Five-Dimensional optical recording mediated by surface plasmons in gold nanorods

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Introduction:

Many efforts have been made to increase capacities of data storage devices through multiplexing. Techniques such as spatial dimensions, polarisation and wavelength have individually been used to increase information density on optical recording devices. However, this had never been integrated into a complete, five-dimensional recording platform that would offer huge increases in data capacity.

This recording method would revolutionise the optical storage industry. Gold nanorods immersed in polymer are used in this experiment due to their unique longitudinal surface plasmon resonance (SPR). A DVD size disk of this medium can hold 1.6 Tbytes of data. However, it is the lack of this recording medium that impedes this technique becoming a commercially viable solution.

This experiment explores the use two additional dimensions of optical recording through SPR to increase information density.

Recording technique:

Gold nanorods have unique properties of longitudinal surface plasmon resonance (SPR). This is a highly desirable aspect of a recording medium as this causes excellent sensitivity in the extra two dimensions of wavelength and polarization. The high sensitivity maintains signal integrity between multiplexed information.

Data recording uses laser pulses to induce temperature rises in the selected nanorods. A temperature rise past the melting point changes the aspect ratio and orientation, producing shorter rods or spherical particles. Each wavelength of laser pulse affects a certain aspect ratio of nanorod (see figure 2). Also, each polarisation of laser pulse affects the nanorods that are aligned in that particular plane (see figure 1).

The laser pulses were at femtosecond intervals and a single pulse was used. A pulse train of lasers would cause increasing thermal effects on the recording.

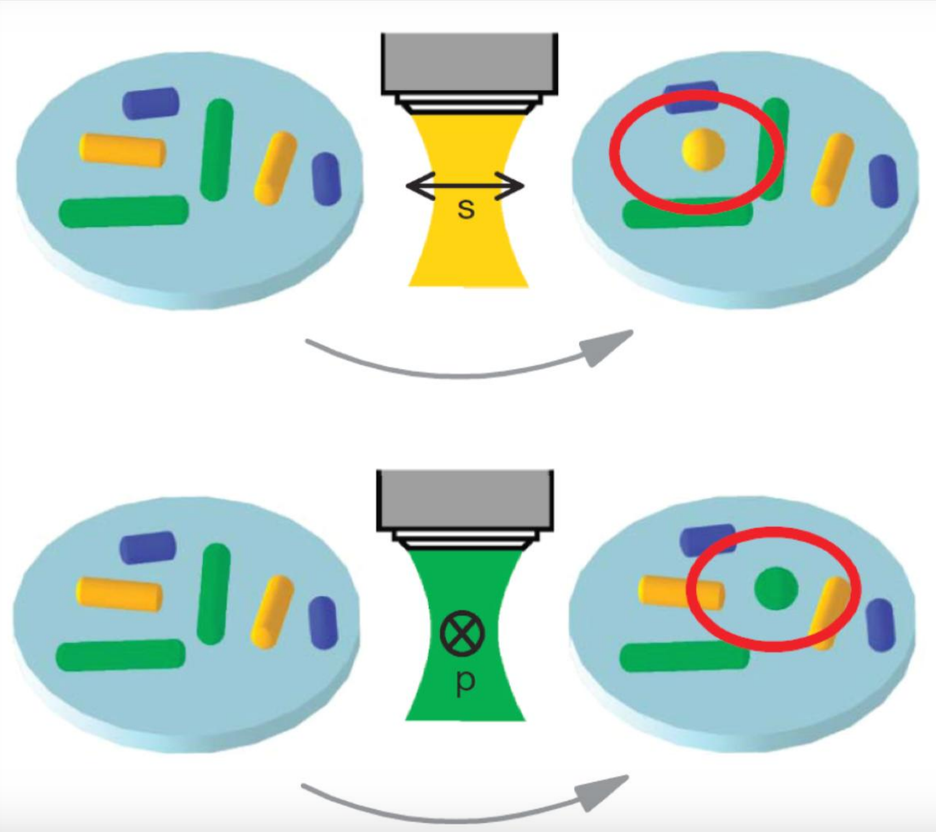

Figure 1: A schematic illustration of how the polarisation of the recording laser effects the nanorods that are only aligned in that plane of polarisation.

