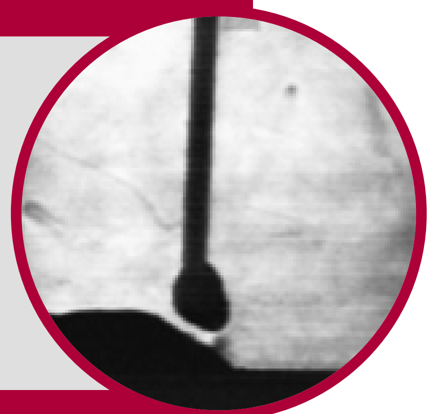
APPLICATIONS brief

OXFORD LASERS
IMAGING DIVISION

Do you image Bright Objects?

Three ways to look deeper...

Arcs and Welding



Explosions

Hot Metal

www.oxfordlasers.com

APPLICATIONS brief

How does it work?

When is it useful?

Imagine trying to study the flow of molten metal in a welding process, or the failure mechanism in a jet engine explosion, or the malfunction of an arcing circuit breaker. The high brightness of such events makes it impossible to see what is happening. VisiBrite technology allows engineers for the first time to “see” through the fireball providing powerful insights into any application which is normally obscured by high brightness.

Spectral filtering

Bright objects emit light over a range of wavelengths, dependent on the temperature of the objects and their chemical composition. Only some of these wavelengths will be detected by a given camera. A typical range for a standard visible-light camera is 350-850 nm. On the other hand, laser illumination is at a very specific wavelength, with a typical width much smaller than 1 nm. This is illustrated in Fig. 1, which shows how the light from a laser lightsource might compare with the light from a bright object. If we illuminate the bright object with the laser and place a filter in front of the camera which only allows the laser light to pass, then we make the bright object much darker, but have little effect on the laser illumination. This is illustrated in Fig. 2. In this way we can achieve a reduction in intensity of a factor of ~125, or 7 photographic stops. This technique is called spectral filtering.

