Coherent imaging of guided fields

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Abstract

A photon scanning tunneling / atomic force microscope will be developed to measure the field distribution (amplitude, phase and time) in integrated optical devices. The microscope will be applied on real devices like splitters, converters, multiplexers, etc.

1. Introduction

The design of integrated optical devices is in general based on numerical simulation techniques. The performance of the devices is usually verified by comparing the input and the output signal of a complete device with the simulated values. A review of the some comon methods of characterization integrated optical waveguides is reported in [1].

A new optical method will be developed to image the field distribution (amplitude, phase and time) in integrated optical devices. A stand-alone version of a photon scanning tunnelling microscope (PSTM) combined with a atomic force microscope (AFM) will be developed. With this microscope it will be possible to measure simultaneously the field distribution in a waveguide and its topography with a resolution of $\lambda/50$. The proposed method provides detailed information on amplitude, phase, polarisation and time of optical fields in complex integrated optical waveguide devices at real operation conditions, without interfering with the actual operation. This complete information cannot be obtained with alternative methods. A direct confrontation with simulated field distributions (e.g. beam propagation method) becomes feasible, allowing optimization of both theory and the actual device performance. Initially the project will be a feasibility study to demonstrate the application potential of the novel method. At the same time the configuration is such that any type of waveguide system can be accomodated, which allows study of actual development and even commercial devices. This microscope will be applied to real devices like waveguide splitters, wavelength multiplexers, mode switchers and converters, etc..

2. Experimental

In an introductory experiment [2] we have obtained some amplitude maps of various channel waveguide systems, as shown in figure 1. The figure shows the corresponding images of topography (AFM) and field distribution (PSTM).

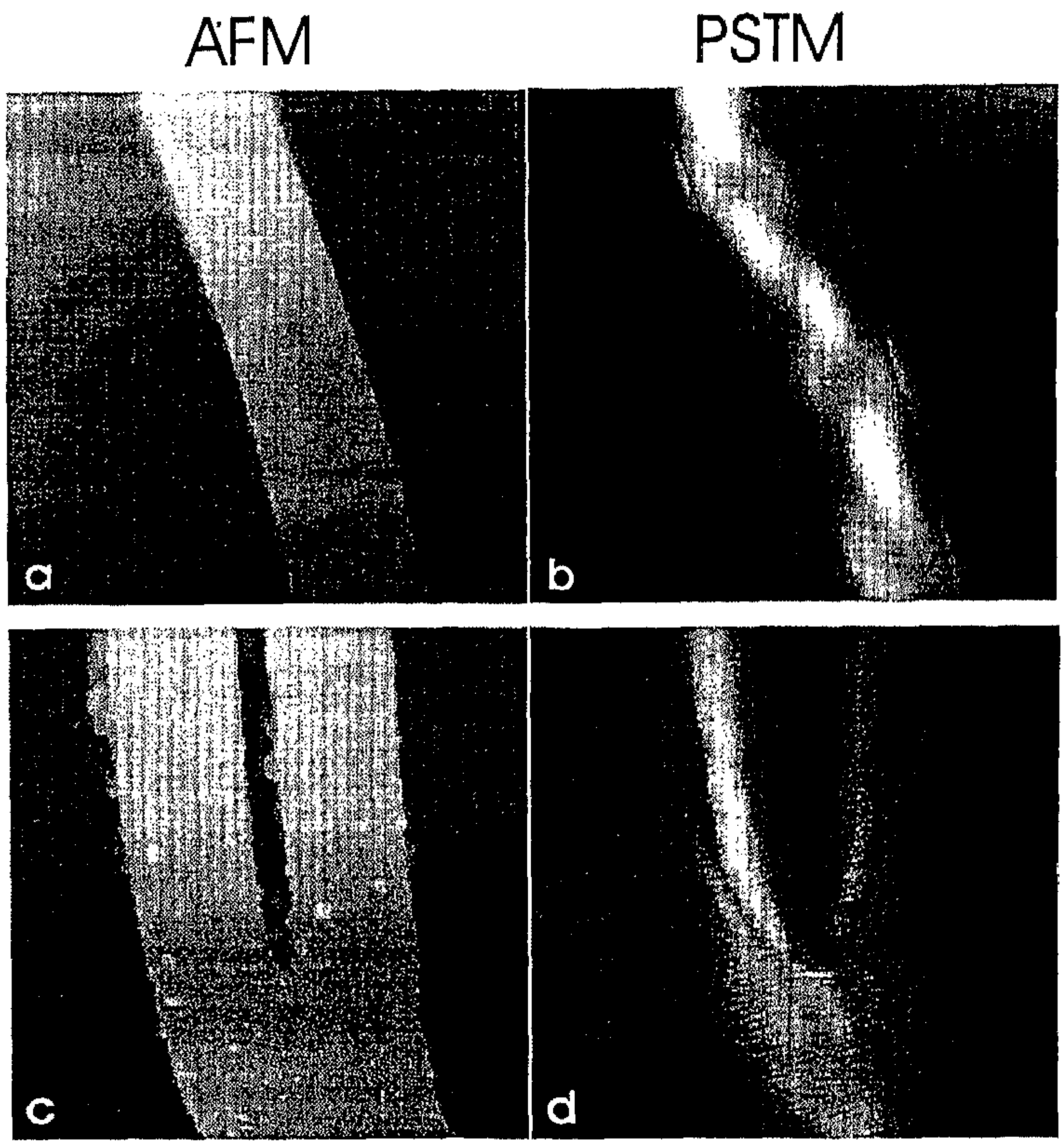

Figure 1: Corresponding AFM (left) and PSTM (right) images of various channel waveguides, 5 μm wide, over 100 μm length, showing topography and field distribution in the channel for given conditions.

a, b: A channel guide with mode-beat between TM_0 up to TM_3 mode.

c, d: A Y-junction of a 10 μm guide to two 5 μm guides.

