

Thermally Assisted Recording Pushes Magnetic Storage Densities beyond Traditional Limits

The desire to increase magnetic storage densities requires downscaling of the bit dimensions, which are currently limited to ~50 nm. In the past, this was made possible by reducing the grain size of the recording media. However, the decrease in grain size will eventually reach the superparamagnetic limit, at which thermal energy is sufficient to randomize the magnetization direction. Consequently, further increases in recording densities require materials with higher magnetic anisotropy energy. While these materials are available, they cannot be used because the magnetic field of the recording heads is insufficient to write these materials. Recently, a group of researchers at the IBM T.J. Watson Research Center in Yorktown Heights, N.Y., demonstrated that by thermally assisting the recording process, very high-density magnetization patterns could be written, therefore breaking the record on magnetic storage density.

In an article published in *Applied Physics Letters* on February 2, researchers H.F. Hamann, Y.C. Martin, and H.K. Wickramasinghe described their experiment in detail. They placed an atomic force microscope tip (radius, ~5 nm) in close vicinity to a magnetic film of TbFe on a mica substrate or a Co/Pt multilayer film, also on a mica substrate. The tip was heated by a laser diode. Some of the energy was transferred on a very local scale from the tip to the magnetic film, which was then heated to close to its Curie temperature. The magnetic bias field was applied to align the magnetization in the heated region. The heated region of the film had a substantially lower coercivity and could be magnetized with a small field.

On the basis of magnetic force microscopy measurements, the researchers said that the recorded spot sizes are less than 30 nm in diameter. The magnetization patterns obtained on the thin film correspond to a storage density of ~400 Gbit/in². The researchers believe this is the highest magnetic storage density reported. Furthermore, by thermal modeling, they predicted that an even smaller heated spot size can be realized. That means, potentially, a recording density of >1 Tbit/in.² can be achieved.

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Photodetectors Fabricated Using Electrostatic Self-Assembly

Organic semiconducting polymers are attractive materials for use in photovoltaic (PV) detectors because of their tunability and flexibility. However, excitons in or-

ganic PV devices are easily quenched and have limited diffusion lengths, making it essential to have good control over layer thicknesses. Using spin coating, it is often difficult to obtain the desired ultrathin

polymer films. Electrostatic self-assembly can produce very thin films through alternate deposition of oppositely charged polyelectrolytes. As reported in the February 10 issue of *Chemistry of Materials*,

Femtosecond Lasers Facilitate Writing of 3D Colored Images with Precipitation of Au Nanoparticles in Glass

A number of researchers have previously reported the application of femtosecond (fs) laser pulses to three-dimensional (3D) direct writing of structures buried in materials. In the February 15 issue of *Optics Letters*, J. Qiu of the Chinese Academy of Sciences and the Japan Science and Technology Agency, K. Hirao of Kyoto University, and colleagues with the Photon Craft Project describe a femtosecond laser-assisted method that precipitates nanoparticles within a silicate glass with 3D control of the area that is precipitated. This enables the creation of well-defined structures within a monolith of glass. The researchers' interest in developing this approach was piqued because the optical properties of noble-metal nanoparticles differ from those of their bulk form due to the quantum size effect and increased surface area, resulting in much larger third-order nonlinearities and an ultrafast nonlinear response time.

The silicate glass had a composition of 70SiO₂•10CaO•20Na₂O (mol%) and was doped with 0.1 mol% Au₂O₃. An 800 nm laser system with 120 fs pulses at 1 kHz was used to structurally modify the glass. The high intensity of the beam, due to the tightly focused spot (9 μm spot diameter at the beam waist in the glass) and short pulse duration, causes multiphoton ionization of the glass. During the ionization, an electron-hole plasma is formed that recombines to produce white-light emission. However, some of the free electrons from the ionized glass are captured by the Au ions to form Au atoms. The process also forms hole-trapped nonbridging oxygen sites due to the ionization of the glass. After the glass is annealed for 30 min at 550°C, the Au atoms precipitate into nanoparticles. Transmission electron microscopy analysis confirmed the existence of the Au nanoparticles in the irradiated area, with sizes ranging from 5 nm to 10 nm. Spectroscopic analysis showed an increase in the absorption in the irradiated sample at wavelengths of 310 nm, 420 nm, and 620 nm, all of which can be ascribed to hole-trap centers at the nonbridging oxygen atoms. An absorption peak at 530 nm was observed after annealing. The peak wavelength increased with increased annealing time, which points to the surface plasmon resonance of the particles as the source of this absorption line.

By changing the position and depth of focus of the beam, the location of the nanoparticles can be controlled, thus allowing for the writing of 3D images, as shown in the Figure with the image of a butterfly. For the intensity used to construct the butterfly, illumination with the 9 μm spot resulted in a region ~40 μm in diameter in which the properties of the glass were changed. The researchers determined that the size of the region affected could be controlled from a few hundred nanometers to a few millimeters by altering the intensity and the spot size of the incident laser beam. The researchers also used an optical Kerr shutter experiment to measure the temporal response of the nanoparticles, obtaining a Kerr signal response of 240 fs for a 500 fs pulse width (inside the glass). This development has applications in industrial art, high-density memory storage, and all-optical ultrafast switching for optical communications.

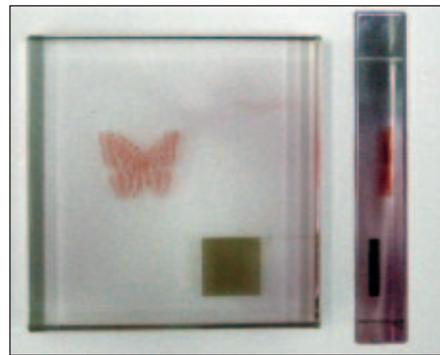


Figure. A butterfly created within a glass sample by femtosecond laser pulse excitation followed by oven annealing. The gray image has not been annealed. The size of the glass sample is 50 mm × 50 mm × 8 mm. The width of the butterfly is ~15 mm. Front and side views are presented.