

[0042] The light source 11 emits light within a broad band in visible wavelengths, which could cover targeted excitation wavelengths. In an embodiment, the light source 11 is an LED having a viewing angle of 10 degrees. However, the light source 11 is not limited to the LED, and other kinds of light source, such as mercury lamps and halogen lamps covering visible wavelength are feasible.

[0043] In an embodiment, the illumination unit 1 includes a housing 15, and plural channels are formed in the housing 15 and are positioned linearly. Each channel has its own light source 11, and a pinhole 14 with an aperture of 2 ± 0.5 mm in diameter is provided in front of the coating surface of the first tunable filter 12. For example, as shown in FIG. 1, there are three channels positioned linearly. Certainly, the number of the chambers is not limited to three, and may be varied for different requirement.

[0044] In an embodiment, the material of the housing 15 of the illumination unit 1 is black ABS (acrylonitrile butadiene styrene) for its low thermal conductivity, high thermal resistivity, and reduction of internal light scattering. Other kinds of black plastic materials with low reflectivity, or aluminum coated by black anodized coating possessing low reflectance and high absorptance are feasible.

[0045] In an embodiment, the illumination unit 1 further includes a focusing optics 13 positioned between the first tunable filter 12 and the fluorescence chamber 22. The focusing optics 13 converges the filtered light to the liquid container held in the fluorescence chamber 22. The position of optics offset downward from the optical axis of the light source 11 is around 1.3 ± 0.2 mm, which is optimized to reduce the noise signal. The focusing optics 13 is made of BK7 glass, and other kinds of optical grade polymer are feasible.

[0046] FIGS. 3A, 3B and 3C show the optical paths of the illumination unit when the first tunable filter is rotated at 0, 40 and 75 degrees, respectively, and FIG. 4 shows the superimposed optical paths of FIGS. 3A, 3B and 3C. As shown in FIGS. 2-4, the light provided by the light source 11 passes the pinhole 14 first, and then filtered by the first tunable filter 12. The filtered light is converged by the focusing optics 13 to the liquid container held in the fluorescence chamber 22 to excite the fluorescent dye of the targeted probe.

[0047] The first tunable filter 12 of the illumination unit 1 works as an excitation filter, and the orientation of angular rotation of the first tunable filter 12 faces towards the focusing optics 13. Besides, the pinhole 14 with the aperture of 2 ± 0.5 mm in diameter is required in front of the coating surface of the first tunable filter 12. In an embodiment, the size of the first tunable filter 12 is 6 x 9 x 2 mm for each channel, but its size might change for different applications. The pinhole 14 is required to prevent the excitation light beam at large angle causing scattered light, which is one of the sources of background noise.

[0048] FIG. 5 shows the spectra of the first tunable filter of the illumination unit. As shown in FIG. 5, the spectrum of the first tunable filter 12 is gradually shifted to shorter wavelength areas when the rotation angle of the first tunable filter 12 increases. The maximum pass band is around 60 nm. By selecting the proper fluorescent dyes, the illumination unit 1 could excite a series of fluorescent mixtures falling within the spectra range. It provides higher flexibility of dye selection for potential customers.

[0049] In an embodiment, the first tunable filter 12 includes an angle variable filter (AVF). The peak wavelength of the first tunable filter 12 shifts up to 60 nm for its rotation. However, other types of tunable filter might be applied, such as linear variable filter. Linear shift of this kind of filter in front of the optical

WHAT IS CLAIMED IS:

1. A multi-color fluorescence detection device, comprising:

a fluorescence chamber adapted for accommodating a fluorescent mixture;

an illumination unit comprising at least one light source and at least one first tunable filter, wherein the light source provides a broad band illumination, and the first tunable filter passes light at different pass bands to excite the fluorescent mixture based on locations or angles of the first tunable filter;

a detection unit comprising at least one second tunable filter and at least one photo-detector, wherein the second tunable filter passes light emitted from the fluorescent mixture at different pass bands based on locations or angles of the second tunable filter, and the photo-detector receives fluorescent signals and converts the fluorescent signals to electrical signals; and

an actuation unit adapted for driving the first tunable filter and the second tunable filter to different locations or angles to control variations of pass bands for excitation and emission, respectively.

2. The multi-color fluorescence detection device according to claim 1 wherein the first tunable filter of the illumination unit and the second tunable filter of the detection unit both comprise an angle variable filter or a linear variable filter.

3. The multi-color fluorescence detection device according to claim 1 wherein the maximum pass band of the first tunable filter of the illumination unit and the second tunable filter of the detection unit is 60 nm.

4. The multi-color fluorescence detection device according to claim 1 wherein the light source is an LED.

5. The multi-color fluorescence detection device according to claim 1 wherein a pinhole is provided in front of the first tunable filter in an optical path of the illumination unit.

6. The multi-color fluorescence detection device according to claim 5 wherein the pinhole has an aperture of 2 ± 0.5 mm in diameter.
7. The multi-color fluorescence detection device according to claim 1 wherein the illumination unit further comprises a focusing optics positioned between the first tunable filter of the illumination unit and the fluorescence chamber.
8. The multi-color fluorescence detection device according to claim 7 wherein a position offset of the focusing optics downward from an optical axis of the light source is 1.3 ± 0.2 mm.
9. The multi-color fluorescence detection device according to claim 1 wherein the fluorescence chamber has a front aperture and a rear aperture.
10. The multi-color fluorescence detection device according to claim 1 wherein the front aperture locates 7 degrees tilted clockwise from a direct optical axis.
11. The multi-color fluorescence detection device according to claim 1 further comprising a heater for providing thermal control for the fluorescence mixture.
12. The multi-color fluorescence detection device according to claim 11 wherein the heater comprises a thermoelectric cooling (TEC) heater.
13. The multi-color fluorescence detection device according to claim 1 wherein the detection unit further comprises a condensing optics positioned between the fluorescence chamber and the second tunable filter of the detection unit.
14. The multi-color fluorescence detection device according to claim 1 wherein the detection unit further comprises an imaging optics positioned between the second tunable filter and the photo-detector of the detection unit.
15. The multi-color fluorescence detection device according to claim 1 wherein the photo-detector comprises a silicon photodiode.
16. The multi-color fluorescence detection device according to claim 1 wherein the actuation unit comprises a servo motor, a rotary actuator driven by fluid or vacuum

pressure, a piezoelectric (PZT) actuator, an electro-actuated polymer (EAP) actuator, or an electromagnetic motor.

17. The multi-color fluorescence detection device according to claim 1 further comprising plural channels positioned linearly, each of which has its own light source, fluorescence chamber, photo-detector and a pair of first and second tunable filters.

18. The multi-color fluorescence detection device according to claim 1 further comprising plural channels positioned linearly, each of which has its own light source, fluorescence chamber and photo-detector, wherein a single pair of first and second tunable filters is moved to scan through the plural channels in turn.

19. The multi-color fluorescence detection device according to claim 1, wherein the first tunable filter of the illumination unit and the second tunable filter of the detection unit both comprise an angle variable filter.

20. The multi-color fluorescence detection device according to claim 1, wherein the actuation unit has plural configurations for detecting plural fluorescent dyes respectively.