Ultra-high capacity petabyte optical discs for low energy consumption big data centers

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Optical memory has a superior performance including ultra-high data transfer rates and energy efficiencies compared with hard drive disc used in big data centers. Unfortunately, the current optical storage techniques including DVD and Blue-rays are still limited by the diffraction nature of light, where the smallest recording bit cannot exceed half of the wavelength and hence the capacity is far below the petabyte density requirement for big data application. To overcome this challenge, the aim of this project is to develop an optical memory technology which can break the diffraction limit, obtain nanometer resolution for data recording and reading and eventually achieve Petabyte data capacity storage.

The first aim of the project is to develop a solid memory medium. The medium should support super-resolution data recording to enable ultra-high capacity data storage. The medium should also support super-resolution data reading. Different from the well- developed two-beam super-resolution nanoscopy using nanoparticle or dye molecules, the material used in this project should be a homogeneous solid film. For this reason. The Fellow have developed a new material. This material is in a liquid status at the beginning. After coating on an DVD like optical disc and illuminated by ultra-violate light, the material becomes a solid film. When using a two-beam optical data recording system to write bits inside the material, bits separation about 80 nm can be achieved because of the resolution improvement by overcoming the diffraction limit. This enables recording about several· hundreds of Terabyte data in a DVD sized disc. After bit recording, the material at the position where bits have been recorded is modified. Significant fluorescence emission difference can be observed before and after bit recording. Based on the fluorescence difference, by using a fluorescence based two-beam nanoscopy, the recorded data can be successfully read out. By similar ways to make a DVD size, two-beam disc based on this material can be fabricated by an industry DVD-making instrument.

The second aim of the project is to develop a prototype dynamic drive system for super- resolution data recording and reading. The function of the drive system is similar to the commercial available optical drive used for DVD disc. The fellow have developed a system based on the commercial available optical drive but with totally different optical setup and system control configuration. The current developed system has a home-made electronical circuit to drive the motors rotating the optical disc, moving the optical pickup and moving the focal lens. The system has a home-build two-beam optical setup to enable super- resolution data recording and reading. The optical setup has also added with components to enable multi-focal parallel data recording and reading. By building an all-in-one control system software, the system can record and read data with a disc rotation speed of 20 rpm.

In conclusion, by conduction this project, the fellow have successfully demonstrated optical data storage with resolution beyond the diffraction limit. A material enables 80 nm bit separation data record was developed (The aim is 50 nm). Two-beam disc based on this material has been fabricated using an industry DVD-making instrument. A prototype drive system has been developed which enables data recording and reading while the disc is rotating. By adding the multi-focal parallel sub-system, the data output rate can be at the magnitude of 10 MB/s. The work done by the Fellow indicates the feasibility to apply this petabyte optical memory technology in big data centers.