discrepancies.

We embarked on the present experiments to try to determine whether these serious discrepancies result from incomplete understanding of the physical principles or from experimental difficulties. Our first experiments[3] measured the energy shifts caused by an intense laser field (up to 10^{10} W/cm^2 at 1064 nm) for four closely spaced levels in Ca, three levels with Rydberg configurations and one with a more complex configuration. We found that the three Rydberg levels undergo a ponderomotive energy shift, while the other level is shifted only about half as much. The approximation that leads to the ponderomotive value for Rydberg levels breaks down for this latter "non-Rydberg" level. We then studied in detail about 15 Rydberg levels in Xe perturbed by intense 1064 nm laser radiation.[4] All of the levels investigated display ponderomotive energy shifts, including one level that had been previously reported to have an energy shift less than half the ponderomotive value.[1]

In both the Ca and Xe experiments, a relatively weak tunable probe laser excites an atomic level that is energy shifted by a strong Nd:YAG laser (1064 nm). Besides shifting the energy levels, the Nd:YAG laser also ionizes the excited atoms, and the ions are detected as the probe laser is tuned through the transition. The resulting ion signals (as a function of probe laser frequency) agree very well with models of the process that predict essentially ponderomotive energy shifts for the Rydberg levels.[5] The experimental data reproduce well the predicted widths and shapes as well as the energy shifts (see figure). These experiments should restore confidence in the simple picture of a Rydberg electron behaving essentially as a free electron when subject to an intense electromagnetic field with photon energy much larger than the Rydberg binding energy.

* Also with the University of Maryland, College Park, Md.

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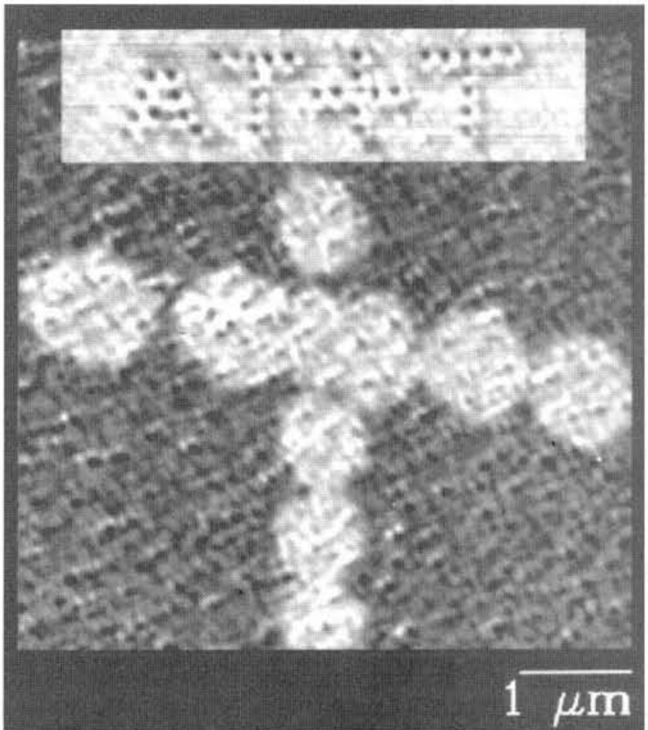
NEAR-FIELD OPTICS

Near-Field Magneto-Optics and High Density Storage

By E. Betzig, J. K. Trautman, R. Wolfe, E. M. Gyorgy, and P. L. Finn, AT&T Bell Laboratories, Murray Hill, N.J., and M. H. Kryder and C.-H. Chang, Data Storage Systems Center, Carnegie Mellon University, Pittsburgh, Pa.

We have demonstrated a new read/write data storage technique[1] capable of recording up to 45 billion bits of information per square inch of media, or 100 times more than in current compact disks and 300 times more than in state-of-the-art magnetic hard drives. At this density, a palm sized disk could record up to 17 hours of compressed HDTV programming. Alternatively, two copies of *War and Peace* could be stored in an area about the size of the head of a pin.

As with conventional optical storage systems, our new method uses a laser to read and write bits on the recording medium. However, rather than focusing the light with a lens, which results in a spot of diffraction limited size, we funnel the light through a tapered optical fiber that has been coated with opaque aluminum everywhere except for a small hole at the very tip. If the hole is placed sufficiently close to the medium, in what is known as the near-field region, then the emitted light can form a spot much smaller than can ever be achieved with a lens. For example, the pattern at the top of the accompanying figure was written using our near-field storage method, and consists of individual bits of ~0.1 μm diameter. Elsewhere, we have produced bits as small as 0.06 μm. Over the rest of the figure, much larger bits, approaching 1 μm diameter, can be seen. These were produced by conventional far-field techniques and are representative of the size currently used commercially. In both cases, the medium was a platinum/cobalt (Pt/Co) multilayer film developed for conventional magneto-optic recording.



Comparison of bit sizes in near-field (top) and far-field optical recording.

Actually, the storage work is but one spin-off from our broader research into near-field scanning optical microscopy (NSOM),[2] which combines many of the advantages of traditional, far-field optical microscopy with much higher spatial resolution (currently as good as ~12 nm). Other applications include superresolution optical lithography, localized optical spectroscopy, and the non-invasive imaging of biological systems.

