Application Note

The characteristics of a laser for holography

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Holography is a science of creating and recording light patterns that result from interference between two light beams, one (the reference beam) is directly incident on the recording media, the second (object beam) has interacted somehow (transmitted through or reflected from) the subject of the study. Rather than an image as recorded by standard photography, a holographic image is a record of the phase and amplitude intensities of the two paths as they arrive at the recording media. (Fig.1) The resultant image when seen under normal light is a meaningless and random pattern of variations in opacity. When illuminated by a suitable light source, the light path is recreated, and the original object can be seen as if it were still present. Fine detail, dimensions and of course the 3D nature of the object is almost exactly reproduced.

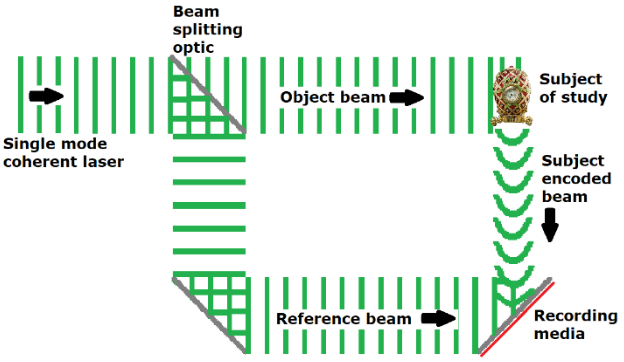

Fig 1. One example set up for holographic recording

Many will recognise holograms as they are used in everyday objects such as credit/bank cards to ensure security, labels that seal boxes proving originality and of course holograms as graphic art. Due to the highly faithful nature of the holographic image, they have also been used to record and show precious items that cannot normally be on display to the public, such as the collections of the Faberge museum in St Petersberg by the Hellenic Institute for holography. (link)

Holography is however more than a technique for secure or unusual image recording and many other applications exist, such as surface metrology, microscopy or data storage also benefit from the science. Holography is key to future developments such as virtual and augmented reality.

As seen from fig 1. The primary light source for holographic applications is a laser for a number of characteristics:

- Coherence length
- Power density
- Wavelength stability
- Wavelength range

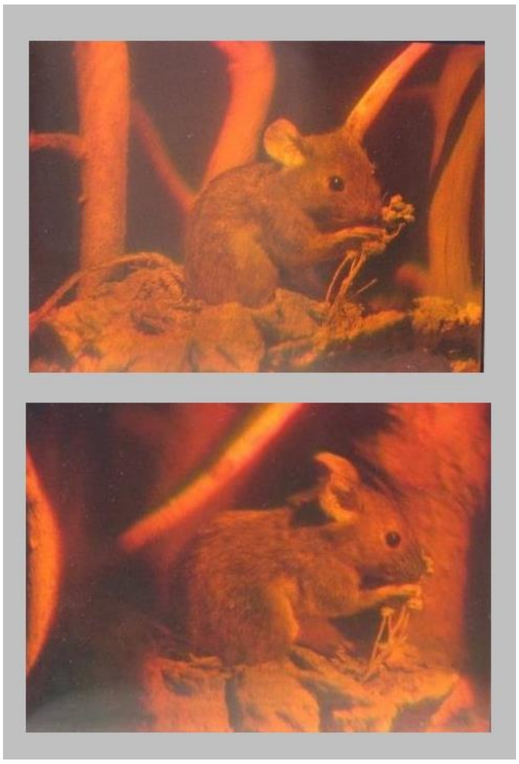

Fig 2. Example of hologram. Two photographs of the same hologram
Holo-Mouse.jpg: Georg-Johann Lay

There are different methods for creating the holographic recording, but the laser is the principle source of the coherent light. Since the "image" creation is based on the phase difference between the two light paths, caused by the object of the study, any phase difference (non-coherence) caused by the laser through multi-mode operation, will either destroy the resolution or severely reduce the available depth of field of the final image. The coherence length (narrow linewidth) of the laser is a key characteristic that needs to be considered in setup design. This is not so critical during the reproduction of holographic plates and the coherence can be much shorter.

Similar to standard photography, creation of an image needs an exposure time, and as with a normal camera, this exposure time is dependent on the sensitivity of the recording media and the amount of light that is available. As the source of light for holography is the laser, higher power outputs offer shorter exposure times and/or larger fields of view. Thought should however be given to the effect of optical power on the object. (Fig 2)

For static objects in a vibration isolated environment, exposure time becomes less critical, and lower power lasers can be considered, however in these cases, wavelength stability and drift of the laser should also be considered. Slight drift or hopping of the wavelength can cause distortion of the image and loss of clarity of the final image.

The final consideration when looking at lasers for holography is the actual wavelength needed for the best results. As mentioned earlier, security patches and labels would be useless if they were recorded in the IR region outside the range of the human eye. The eye however has different sensitivity to different wavelengths through the visible region. Many modern holographic images make use of multiple wavelengths, red green and blue in order to produce a coloured final image.

Other holographic applications that do not rely on the eye as their "reading" apparatus can be operated outside the visible region. Data storage for instance has no need for visibility and would indeed benefit from shorter wavelengths that offer higher density storage.

UniKLasers Ltd

UniKLasers design and manufacture a range of single frequency lasers ideal for the highest demands of holography applications.

Using patented BRaMMS technology, that replaces an end cavity mirror with a volume Bragg grating (VBG) and Michelson interferometer, the combination of which offers ultra-narrow line-widths below 500 kHz, meaning coherence lengths in excess of 100metres, that are stable to picometre levels over 4 hours of operation. Additionally, the high efficiency of the single frequency allows the generation of high power outputs in a wide range of wavelengths covering the UV-Vis-NIR.

- Wavelength range: UV-Vis-NIR
- Line-width: <500 kHz
- Coherence length: >>100 m
- Power: Up to 1.5 W*
- Wavelength stability: As low as 1.1pm* over 4 hours

*Wavelength dependent