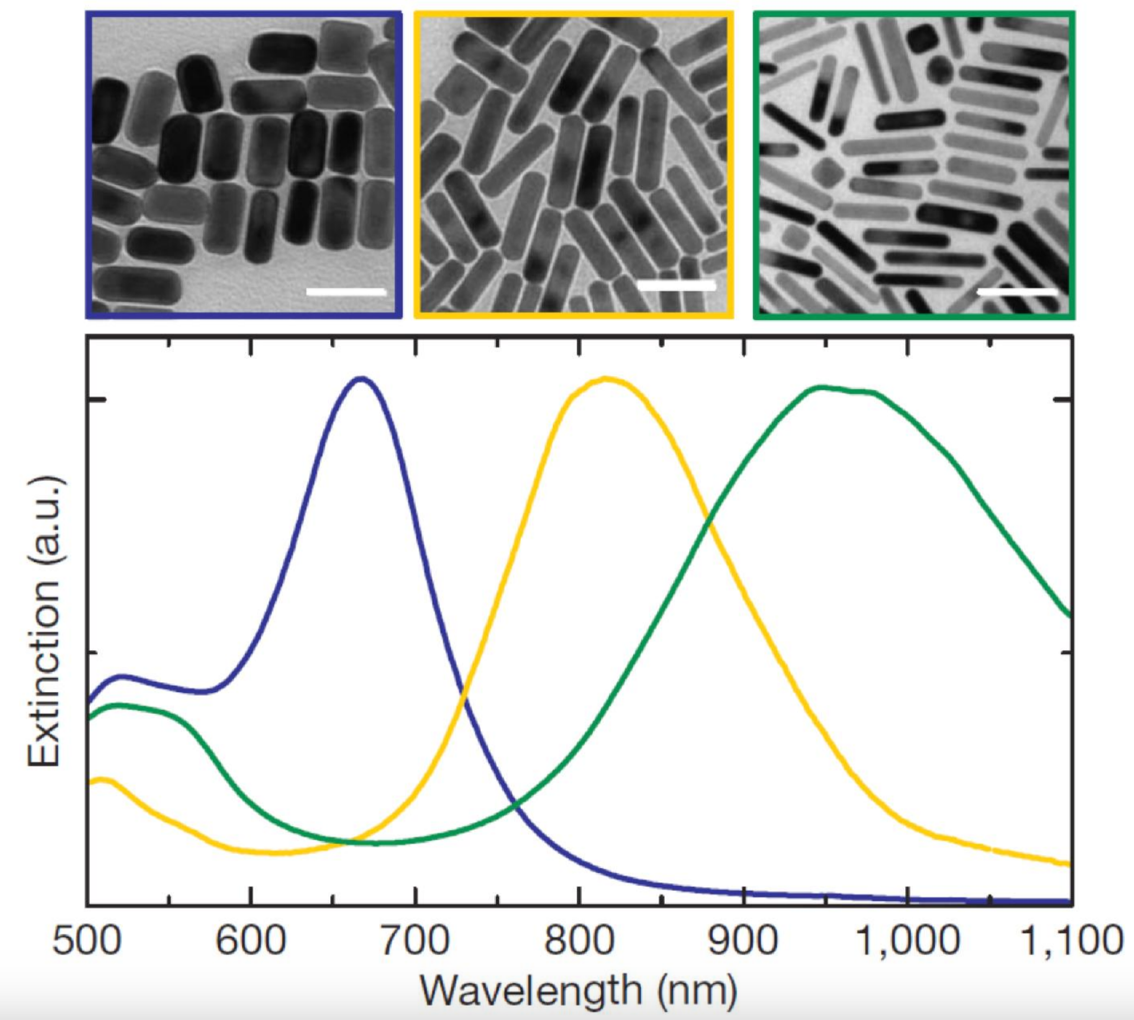

Figure 2: A representation of how the aspect ratio of the nanorods relate to the wavelength they associate to. The normalised extinction spectra shows how each set of aspect ratios behaves (blue to green, 37x19nm (aspect ratio 2±1), 50x12nm (aspect ratio 4.2±1), and 50x8 nm (aspect ratio 6±2)).

Experimental method and readouts:

Two-photon luminescence (TPL) is used as a means of obtaining readouts of the information recorded.

The readouts of the information stored are collected by illuminating the medium with a specific read laser. When unpolarised 'white light' is used to illuminate the medium, the detector (shown in figure 3) will produce an image of the combined patterns. However, when the corresponding wavelengths and polarisations of light are used, each pattern can be read out individually without crosstalk.

