

SYSTEM FOR CAPTURING SCENE AND NIR RELIGHTING EFFECTS IN MOVIE POSTPRODUCTION TRANSMISSION

5 FIELD OF INVENTION

The invention in general relates to the hardware and software solution for postproduction effects.

- 10 In particular the invention relates to the system for capturing scene with the simultaneous use of visible and infra red light for alpha channel creation and relighting effects in movie postproduction.

BACKGROUND OF INVENTION

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- Chroma key compositing or chroma keying, is a special effects/ post-production technique for compositing (layering) two images or video streams together based on color hues (chroma range). The technique has been used in many fields to remove a background from the subject of a photo or video - particularly the newscasting, motion picture and videogame industries.
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The chroma keying technology relies on image manipulation. Information about the foreground object and color range to be removed is recorded within a single video layer.

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- One of the main draw back of the chroma keying technology is that in the process of the color range removal, semi transparent areas and fine details along the edges of the foreground objects are lost. In order to control the same in present chroma keying technology, the chroma keying workflow has been updated by some software solutions (such as Autodesk Flame, Adobe Aftereffects, etc.) and
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development of the greenscreen \ bluescreen surfaces - more precise algorithms for color range removals and development of special fabrics.

5 Apart from the above draw back, the chroma keying technology requires large uniform surfaces (greenscreen \ bluescreen) to create a sufficient chroma difference between foreground and background.

Hence it is required to address the long felt need of providing system for highly automated and precise derivation of alpha channel in order to divide the captured
10 scene into the foreground objects and background

SUMMARY OF THE INVENTION

A system for capturing scene with the simultaneous use IR and VIS light for alpha channel creation and relighting effects in movie postproduction transmission
15 comprising the subsystems of:

- Lighting sub system,
- Electro-optical system for simultaneous acquisition of the video in VIS and NIR, and

20 Video post-processing converter for generation of alpha channel from the NIR video signal to perform determination between the foreground objects, illuminated with NIR light source and background. Video post-processing converter uses VIS images to obtain information for more precise alpha channel derivation.

25 These and other objects, features and advantages of the present invention will become more apparent from the ensuing detailed description of the invention taken in conjunction with the accompanying drawings.

DESCRIPTION OF DRAWINGS

30 The present invention will be understood and appreciated more fully from the following detailed description taken in conjunction with the appended drawings in which:

Figure 1.A illustrates a schematic diagram of the invention wherein

1. Light
2. Image sensor sensitive to IR
- 5 3. Image sensor sensitive to VIS
4. Lens
5. Infrared video acquisition unit
6. VIS Camera

10 **Figure 1.B** illustrates the details of optical drivers, wherein:

1. Light
2. Color splitting system (eg. prism, mirror)
3. Relay optics (optical system to keep the focal length of lens)
4. Relay optics (optical system to keep the focal length of lens)
- 15 5. Bandpass interference filter
6. Image sensor sensitive to IR light
7. Software processing unit / output module
8. IR
9. VIS

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Figure 2 illustrates a schematic diagram of the invention, wherein

1. Foreground
2. VIS lights
- 25 3. IR lights
4. VIS camera with infrared video acquisition unit
5. IR Light ramp detail
- 5.1. IR Lights
- 5.2 Hinges

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Figure 2A illustrates a schematic diagram of an embodiment of the camera of the invention, wherein

1. Light
2. Hot mirror
- 5 3. Lens
4. Narrowband filter
5. DSLR camera VIS
6. DLSR modified camera IR

10 **Figure 3A and 3B.** Illustrates the difference between VIS and IR image.

Figure 4A Illustrates image sensor sensitive used in one of the embodiment of the invention.

15 **Figure 4B** Illustrates Foveon image sensor with the addition of layers of IR used in another of the embodiment of the invention.

Persons skilled in the art will appreciate that elements in the figures are illustrated for simplicity and clarity and may have not been drawn to scale. For example, the dimensions of some of the elements in the figures may be exaggerated relative to
20 other elements to help to improve understanding of various embodiments of the present invention.