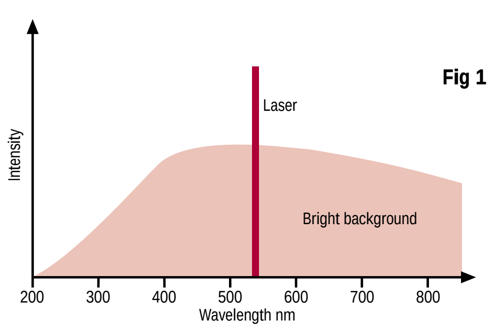


Fig 1

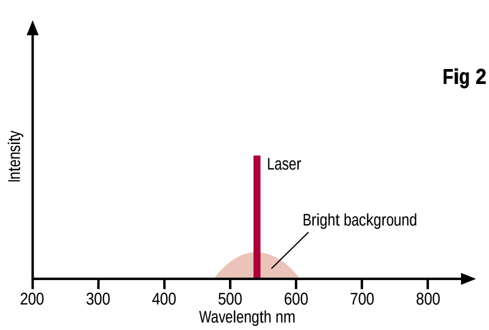


Fig 2

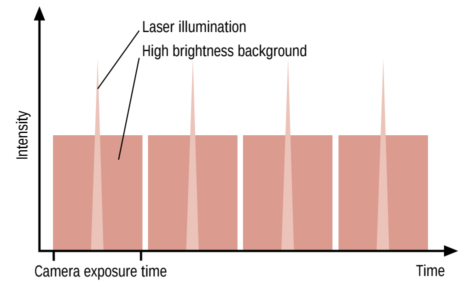


Fig 3

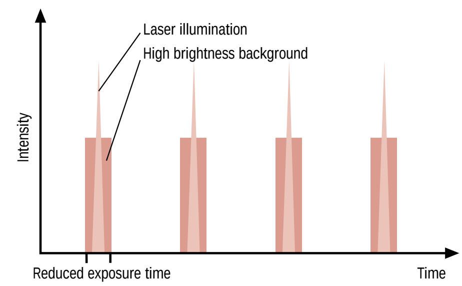


Fig 4

Temporal filtering

Sometimes, spectral filtering alone is not enough to reduce the intensity of the bright object in the image. In this case we can get even more contrast between the laser illumination and the bright subject by using temporal filtering as well. We might use a camera exposure time of 1/10 000 of a second (100 µs), which is the shortest time typically available on electronic cameras. On the other hand we can illuminate with a laser pulse lasting no more than 50 ns. The contributions to the image brightness from the laser and the bright subject are shown in Fig. 3. If, we place a very high speed opto-electronic shutter in front of the camera however, we can reduce the exposure time of each frame to 100 ns, and still capture all of the laser pulse. This is illustrated in Fig. 4. In this case we have reduced the brightness of the bright subject by a factor of 1000, or 10 photographic stops, with no reduction in the apparent brightness of the laser. This technique is known as temporal filtering.

Summary

By using a combination of spatial and temporal filtering, it is possible to reduce the brightness of a bright subject, compared with laser illumination, by a factor of up to 125 000, equivalent to 17 photographic stops. Figures 5 and 6 show how this can be applied to a small indoor firework. In Fig.5 (conventional lighting) we see the light from the flame blinds the camera. But in Fig.6 using VisiBrite technology the melt region ahead of the flame is clearly visible

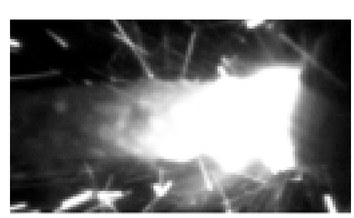


Fig 5

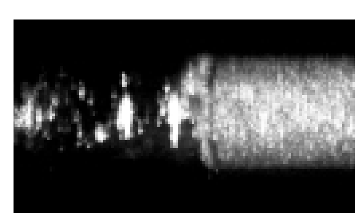


Fig 6

Who’s using it?

Electrical circuit breakers

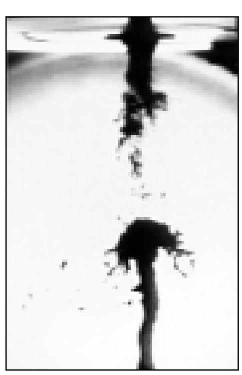
General Electric (GE) of the USA, make a range of industrial circuit breakers. In order to test them and improve performance, they are subjected to very high currents, and a high speed movie made of the opening of the contacts. However, when the current is very large (hundreds of amperes) a powerful electric arc is present, which is so bright the camera is dazzled. This problem cannot be solved by simple filtering because it would make invisible the early part of the process, when no arc was present. Using an Oxford Lasers VisiBrite system, GE were able to totally eliminate the bright arc from the images, and follow the opening process with a high speed video camera.

Aircraft engine tests and other explosions

In order to obtain approval for a new aircraft engine type, destructive testing is used. Explosives are used to break off one of the turbine blades in a running engine. This leads to the complete destruction of the engine and the manufacturers must show that no part of the debris escapes the outer casing of the engine. However, until now the data was very limited because of an intense fireball formed during the test. This blinded the cameras and meant that only the first part of the explosion could be imaged. However, by using Oxford Lasers VisiBrite Technology, engineers at one of the world's leading aircraft manufacturers, have managed to see much later into the explosion – the use of laser illumination simply removed the fireball from the image. In tests like this, it is important to be able to operate from long distances, and in tests with the US army Oxford Lasers has demonstrated that an area greater than 2 meters (7') wide can be studied from a distance of 30 meters (100').

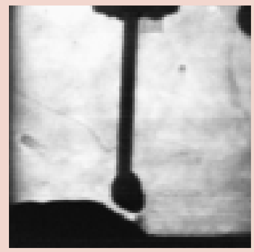
Metal Sprays

Oxford Lasers VisiBrite systems have been used by researchers to study industrial metal sprays. The image right was taken by the United States Department of Energy, and shows the break up of a stream of molten metal, without blinding of the camera on account of intense emission by the subject. Another team at the University of Oxford in the UK, has used VisiBrite imaging to study the deposition and droplet bounce processes involved when metal sprays hit coating targets.