This process used three different wavelengths, two different polarisations and three separated recording layers. A total of 18 patterns can then be recorded at the same area with this process. A readout of the data was then performed and interpreted through a raster scan. This was then used to observe the initially recorded information as images (see figure 4).

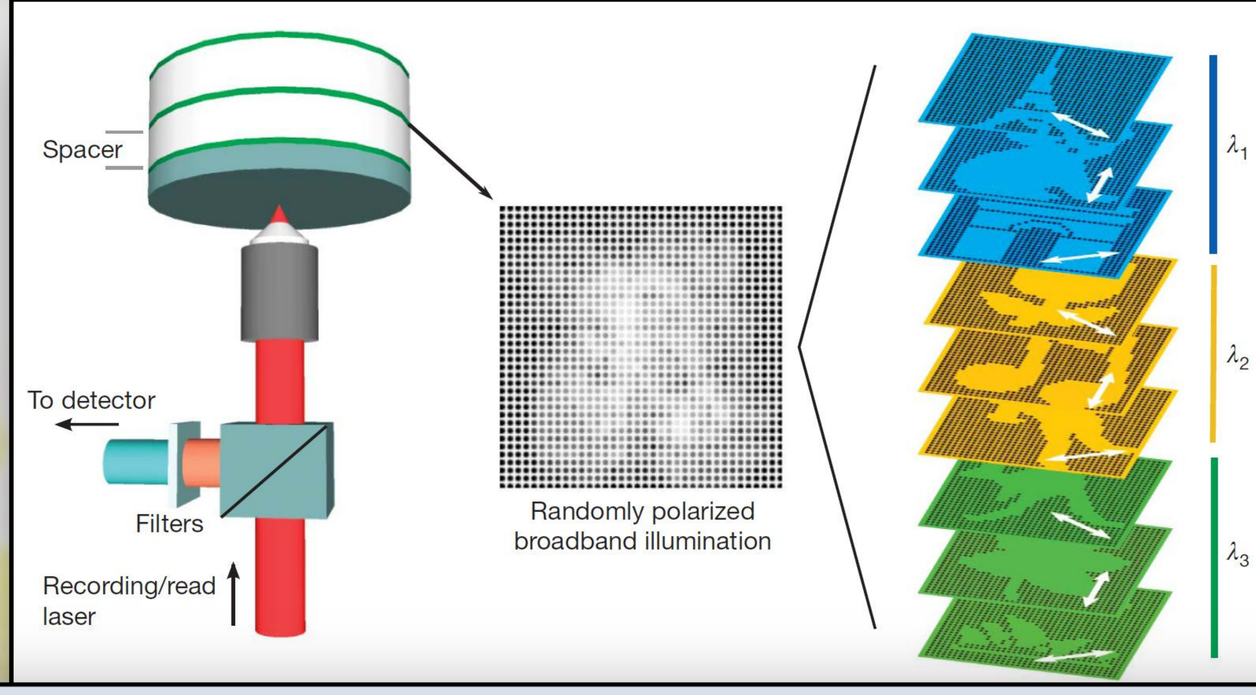

Figure 3: The read laser of unpolarised 'white light' produces a merged single image (middle). When the read laser has distinct wavelengths and polarisations the detector collects, bit by bit each recorded image individually (right).

