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Local light polarisation mapping and electromagnetic field imaging by SNOM

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Abstract. An influence of the incident light polarization on the aperture probe collection SNOM images have been investigated. Great difference between reflection SNOM images obtained at two orthogonal linear polarizations of the incident light have been observed. The SNOM images of domains and domain walls were studied. Three-dimensional light confinement near small hole in thin metallic film have been mapping by SNOM aperture probe.

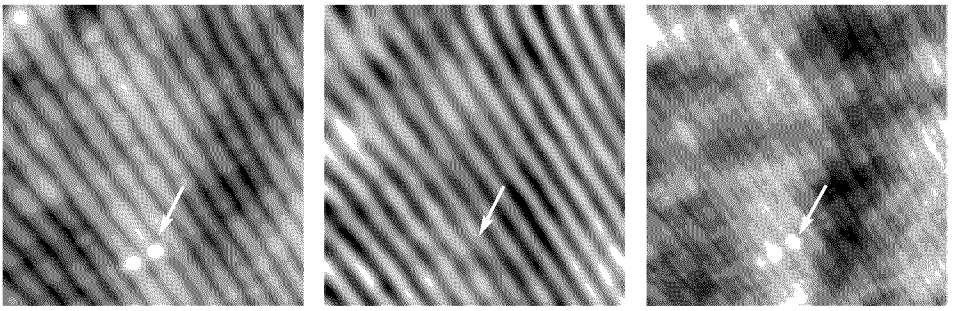
Scanning near-field optical microscopy (SNOM) is rapidly emerging as a powerful tool for studying nanometer-scale phenomena such as optical properties of submicro- and nanostructures [1, 2]. Wide ranging of SNOM application demands to apply different modes of SNOM operation with different optical image formation mechanisms. This situation induces the great interest on the field of the physical principles of SNOM operation. Most popular aperture type SNOM is based on metallized sharpened optical fiber probe witch may used both as nanosource or as nanodetector. The possibilities and limitations of SNOM with aperture type probe used as local electromagnetic field detector were the aim of presented work.

The experimental device was described previously [3, 4]. It is module type scanning probe microscope witch was operated in SNOM mode. Nonoptical shear force probe sample distance regulation based on quartz tuning fork was used [5]. Chemical etching techniques [6, 7] were used for preparing sharpened optical fiber. The optical schemes of the device provide to use different optical elements combinations.

An influence of the incident light polarization on the aperture probe collection SNOM images have been investigated. Diffractional gratings which had been preparing by means of laser induced photoelectrochemical etching of doping GaAs and InP were used as the samples for this observation. In Fig. 1 a great difference between reflection SNOM images obtained at two orthogonal linear polarization state of the incident light is demonstrated. Dramatically decreasing of the individual features optical contrast in the case of *s*-polarization of incident light is noticed. Simple explanation of this effect may be the matching of electromagnetic boundary conditions at a dielectric-metal interface [9].

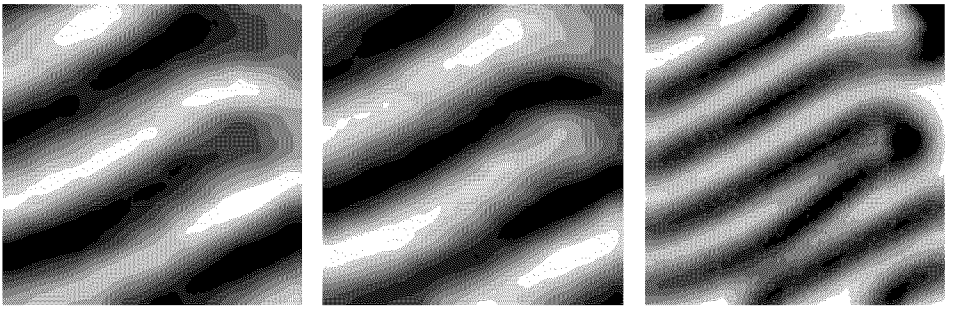
Iron-garnet films are one of the most popular objects for transmission SNOM magnetooptical investigation [8]. Optical images of iron-garnet films were shown in Fig. 2, where three different orientation of polarizers were applied for the differentiation between the optical images of domains and the optical images domain walls. It is seen that the polarization of local electromagnetic field detected by aperture SNOM probe permit us to resolve the distribution of polarization state in three dimensions.

Three-dimensional light confinement near small hole in thin metallic film have been mapping by SNOM aperture probe. The main aim of this part of the work was to observe the spatial distribution of evanescent light components. In Fig. 3 the local electromagnetic field with respect to sample probe distance is demonstrated. It is clear that decreasing of



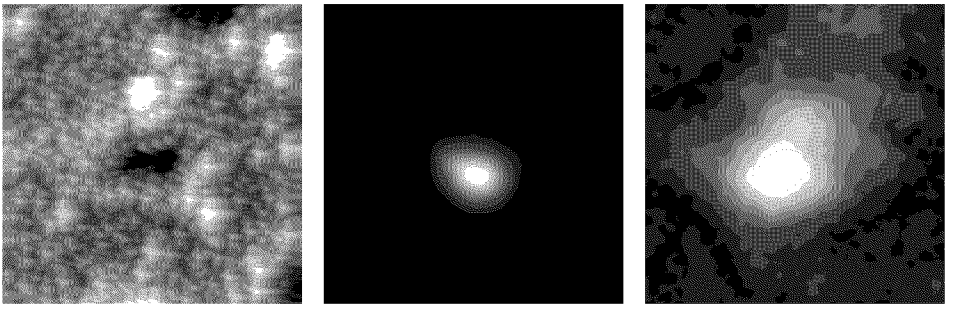
(a) (b) (c)

Fig. 1. Topography and optical images of the same region of 400 nm InP diffractional grating (scan size 4800×4800 nm^2 for all images): (a) topographic image with 35 nm full grey scale; (b) optical image obtained with s-polarization incident ligth; full grey scale 250 arb. units; (c) optical image obtained with p-polarization incident light; full grey scale 480 arb. units. Arrows indicate the place of single defect.



(a) (b) (c)

Fig. 2. Optical images of the same region of iron-garnet film (scan size 5700×5700 nm^2 for all images): (a) and (b) images of magnetic domains with inverse contrast; full grey scale about 1100 arb. units; (c) domain walls image; full grey scale 550 arb. units.



(a) (b) (c)

Fig. 3. Topography and optical images of the same region of experimental CD surface after special Al deposition and subwavelength holes formation (scan size 2500×2500 nm^2 for all images): (a) topographic image with 170 nm full grey scale; (b) optical image obtained at sample probe distance 5 nm ($\lambda/100$); full grey scale 1500 arb. units; (c) optical image obtained at sample probe distance 500 nm (λ); full grey scale 500 arb. units.

the integral intensity accompanied simultaneous increasing of lateral size of hole optical image. This result demonstrate the localisation of evanescent light components.

In conclusion it must be say that the local probing of the electromagnetic field realised by means of aperture type SNOM probe allow to observe several properties of the mapping light. This mode of SNOM operation provide complementary potential in comparison with the conventional SNOM mode which use aperture probe as nanosource of irradiation and detect light in far field. Effects associated with different combinations of incident light properties as it may be seen from the presented results require further investigations

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