OPTICAL NEAR FIELD AND PLASMONICS

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Abstract

Plasmonics have known a very important development due to particular properties of plasmons such as : field confinement , field amplification and resonance phenomenon. Optical near field microscopies can be used for probing or modifying plasmons.
In this article we will present results obtained on plasmons characterization by using Optical Near Field microscopies.

During last years , some work has been done to observe and characterize plasmonic excitation [1-9]. For the first time the Dawson paper demonstrated the plasmon propagation at resonance.

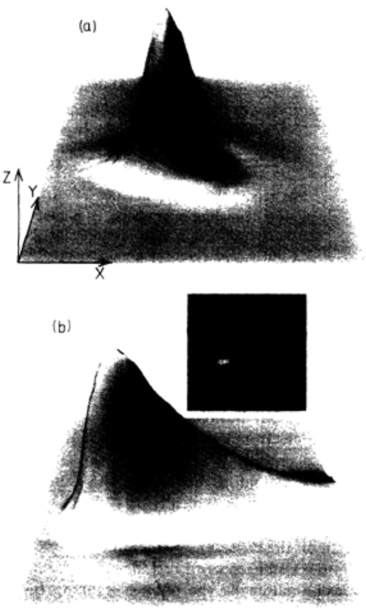

Fig. 1a) Image of evanescent field intensity measured with a SNOM on a bare prism at greater than critical angle of incidence; b) SNOM image of the near field of the plasmon excited at the interface gold air of a 53nm Au thin film. The exponentially decaying tail is due to surface plasmon propagation and attenuation; Scan ranges are 40µmx40µm [2].

Controling the generation of surface plasmons is of great interest. We will give results on excitation of plasmons by an edge or by periodical tiny holes as shown by the famous work of Ebbesen, see fig. 2.

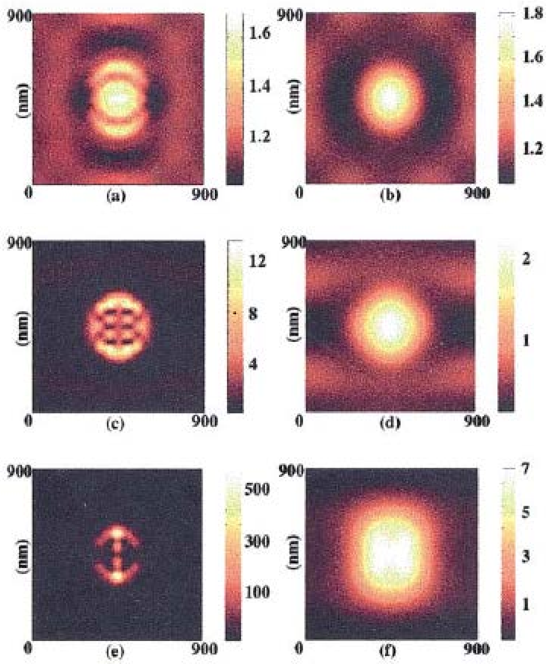

Fig. 2 : Distribution of the calculated transmitted light intensity over a hole for (a),(b) 330nm, (c), (d) 800nm and (e), (f) 1420nm wavelengths at distances of (a),(c),(f) 15nm and (b),(d), (f) 100nm above the surface. Hole diameter is 300nm, lattice period is 900nmPolarization of incident light in vertical, the color scale is the same for all images [4]

The distribution of light inside the holes is due to the different directions of surface plasmons. Another way to control plasmon propagation is to use gratings to generate Cosine –Gauss beam. The cosine-Gauss beam does not diffract while it propagates in a straight line and tightly bound to the metallic surface for distances up to 80 µm. The generation of this highly localized wave is shown to be straightforward and highly controllable, with varying degrees of transverse confinement and directionality, by fabricating a plasmon launcher consisting of intersecting metallic gratings. Cosine-Gauss beams have potential for applications in plasmonics, notably for efficient coupling to nanophotonic devices, opening up new design possibilities for next-generation optical interconnects. They have been characterized by SNOM as shown on fig.3

