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Optical Delivery in Energy-Assisted Magnetic Recording (EAMR) Systems

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Energy-assisted magnetic recording (EAMR) is considered as one of the most promising future technologies in the hard disk drive (HDD) industry for ultra-high density magnetic recording. The EAMR technique requires the use of a laser beam to define magnetic recording features, where high efficiency optical coupling and delivery of highly focused optical beam at low cost for large volume manufacturing (LVM) are key challenges in building such systems. Currently there is a huge gap between HDD industry status and the requirement for implementation of EAMR technology. This thesis work intends to provide effective and feasible optical delivery scheme for EAMR functionality.

Specifically, we have proposed the design and fabrication of an on-wafer micro focal lens to achieve high-efficiency optical coupling of external laser beam into magnetic read/write head at low cost. The demonstrated fabrication process and robustness analysis results confirm that the on-wafer micro focal lens can meet stringent LVM requirements. Advanced dielectric tapered waveguide is also proposed for delivery of highly focused beam for EAMR. Three-dimensional finite-difference time-domain (FDTD) simulation results show that specially designed dielectric tapered waveguides can provide higher optical efficiency compared with metallic near field transducers (NFTs), and do not encounter overheating or self-burning issues. We have also demonstrated the feasibility of integration of on-wafer micro focal lens with dielectric tapered waveguide to realize optical delivery functionality in EAMR systems. The proposed structures can be produced using standard industry top-down fabrication process, which facilitates the integration of such structures with conventional magnetic head industry manufacturing at low cost.

Finally, several specific aspects in EAMR applications have been discussed, including magnetic single bit scale, thermal energy and optical power requirement for EAMR function, and thermal diffusion or heat conduction analysis in EAMR systems. The estimated and analyzed results show that the thesis work is promising to achieve magnetic recording density at about 1Tbit/inch^2 for use in next generation hard drives, with the combined use of appropriate recording medium materials satisfying certain thermal properties.