Terms and their definitions:

25 Alpha Channel - black and white video channel used to determine transparency of video layers.

Chroma Keying - Current method of creation of an alpha channel based on calculation of the chroma difference between background and foreground objects.

30 Color range of the top layer of the composite image is made transparent by software manipulation in postproduction.

Greenscreen / Bluescreen - Requirement for the chroma keying process. Uniform and evenly lit background of the scene.

VIS/NIR/IR - Specifies various wavelength ranges of light as electromagnetic radiation, where VIS stands for visible light (wavelength range 390nm - 750nm), NIR stands for invisible near infrared light (wavelength range 750nm - 1400nm), and IR stands for invisible infrared light (wavelength range 750nm - 1mm).

DETAILED DESCRIPTION OF THE INVENTION

The preferred embodiments of the present invention will now be explained with reference to the accompanying drawings. It should be understood however that the disclosed embodiments are merely exemplary of the invention, which may be embodied in various forms. The following description and drawings are not to be construed as limiting the invention and numerous specific details are described to provide a thorough understanding of the present invention, as the basis for the claims and as a basis for teaching one skilled in the art about making and/or using the invention. However in certain instances, well-known or conventional details are not described in order not to unnecessarily obscure the present invention in detail.

The invention provides for a system for highly automated and precise derivation of alpha channel in order to divide the captured scene into the foreground objects and background.

In an embodiment of the invention, the invention comprises of the following three main subsystems:

(A) Lighting sub system comprising of narrowband/monochromatic light sources in NIR (near infrared range) of light spectrum and common studio lights in VIS (visible part) of the spectrum (preferably fluorescent tubes),

(B) Electro-optical system for simultaneous acquisition of the video in VIS (color RGB video acquisition) and NIR (tuned to the same wavelength as the NIR light source using narrowband interference filter), and

- 5 (C) Video postprocessing converter optimized for generation of alpha channel from the NIR video signal in order to perform near-to-perfect determination between the foreground objects (illuminated with NIR light source) and background.
- 10 The above described system can effectively replace the common chroma-keying technique without the need of any special background on the scene e.g. blue-screen or green-screen.
- 15 The principle of the invention can be described as follows. The object is placed within the FOV (field of view) of the special camera sensitive to two part of the spectrum - NIR (near infrared range) and VIS (visible light). The camera produces two output video signals, which are available separately at the output of the system as a common color video signal for the VIS part of the spectrum and a
- 20 grayscale video signal for the NIR part of the spectrum.

The object is illuminated simultaneously with the special lighting system emitting the light in the VIS and NIR parts of the spectrum. The NIR lights are narrowband and tuned to a particular wavelength. This property can be achieved preferably by

25 an array of NIR LEDs emitting light with central wavelength for example of 850nm and having very narrow spectrum width (full-width, half-maximum FWHM) of few nanometers. The wavelength is selected in order to reach still high sensitivity in this spectral region for common silicon based camera sensors. At the same time this wavelength is practically invisible for a human eye and also

30 common VIS color cameras have negligible sensitivity for the same wavelength.

The LED array is formed in the way to create focused beam of the NIR light directed on the object and minimizing reflections from other objects behind. The LED array allows stepwise or continuous power level control in order to set the required dynamic range in acquired video signal and at the same time conforming
5 hygienic limits on emitted power in the case if the object is a human being or an animal. The object is at the same time illuminated with a common VIS studio lighting system. This system should be based on fluorescent tubes to minimize emitted power in the NIR part of the spectrum. This VIS light is directed on the object to obtain desired image captured by the VIS camera. This procedure is done
10 in a way common in the film production conforming technical and aesthetic rules. The VIS and NIR light is reflected by the object. Since the NIR light is directed only on the foreground object there are no other reflections from other objects in the scene covered in the FOV or these are negligible. The reflection of VIS light from other objects than the foreground one is allowed. The mixture of reflected
15 light in the VIS and NIR part of the spectrum passes through the objective lens. Afterwards it enters a multispectral optical subsystem.