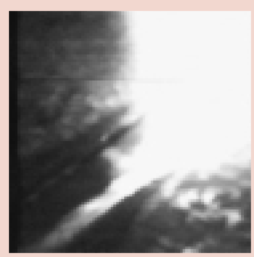
Welding

Visibrite systems have been used to study welding processes in which very bright arcs are present. The image shown here (below) is a still from a high-speed movie taken at 4500 frames per second of an arc welding process. Under normal imaging conditions the arc would completely dominate the image, giving a "white out".



Courtesy Edison Welding Institute/OSU

Below are images of a laser welding process, with and without Visibrite technology. Researchers wanted to study the melt pool behind the weld region. It is clear that in the conventional image no detail is visible, but when the VisiBrite technology was applied the melt pool detail became clear.



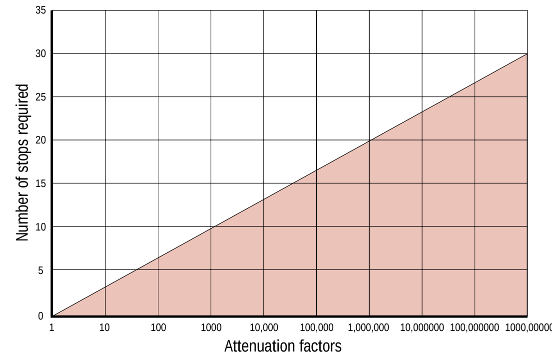
Conventional Image

VisiBrite Image

Which system?

How much attenuation do you need?

Using your current imaging system, by what factor must the brightness be reduced in order to make the bright object in your image disappear? Express your answer in photographic stops. Use the graph (right) to convert from attenuation factors into stops. If you do not know the number of stops you require, please contact Oxford Lasers for an opinion. We have never found an application which requires more than 17 stops. In any case you can continue to the box below "Choose a laser"

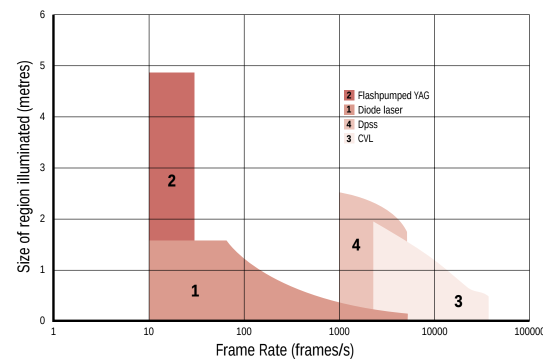


Choose a laser.

Consider the maximum frame rate you will require, and the maximum area you wish to illuminate. Use the graph (right) to pick the lowest numbered laser which is capable of illuminating the area you require at the frame rates you require.

Use the table below to see how many stops of attenuation can be achieved from (wavelength filtering) the laser alone:

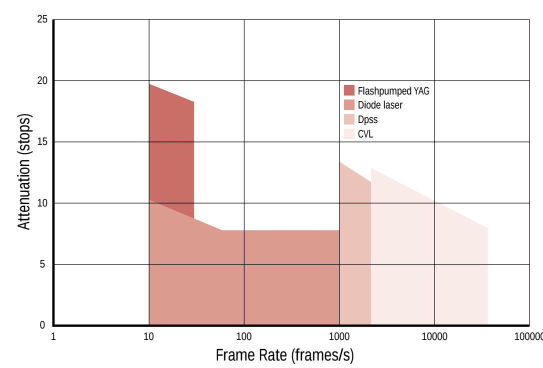
Laser	Attenuation (stops)
Flashpumped YAG	**8**
Diode Laser	**5**
CVL	**8**
DPSS	**8**



Decide whether you also need a high speed shutter.

If you have enough attenuation from wavelength filtering alone, there is no need for a high speed shutter. If not, use the graph below to find the extra attenuation which can be added by using the shutter with the laser type you have chosen.

- More attenuation may be possible if you do not illuminate the maximum area shown in the "Choose a laser" box. Contact Oxford Lasers for details.
- If your camera includes a shutter then it may be possible to achieve some of the attenuation shown above using the camera alone. Contact Oxford Lasers for details.



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