A switchable source for extremely high magnetic field gradients

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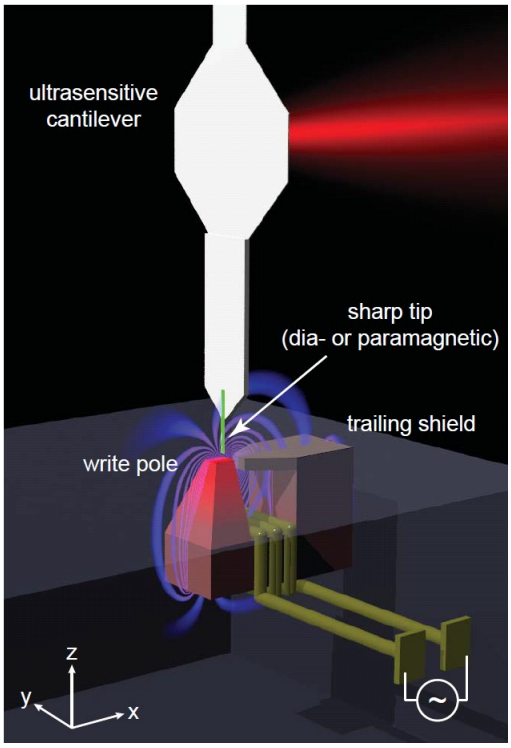

Artistic rendering of the experiment performed. An ultrasharp diamond needle is attached to the end of a cantilever that serves as a highly sensitive mechanical detector. We scan the needle over the surface of a commercial write head device and record the forces between the diamagnetic polarization in the diamond and the pulsed magnetic field gradient generated by the write pole.

Nanoscale control over magnetic fields is an essential capability in many areas of science and technology, including magnetic data storage, spintronics, quantum control of spins, and nanoscale magnetic resonance imaging. The attainable magnetic field strength and switching speed impose severe restrictions on applications and limit the range of feasible experiments. In our work, we demonstrate that the write pole of a commercial hard drive is ideally suited to overcome these restrictions. We have developed a new variation of scanning force microscopy that allows us to characterize the magnetic field generated by a write head with a resolution of about $10\,\mathrm{nm}$. We find fields up to $\sim 0.9\,\mathrm{T}$ and field gradients up to $2.8 \times 10^7\,\mathrm{T/m}$, which is roughly $5\times$ higher compared to that of the best static tips. By design, field and gradient are switchable in $\sim 1\,\mathrm{ns}$. Write heads could thus be a powerful tool for many research groups and facilitate novel experiments.