Phase maps of the relative phase of the field distribution will be recorded by including the PSTM in on branch of a Mach-Zehnder type interferometric set-up (figure 2). The mutual stability of the PSTM path and the reference path determines the accuracy of the phase measurement. We aim for a phase accuracy of $\approx 3\%$. The operation of multiplexing and switching waveguide devices depends critically on the development of the phase in the transition area, which will be subject of investigation.

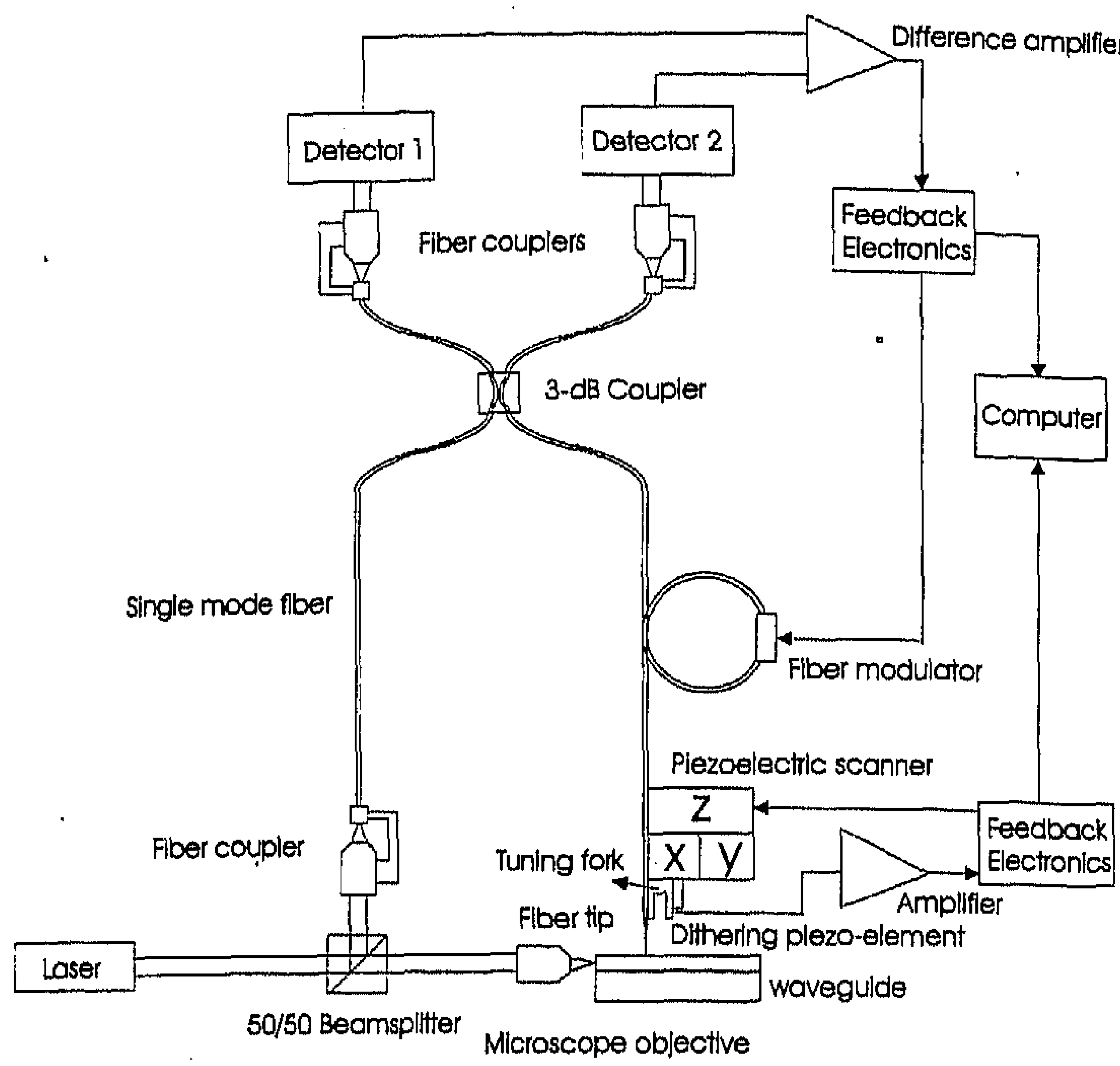

Figure 2: A Mach-Zehnder type interferometric set-up for the imaging of the phase of integrated optical waveguide devices.

Only amplitude images of the optical field distribution of waveguide devices have been obtained with PSTM [1-11]. Phase and time-resolved images of integrated optical waveguide devices with PSTM have not been obtained yet to the knowledge of the authors.

3. Conclusions

PSTM is a promising method to characterize integrated optical waveguide devices compared to other characterization methods. The detailed information that can be obtained with PSTM cannot be obtained with an other method. This detailed information will be used for the optimization of both the design and the performance of integrated optical waveguide devices.

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