The multispectral subsystem consists of a relay lens to extend the optical path so that the object is projected sharply to the focal plane of both image sensors for the
20 VIS and NIR cameras. The light beam is then divided by a prism coated for the VIS part of the spectrum with wavelengths up to 700nm and NIR part of the spectrum with wavelengths above 700nm. Both NIR and VIS light beams then pass again through relay lenses to have the object properly focused on the image sensors. The NIR beam is then filtered with a narrowband interference filter tuned
25 to the same wavelength as emitted by the NIR light source, preferably 850nm. The spectral width of the filter (full-width, half-maximum FWHM) should be the same as the width of the used NIR LEDs so that the sensitivity of the NIR camera to VIS part of the spectrum is considerably reduced. This particular alternation causes that only the objects illuminated by the beam of the NIR light source will
30 be captured by the NIR camera, other parts of the scene in the FOV will stay considerably underexposed, which is a key characteristic for a successful mask

creation. Video acquisition, at NIR and VIS run simultaneously with the same framerates and in synchronism. Due to the splitting prism there is no interference with the NIR light sources and the image of the object depends solely on the setup of the VIS light source.

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The unique combination of lighting and electro-optical video capturing system introduced in this invention creates at the same time well exposed image of the object in colors and high contrast mask. Since most of the common objects including human skin and hair have high reflectivity in NIR part of the spectrum, the alpha channel obtained from the NIR camera can be used for easy decomposition of the captured color image into the foreground object (almost white level) and background (almost black). Even with optimized design of optical and electronic part of the system there are imperfections especially in the spatio-temporal alignment of the captured color VIS and NIR video sequences. The generation of a precise keying mask can be also deteriorated by a noise introduced especially at low light levels.

The another part of the system consists of a set of real time video post processing converter designed to overcome the above mentioned issues and get a masking signal from the NIR camera with a very precise spatio-temporal alignment to the VIS image.

Several experiments have been conducted to test the functionality of the invention. In an embodiment of the invention it comprises of two identical DSLR (digital single lens reflex) cameras (such as Canon 550D). One of the cameras has been modified by removing the IR blocking filter to enhance its sensitivity to the invisible NIR spectra. In order to comply with a perspective of the captured scene in VIS and NIR, the two cameras must have a common optical axis. This has been achieved by using a suitable optical element that splits the incoming light to the direction of the lenses of both cameras. In order to maximize efficiency, the hot-mirror configuration for 45 degrees to the incident rays has been used. A

narrowband interference filter has been placed in front of the lens of the modified NIR DSLR camera to select specific wavelength corresponding to the used NIR lighting. (Figure 3)

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In other embodiment of the invention the lighting of the scene in the NIR has been done with arrays of IR LEDs 850nm common in surveillance systems.

