chengdu 610054, China



Under the double bowtie structure. (a) the focusing spot profile diagram. (b) the variation of the electric field intensity with working distance (D) and (c) the variation of E^2/E_0^2 and FWHM with working distance (D).

Abstract: The Bowtie aperture structure is widely applied in the realm of nanometer direct-writing lithography for obtaining the focusing spots beyond the diffraction limit. However, the shape of spots obtained is elliptic under the Bowtie structure because the electric field is enhanced and located only in perpendicular to the aperture gap. This characteristic impacts the applications of Bowtie structure. To attain high-resolution and circle-symmetric focusing spots, the double Bowtie structure is proposed. The electric field is enhanced and located in both x and y directions due to the symmetry characteristic of the double Bowtie aperture. The free electrons are accumulated at four tips of the gap of the double Bowtie aperture, which stimulate the localized surface plasmas (LSPs) and develop the double-dipole oscillation mode. This characteristic attributes to obtain circle-symmetry spots and enhance the electric field intensity of transmission light. The simulated results demonstrate that the electric field intensity of transmission light is 22 times than that of incidence. However, the electric field intensity of transmission light decays in the form of exponential with the increasing of the working distance.

The electric field intensity of transmission light decays with exponential perpendicularly to the interface of metal/insulator but still propagates parallel to interface as evanescent wave. The transmission light is coupled into the interface of metal/insulator by this electric field generated by the evanescent wave, and which further stimulates surface plasmas (SPs). The silver, as a common waveguide material, can enhance and magnify the evanescent wave. We combine the double Bowtie structure with metal-insulator-metal structure. Although the electric field intensity still decays with exponential, the electric field intensity attained keeps 1 time as large as that of incidence light when the distance approaches to 50 nm. The propagation distance of light is obviously prolonged which benefits from the characteristic of the transmission enhancement of the upper silver and the characteristic of reflection of the bottom silver.

Therefore, the double Bowtie aperture has an advantage in obtaining high-resolution and circle-symmetry spots. Metal/insulator/metal structure combined with the double Bowtie aperture further attributes to prolong the transmission distance of light. This advantage facilitates the applications of Bowtie structure in nanometer direct-writing lithography technology.

Keywords: Bowtie aperture structure; nanometer direct-writing lithography; electricity enhanced characteristic; metal-insulator-metal structure

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