Near-field polarization measurements based on two arbitrary, orthogonal optical field components

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Summary

Using a multi-heterodyne scanning near-field optical microscope, we detect two arbitrary, orthogonal components of the near field. A numerical treatment of the experimental data allows the retrieval of the transverse and longitudinal components of the modes propagating in a waveguide for Bloch surface waves.

Introduction

The State of Polarization (SOP) of a monochromatic, coherent field is fully characterized by two amplitude components and the relative phase difference between them. In near-field microscopy, the scattering occurring at the probe-sample system complicates the direct measure of the SOP: the measured far-field SOPs does not generally correspond to the near-field SOPs at the probe position.

Combining a multi-heterodyne interferometer with a Scanning Near-Field Optical Microscope (SNOM) [1], we measure in an arbitrary orientation two orthogonal components – in amplitude and phase – of the near field collected by the probe. A numerical treatment of the experimental data allows the retrieval of the SOP in any other orientation. The calculation involves an optimization criterion based on *a priori* information concerning the field.

Discussion

The waveguide is an ultra-thin ridge waveguide for Bloch Surface Waves [2]. We first demonstrate that it sustains only three modes and that we can selectively excite them by choosing the wavelength and the excitation polarization [3]. We then retrieve the transverse and longitudinal field components of the three modes.

In order to illustrate the procedure, we present in Fig. 1 the results concerning the fundamental mode. The direct measurements are shown in (a-d). They correspond to two orthogonal components (components 1 and 2) detected in amplitude and phase in a basis of unknown orientation. With the *a priori* knowledge that the longitudinal component is weaker than the transverse one (as suggested from calculations), we arbitrary choose to minimize the intensity of the component 2 (c-d). The transformation is numerically modeled as a combination of a half-wave plate and a quarter-wave plate. The goal is hence to find the best orientation of these elements that minimize the entire intensity of the component 2. Since wave retarders act on the relative phase difference between components, the phase information is therefore required for this optimization.

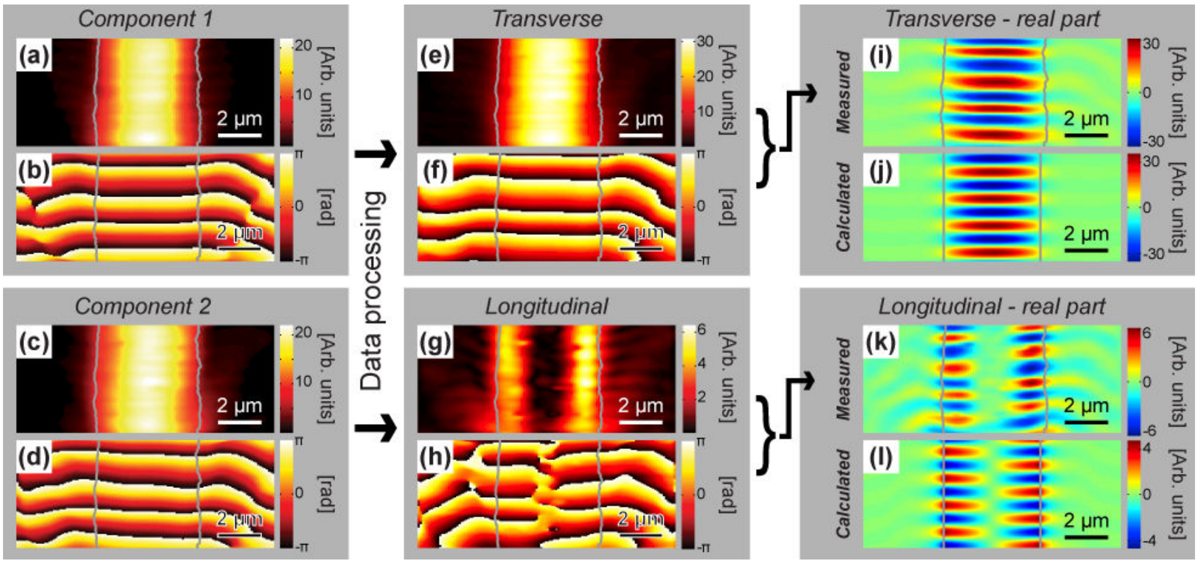

Fig 1. (a-d) Measured orthogonal components (in amplitude and phase) of the fundamental mode in a basis of unknown orientation, (e-h) transverse and longitudinal components after data processing of (a-d), (i-l) real parts of the processed experimental components compared with simulated results.

The minimization process provides the amplitude and phase of the longitudinal components (g-h). At the same time, the intensity corresponding to component 1 is maximized and becomes the transverse field (e-f). The real parts corresponding to transverse and longitudinal fields are shown in (i) and (k), respectively. They can be compared with the real parts of the transverse (j) and longitudinal (l) components of the fundamental mode, as calculated with a Finite Element Method. A good quantitative agreement is found.

Conclusions

The method for separating the field components ultimately rely on the detection of two arbitrary, orthogonal components of an optical field, and on *a priori* knowledge of the field distribution. We applied this method to a ridge waveguide for Bloch surface waves and successfully retrieved the transverse and longitudinal field components of the three modes sustained by the structure. To a certain extent, we can even think of applying this technique without any preliminary information on the desired field, but by analyzing the data with mathematical tools such as symmetries.

References

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