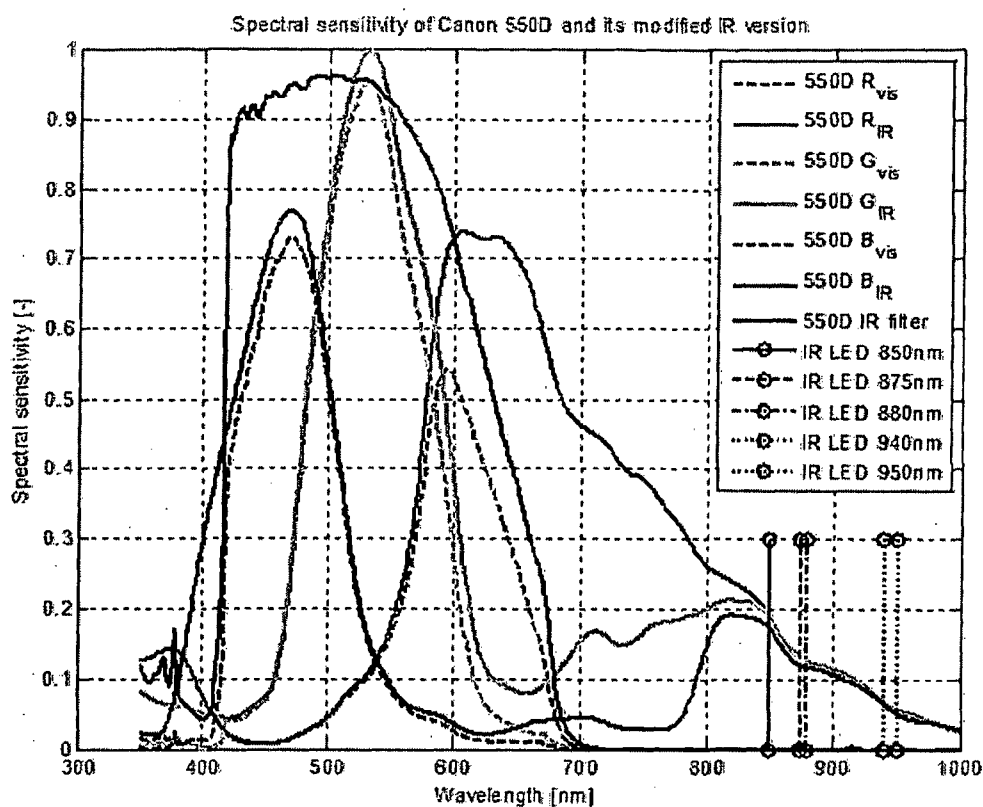
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In another embodiment of the invention the detailed measurements of the spectral sensitivity of individual color channels have been carried out on a modified Canon 550D camera (with removed dust and an IR blocking filter). For comparison, a calculation was performed for the spectral sensitivity of the modified Canon 550D. Results of this measurement have been essential for selecting wavelength of LED used in the array. The measured spectral response curves are shown in the graph below. Spectral sensitivity is standardized to the maximum in the green channel.

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The curves labeled VIS correspond to the spectral sensitivity curves of the unaltered camera and the ones labeled as IR to a modified Canon 550D device. The VIS camera has a wavelength range 430-605nm for a fall to 50% and 415-675nm for a fall to 10% compared to the maximum sensitivity in the green channel. The modified device, the NIR camera, has a range of wavelengths 425-685nm for the fall to 50% and 380-920nm for the fall to 10% compared to the maximum sensitivity in the green channel. The measured curve clearly demonstrates the significant extension of the wavelength range of the NIR camera, especially in the red channel R. In the range of 700-820nm there is a significant increase in sensitivity only in red channel. In the range of 820-1000nm the sensitivity of each channel R, G and B is practically the same. These findings have been illustrated in the Graph 1, below.

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- 5 The plot of the spectral sensitivity of the modified NIR Canon 550D shows the corresponding spectral lines for the IR LED 850, 875, 880, 940 and 950nm. It is obvious that a good compromise between the separation of the visible spectrum and sensitivity is at the wavelength of 850nm. At this wavelength the spectral sensitivity in each channel is approximately equal to 20% of the peak in the green channel.
- 10 channel.

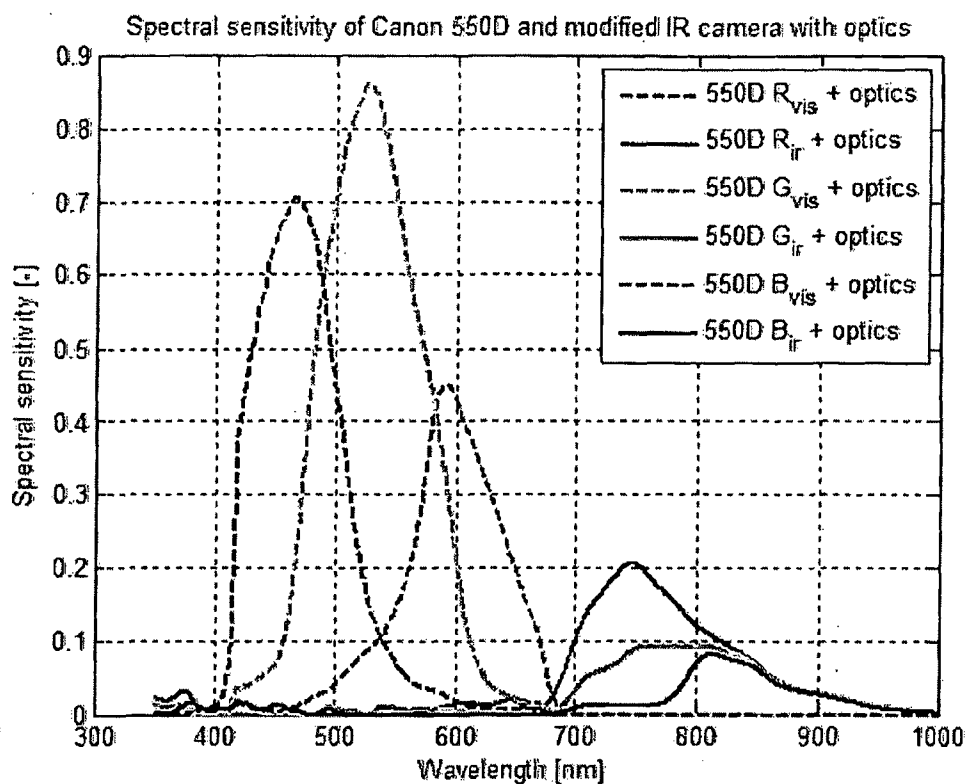
Original VIS camera reaches almost zero sensitivity at this wavelength. A possible alternative would be to use an IR LED with a wavelength between 750 and 850nm. There is, however risk of slight interference between the sensitivity of

