Miniature Fiber Interferometer

C. Hughes, R. Hocken
Center for Precision Metrology, University of North Carolina at Charlotte, USA

cvhughes@uncc.edu

Abstract

As the world moves toward using smaller devices, the data and hardware that these devices contain must follow the same trend. An emerging technology for promoting this trend is plasmonic lithography. This technology utilizes specialized lenses which are installed on writing heads, in place of traditional writing heads used in commercial hard drives. This is done to position the plasmonic lenses in the near field with respect to the hard disk. To measure the motion of the plasmonic writing heads a miniature laser interferometer was developed. The interferometer utilizes a solid state laser diode that is pigtailed to an arrangement of optical fibers. At the measuring interface the optical fibers are inserted into metal sleeves for reliability purposes. The instrument's footprint at the measuring interface is 0.3 mm diameter. Sub nano-meter resolution is obtainable with this device.

1 Application

As new data storage technologies emerge, the market demands require that the devices be cheaper, have higher data capacities, and be smaller. These trends have sparked interest in new micro and nano-scale fabrication techniques to supply such demands [1]. To address the demands of high capacity data storage on hard drives, it is necessary to write the data as small as possible. This requires overcoming the deffraction limit. A technique called plasmonic lithography is being developed to achieve these demands. Plasmons are high energy short wavelength oscillating dipoles which can be used to write small features. The process involves striking a plasmonic lens with incident UV light which excites surface plasmons. Plasmonic lenses in use for this project consist of concentric metal bands spaced such that they excite the resonance of the oscillating dipoles. At the center of the plasmonic lens, an H shaped wave guide is used to guide the plasmons to a particular point. See Figure 1. Currently feature sizes of 50 nm are obtainable [1].

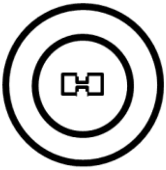


Figure 1: Image of the plasmonic lens used in the writing process [1].

Due to the short range nature of plasmons, the lens must be placed within 20 nm of the writing surface. This is accomplished by placing the lenses on specially designed writing heads which are placed at the end of commercial hard drive suspensions Figure 2.

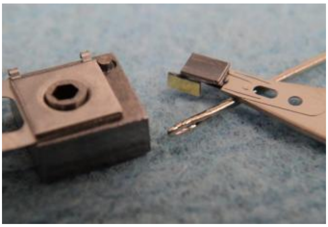


Figure 2: Plasmonic writing head with mirror in place for measurement.

These plasmonic writing heads have been experimentally proven to fly within 20 nm of the surface of a substrate covered disk [2], thus the modified writing head will act as a vehicle to position the plasmonic lens within range of the disk to be written on.

2 Design

Due to oscillations of air bearing flight, a miniature laser interferometer was developed to measure the displacements. This interferometer will act as a sensor for a control loop. Compensation of the oscilatory motion will be achieved by mounting the plasmonic writing head's suspention to a shear PZT actuator. The miniature fiber interferometer is a pair of low finesse Fabry-Perot interferometers where an air gap exists between the cleaved ends of the fibers and a small mirror placed on the plasmonic writing head. These fibers are protected at the measurement interface by metal sleeves. The light source is a 635 nm wavelength solid state laser diode. The laser diode is pigtailed to 125 um diameter, single mode, jacketed, optical fiber. The laser is passed through a Faraday isolator to reduce the amount of reflected light reentering the laser diode. Utilizing three 50:50 splitters, allows for splitting the single launch fiber into two measuring leads, two return leads, and three unused ends. See Figure 3.

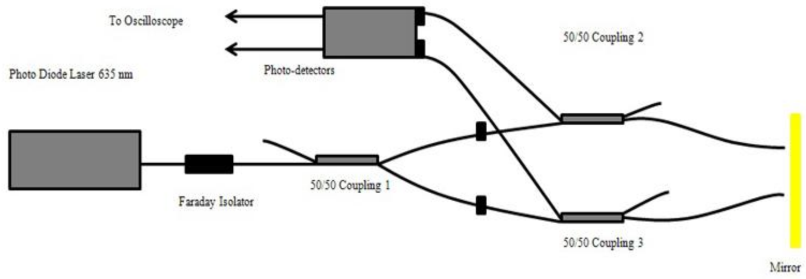
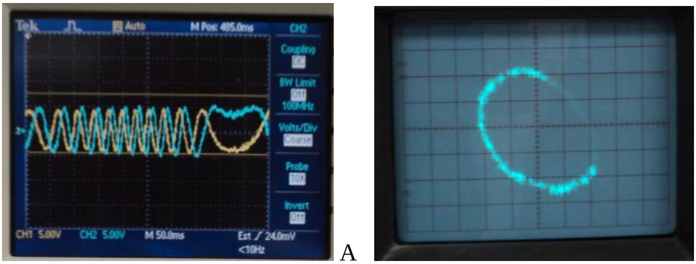


Figure 3: Schematic of the interferometer layout.

To further stabilize the signal, the unused ends were cut at angles and placed in an index matching fluid, eliminating thier contribution to the waveform. At the measuring end, the optical fiber cladding and jacket are stripped, and the fibers are inserted into hypodermic needles to protect them in case of collision. By applying a bead of glue, at the jacket needle interface, additional strain relief is achieved. Each of the return leads is connected to a photo diode and amplifier circuit. This generates sinusoidal output signals for each interferometer. By shifting the two sinusoid signals one quarter wavelength out of phase with respect to each other, a quadrature signal can be generated, where one cycle represents a linear displacement of the object, of half the wavelength of the source laser [3]. The optical path length change can be created by a small rotation (yaw), of the measuring leads, via a flexure. By interpolating the electrical signal from the A quad B interferometers, measurements with sub-nanometer resolution are obtainable. After many experiments it was discovered that a simpler approach to the A quad B technique maybe viable. Using a single interferometer needle, one looses directional information of the oscilation, however this is not nessicary to maintain a position. Instead locking onto the slope of one of the siusoids can be the input to the position feedback loop.

3 Results

The following image was taken of the signals produced using the A quad B technique described above:



A B

Figure 4: The resulting sinusoidal signals (A) and the quadrature signal (B).

The test setup involved gluing a mirror to the side of the shear PZT actuator, near the top to register the full range of travel of the PZT stack. The resulting signal shows 11 cycles, each corresponding to a displacement of half the wavelength of the laser used. Thus about 3.4 um which represnts the full range of travel for the PZT.

4 Conclusion

Using specialized fiber interferometers a measuring device can be created, capable of measureing the motion of writing heads which are used in the hard drive industry. These interferometers are small robust and have potential resolutions of subnanometers.

References:

[1] Pan, L., Park, Y.-S., Xiong, Y., Ulin-Avila, E., Zeng, L., Sun, C., Zhang, X. (2010). Flying Plasmonic Lens at Near Field for High Speed Nano-lithography. SPIE.

[2] Sriturávanich, W., Pan, L., YuanWang, Sun, C., Bogy, D. B., & Zhang, X. (2008). Flying Plasmonic Lens in the Near Field for High-speed Nanolithography. Macmillan Publishers Limited.

[3] Murphy, K. A., Gunther, M. F., Vengsarkar, A. M., & Claus, R. O. (1991). Quadrature Phase-shifted, Extrinsic Fabry-Perot Optical Fiber Sensors. Optical Society of America.