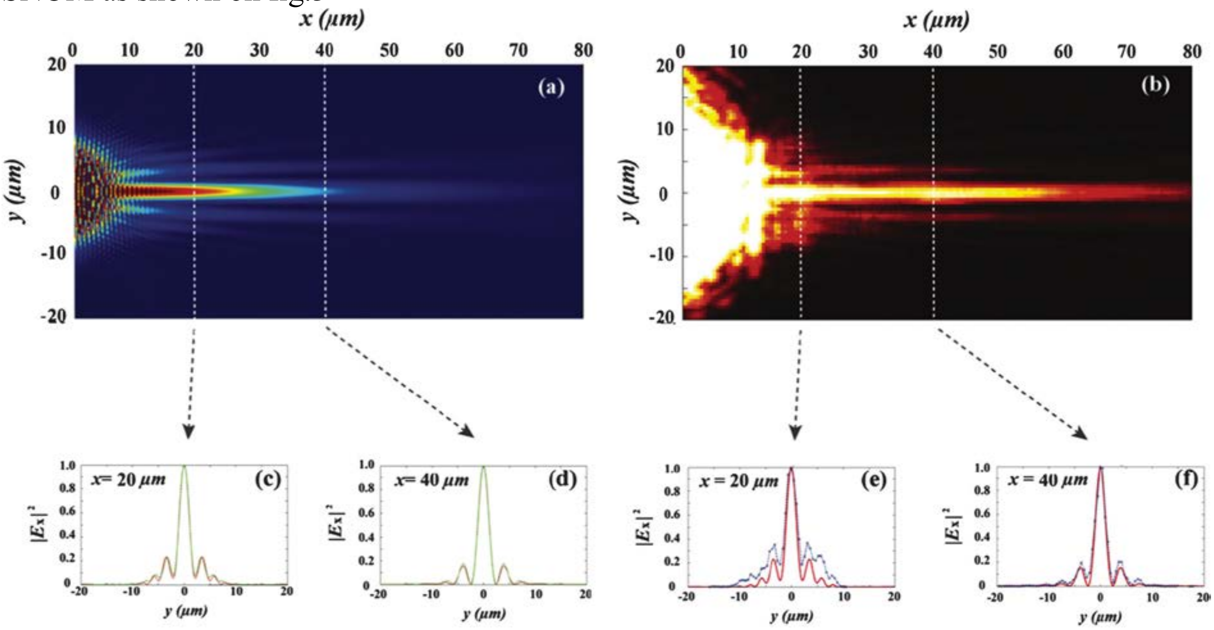

Fig. 3 The LCGB generated by two gratings at an angle as shown in Fig. 1(d). The near-field intensity distributions (in-plane components) obtained (a) by using FDTD simulations and (b) experimentally with an NSOM. (c)–(f) Transverse intensity distributions at specific

propagation distances [green curve, analytical calculations; red curve, simulations by FDTD; blue curve, intensity line scans obtained from the NSOM image (b)[7].

Conclusion

Near field measurement as well as simulations demonstrate clearly the properties of surface plasmon. The confinement of the plasmonic beams and their propagation properties can be controlled by the way of generate them. SNOM has been demonstrated as a powerfull instrument for plamonic study in different configurations.

Acknowledgments
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References

[1**]** P.M. Adam, L. Salomon, F. de Fornel, J.P. Goudonnet: "*Determination of the spatial extension of the surface plasmon field region of a silver film with a Photon Scanning Tunneling Microscope". Physical Review B, **48**, 4, 2680-2683, 1993

[2]Dawson, K.W. Smith, F.de Fornel, J.P. Goudonnet : *"Imaging of surface plasmon launch and propagation using a photon scanning tunneling microscope Ultramicroscopy".* **57**,287-292, 1995.

[3] L. Salomon, F. de Fornel, P. M. Adam, "Analysis of the near-field and the far-field diffracted by a metallized grating at and beyond the plasmon resonance**", Journal of the Optical Society of America A**, 16, 11, 2695-2704, 1999

[4] L. Salomon, F. Grillot, A. V. Zayats, F. de Fornel : « Near-field Distribution of Optical Transmission of Periodic Subwavelength Holes in a Metal Film, **Physical Review Letters**, Vol.86, n° 6,1110-1113 (2001).(article cité dans Science)

[5]L. Salomon, G. Bassou, H. Aourag, J. P. Dufour, F. de Fornel, F. Carcenac, and A. V. Zayats Local excitation of surface plasmon polaritons at discontinuities of a metal film: Theoretical analysis and optical near-field measurements Phys.Rev.B65, 125409,(2002)

[6] D. Brissinger, A. L. Lereu, L. Salomon, T. Charvolin, B. Cluzel, C. Dumas, A. Passian, and F. de Fornel
Discontinuity induced angular distribution of photon plasmon coupling
August 2011 / Vol. 19, No. 18 / OPTICS EXPRESS 17750

[7]Jiao Lin, Jean Dellinger, Patrice Genevet, Benoit Cluzel, Frederique de Fornel, and Federico Capasso, Cosine-Gauss plasmon beam: A localized long-range nondiffracting surface wave, Physical Review Letters 109, 093904 (2012), 5 pages

[8]D. Brissinger, L. Salomon, and F. de Fornel Unguided plasmon-mode resonance in optically excited thin film: exact modal description of Kretschmann–Raether experiment
Vol. 30, No. 2 / February 2013 / J. Opt. Soc. Am. B

[9**]** P. Genevet, J. Dellinger, R. Blanchard, A. She, M. Petit, B. Cluzel, M. A. Kats, F. de Fornel, and F. Capasso
Generation of two-dimensional plasmonic bottle beams
Optics Express 21, 10295 (2013)