15 VIS and NIR camera. Moreover the light at this wavelength the light can be seen with the human eye.

In another embodiment of the invention, to verify the suitability of individual LEDs and their respective wavelengths the test IR LED array has been constructed in the wavelength range of 850-950nm. The LED array has been powered at the same current for all the LEDs. The array has been photographed with original VIS
5 and modified NIR Canon 550D camera (Figure 3.).

The two images compare the result obtained in acquisition with the modified NIR and original VIS cameras. It confirms the above mentioned measurements of spectral sensitivity. All the NIR LEDs (850-950nm) are dark in the image from
10 the original VIS camera. In the image from the modified VIS camera it is clear that it achieves higher sensitivity for the shorter wavelength (850nm LED Left, Right LED 950 nm).

In yet another embodiment of the invention the LED with a wavelength of 850nm
15 has been chosen as the most suitable based on this test. Combined spectral sensitivity of the camera Canon 550D (modified NIR and original VIS) and spectral transmission of optical components (hot-mirror filter and lens) has been calculated. The curves of the spectral sensitivity of individual color channels R, G and B are shown in the plot below. The use of optical components causes only
20 negligible variation of the spectral sensitivity in VIS. This variation is fully covered by the white balance correction. Spectral sensitivity of the modified NIR camera is reduced by the optics. Maximum sensitivity is in the red channel for a wavelength of 750nm. For a wavelength of 850nm (used NIR light source) is approximately the same for all channels and reaches 6% of the maximum
25 sensitivity, which means lower sensitivity approximately by 4EV in NIR channel. Moreover a Zeiss narrowband interference filter has been used with a peak transmission at 850nm in the NIR channel. The findings have been illustrated in the Graph 2, below.



Graph 2

- 5 In yet another embodiment of the invention an array of NIR LEDs has been used. These lamps are common in surveillance applications. It is very important for these lights to verify the hygienic limits. Three lamps have been used in the particular test with angle 30 degrees, power 9W, 96 NIR LEDs at wavelength of 850nm.

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The prototype has been used to capture test video sequences for various conditions in a film production environment. The obtained results show high performance of the prototype even with present spatiotemporal alignment errors. These errors were corrected using standard video post processing tools.

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In yet another embodiment of the invention, the invention comprising of a camera with two image sensors, with a color splitting system (NIR/VIS), common RGB

image sensor and image sensor sensitive to NIR light at particular wavelength (Figure 4.A.). The whole image sensing system is built in one camera body. The light beam coming through the objective lens is divided by a color splitting system into VIS and NIR beams focused on two image sensors. The VIS light is captured
5 by a common color image sensor with CFA (color filter array) with R, G, B filters. The NIR light is captured by an image sensor preferably with the same area and number of detectors as for the VIS light. There is no infrared blocking filter in the NIR channel but a narrowband NIR filter to achieve peak in the spectral sensitivity at the same wavelength as emitted by the used array of NIR LEDs. This
10 embodiment has advantage that there is no need of relay optics.