Of course, numerous other approaches are under investigation for the next generation of mass storage products. The most attractive feature of our near-field optical approach is that it can borrow heavily from the two most popular and commercially proven technologies—the closely flying scan head of magnetic disk drives and the recording media of conventional optical drives. This gives us a head start on the road to commercialization and permits us to take advantage of further improvements in either area. Many engineering challenges remain, including read/write speed, tracking, and fly height issues. Although these are daunting, they are perhaps not insurmountable, and the effort would appear to be justified by the observation that revenues in the mass storage industry total $40 billion annually and can be expected to grow further.

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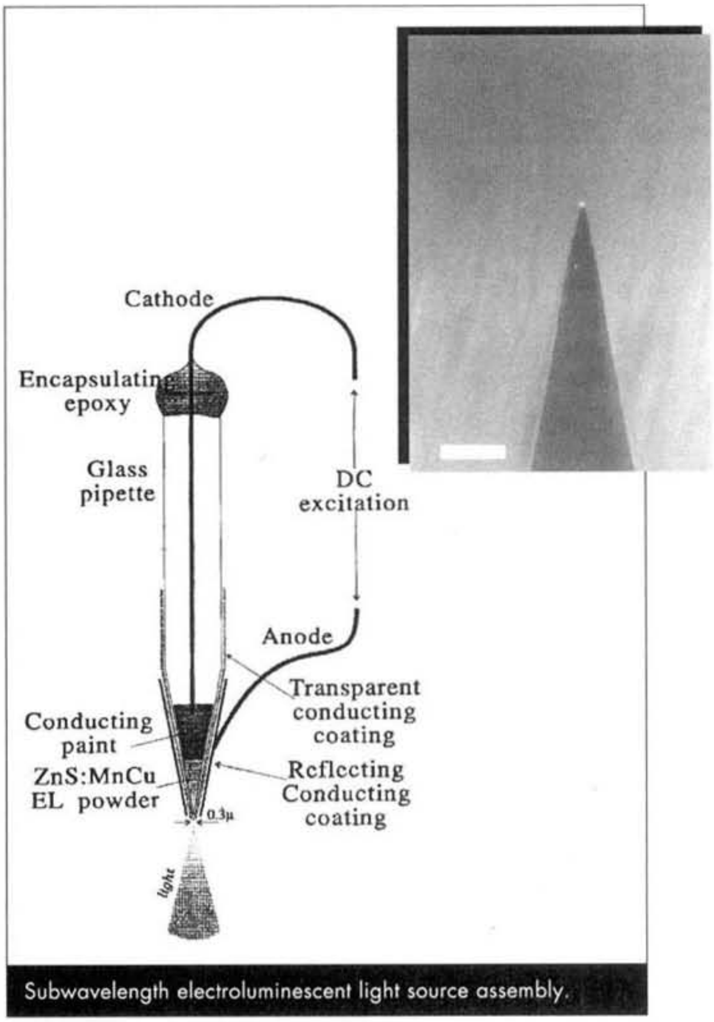
Visible Subwavelength Point Source of Light

By Nily Kuck, Aaron Lewis, Klony Lieberman, and Aron Vecht, The Hebrew University, Jerusalem, Israel

Micro-dimension light sources that can span a wide variety of wavelengths in the visible have been a major goal in optoelectronics for more than a decade. The applications for such light sources span numerous areas of advanced technology, not the least of which is the important problem of storing and retrieving the deluge of information that is engulfing mankind. For example, if a blue emitting source could be produced without any reduction in the size or the optical methodologies employed, factors of 4 improvement in data capacity could be achieved and, thus, a full length movie could be stored on one of today's compact discs. If, on the other hand, geometrical optics is bypassed and an optical device could be created that would be able to interface with the exciting developments of near-field optics,[1,2] in which a subwavelength point of light is brought within the near-field of a surface to be read or written on, then pixel sizes in the nanometer regime can be achieved and orders of magnitude improvement in storage densities could be attained.

The problem with this approach is the fact that the general methodology that has been used to create such a point of light is to pass the emission from a larger laser source through a subwavelength aperture at the tip of a glass micropipette or an optical fiber. Such an approach suffers from an exponential decrease in the intensity of the radiation as it evanescently propagates through the subwavelength hole.

We have focused on ways to circumvent this problem[2,3] and have recently attempted an approach[3] to this problem that has the potential of resolving several of the above issues by producing a submicron, subwavelength point source that can readily produce wavelengths ranging from the deep blue to the red, which can also be interfaced with near-field optics and which is not complicated by problems of evanescence. For this, we have devised a structure using a glass micropipette that allows for the insertion and the electrical excitation of a variety of electroluminescent materials at its very end. This structure (see figure) consists of a standard dc electroluminescent powder, ZnS:MnCu, that is introduced into the tip of a glass micropipette coated with a transparent coating of conducting indium oxide as the anode and an appropriate electrode placed on the inside as the cathode. The emission of our light source for this electroluminescent material is in the tip (see inset) and this light is created at the anode. The smallest size we have achieved to date is 0.3 μm. This is a result of the grain size of the electroluminescent material employed and not the achievable dimensionalities



Subwavelength electroluminescent light source assembly.