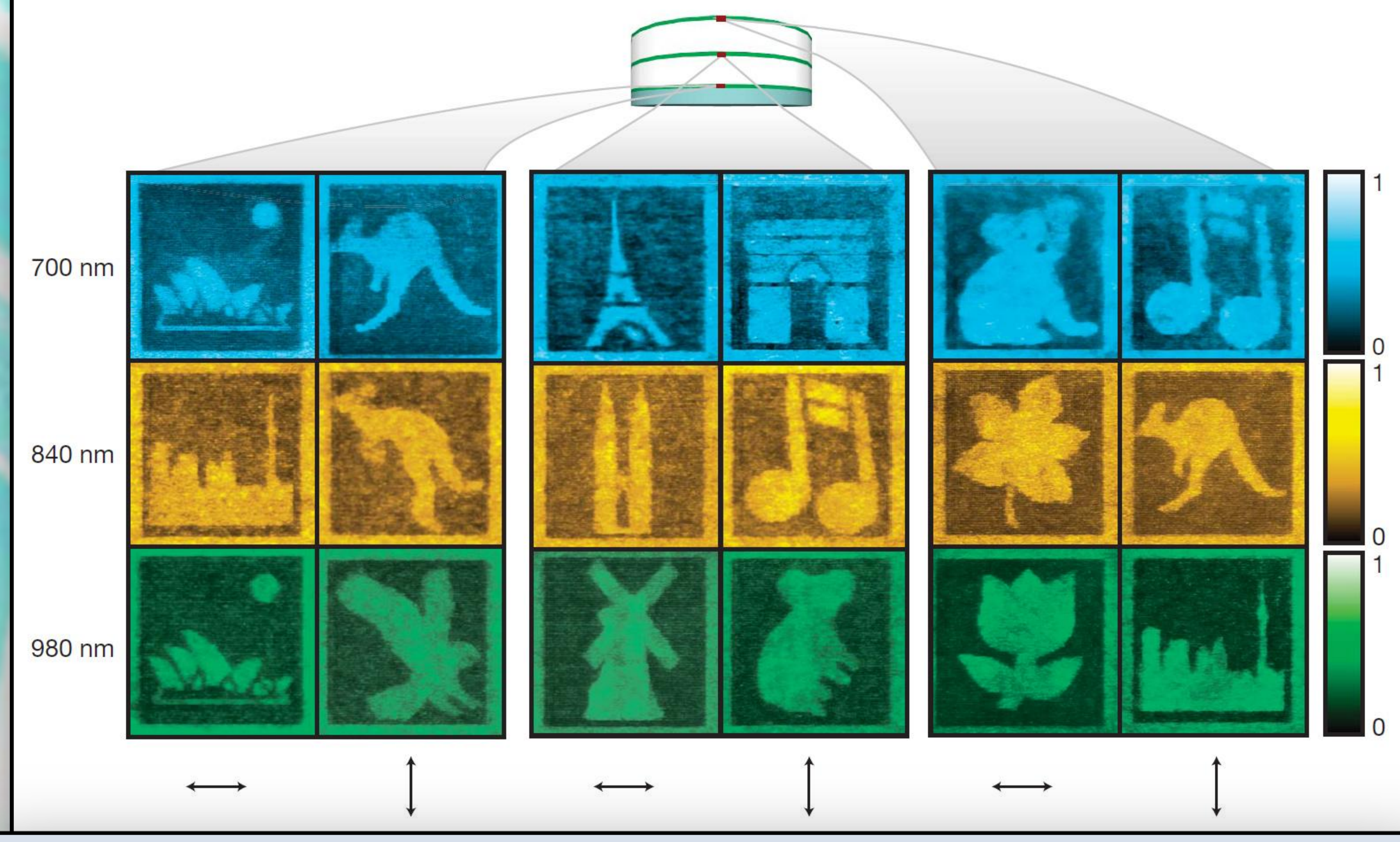

Figure 4: A raster scan of 18 separate images collected from a single unit area of the three layered medium. These clearly distinguishable images prove that this technique of recording is reliable.

Results:

The results proved 18 separate images of 75x75 pixels can be successfully recorded in the same area of the data volume (see figure 4).

These results showed scope to push this method further and recording and readouts using a 10 layer medium were accomplished. The clarity of the results, combined with the fact that a continuous waver laser or laser diode can be used to produce the same effect, proved that the processes are commercially feasible.

A major benefit to this technique of multiplexing is improved security through encryption that is invaluable to a variety of industries. Existing technology in optical recording can also be used. Information can be recorded on a gold nanorod medium at 1Gbits^{-1} when a high repetition rate laser is used. These high recording speeds are achievable by low energy laser pulses. This avoids thermal effects that distort the information that is recorded.

The findings showed a three layer medium of a DVD size disk can hold 1.6 Tbytes of information. A 7.2 Tbyte disk could potentially be achieved through a 10 layer disk with spacing of 1µm.

Conclusions:

It is not normal, especially in a saturated IT industry, to come across a vastly improved recording technique through increased information density, as well as the ability to use existing drive technologies. The only major barrier is a lack of recording medium. There are many advantages to this recording process, including high capacity disks, improved encryption and faster recording speeds. Once a more abundant medium is found that can produce similar results, this will become a large part of computer technology.