In yet another embodiment of the invention the invention comprising of a special designed image sensor that will have CFA (color filter array) with R, G, B and IR filters for a single-sensor camera configuration or Foveon image sensor with the
15 addition of layers of IR as illustrated in Figure 4.B.). The color filters are needed because the photo sensor itself detects the light with almost no wavelength specificity, and therefore color information cannot be separated. If the CFA consisting of a mosaic of color filters is placed in front of the image sensor then the sensitivity of each particular detector on the sensor is modified by the spectral
20 transparency of the filters in the CFA. Usually these filters are primaries Red, Green and Blue to give information about the intensity of light in red, green and blue color channel.

The full color image is then obtained from the raw data by an interpolation
25 technique, called demosaicing. The modified CFA, where some of the R, G or B filters are changed for a narrowband NIR filter will allow a single sensor implementation of the invention. In this case, both, a color video in VIS and a grayscale video in NIR are captured by a single sensor with no need of a color splitting prism or mirror.

The present invention provides an advantage in the clarity of the resulting alpha channel and its real-time recording. It creates the alpha channel directly from the narrowband NIR light reflected by the foreground object. This solution provides near-to-perfect detail level along the edges of the object and eliminates the
5 necessity of any sort of uniform background with chroma difference. Software manipulation is not required to calculate the chroma or contrast difference in order to create an alpha channel from VIS video layer, resulting in loss of details along the edges of the foreground object.

10 This gives considerable advantage both in simplified set construction and in cutting down the time required needed for image postproduction.

While the present invention is described above in connection with preferred or illustrative embodiments, these embodiments are not intended to be exhaustive or limiting of the invention. Rather, the invention is intended to cover all
15 alternatives, modifications and equivalents included within its scope.

CLAIMS:

1. A system for capturing scene with the simultaneous use of invisible infrared light (IR) and visible light (VIS) for alpha channel creation and relighting effects in movie post-production transmission, the system comprising:
 - a lighting sub system;
 - an electro-optical system for simultaneous acquisition of video in VIS and invisible near infrared light (NIR); and
 - a video post-processing converter for generation of alpha channel from the NIR video signal to determine between a foreground object and a background object, wherein the foreground object is illuminated with a NIR light source,
wherein the electro-optical system comprising at least one camera using at least one of a color filter array, at least one bandpass interference filter tuned to the wavelength at which NIR is emitted by the lighting sub system, and a hot mirror, to split VIS and NIR video signals.
2. The system of claim 1, wherein the video post-processing converter uses VIS images to obtain information for more precise alpha channel derivation.
3. The system of claim 1, wherein the lighting subsystem comprising:
 - at least one narrowband / monochromatic light sources in NIR of light spectrum;
and
 - common studio lights, preferably fluorescent tubes, in VIS of the spectrum.
4. The system of claim 1, wherein the electro-optical system comprising of either:
 - at least two video acquisition units, wherein one unit, referred as a NIR camera, is with enhanced sensitivity to NIR spectra and second unit, referred as a VIS camera, for color RGB video acquisition;
a color splitting system; and

at least one bandpass interference filter used in the NIR camera to select specific wavelength corresponding to the used NIR lighting,

or

- at least one camera with more than one image sensors comprising of a color splitting system (NIR/VIS), a common RGB image sensor, and an image sensor sensitive to NIR light at particular wavelength with optical element to keep the focal length of the lens,

Or

- a camera comprising a special designed image sensor that will have CFA (color filter array) with R, G, B and IR filters for a single-sensor camera configuration wherein the image sensor is either CFA (colour filter array) with R, G, B and IR filters or Foveon image sensor with the addition of layers of IR.
5. The system of claim 4, wherein all the optical cameras have common optical axis, achieved by using the optical element that splits the incoming light to the direction of the lenses of the cameras.
 6. The system of claim 5, wherein in the optical element comprises the hot-mirror which is configured to 45 degrees to the incident rays.