Claims

1. A film comprising:

   one or more types of nanostructures; and

   one or more types of ligands bonded to the one or more types of nanostructures;

   wherein the one or more types of nanostructures comprise neodymium (Nd) and ytterbium (Yb); and

   wherein a ratio of a molar concentration of neodymium (Nd) to a molar concentration of ytterbium (Yb) is more than 1 : 1.

2. The film according to claim 1,

   wherein a first emission with a first wavelength of 806 nm by the film in response to the film under radiation of only the near infrared (NIR) light is less than a second emission with the first wavelength of 806 nm by the film in response to the film under radiation of both the near infrared (NIR) light and the mid infrared (MIR) light; and

   wherein a first emission with a second wavelength of 980 nm by the film in response to the film under radiation of only the near infrared (NIR) light is more than a second emission with the second wavelength of 980 nm by the film in response to the film under radiation of both the near infrared (NIR) light and the mid infrared (MIR) light.

3. The film according to claim 1 or claim 2,

   wherein a first emission with a third wavelength of 866 nm by the film in response to the film under radiation of only the near infrared (NIR) light is less than a second emission with the third wavelength of 866 nm by the film in response to the film under radiation of both the near infrared (NIR) light and the mid infrared (MIR) light.

4. The film according to any claim 1 or claim 2,

wherein a first emission with a third wavelength of 866 nm by the film in response to the film under radiation of only the near infrared (NIR) light is more than a second emission with the third wavelength of 866 nm by the film in response to the film under radiation of both the near infrared (NIR) light and the mid infrared (MIR) light.

5. A mid infrared (MIR) detection system comprising:

a film comprising:

one or more types of nanostructures; and

one or more types of ligands bonded to the one or more types of nanostructures;

a near infrared (NIR) source configured to provide near infrared (NIR) light to the film; and

a detector;

wherein the one or more types of nanostructures comprise neodymium (Nd) and ytterbium (Yb);

wherein a ratio of a molar concentration of neodymium (Nd) to a molar concentration of ytterbium (Yb) is more than 1 : 1;

wherein the detector is configured to determine a first emission at a first wavelength from the film when the film is under radiation of only the near infrared (NIR) light, and a second emission at the first wavelength from the film when the film is under radiation of both the near infrared (NIR) light and mid infrared (MIR) light, the mid infrared (MIR) light from a mid infrared (MIR) source; and

wherein the detector is further configured to determine a first emission at a second wavelength from the film when the film is under radiation of only the near infrared (NIR) light, and a second emission at the second wavelength from the film when the film is under radiation of both the near infrared (NIR) light and the mid infrared (MIR) light.

6. The mid infrared (MIR) detection system according to claim 5,
wherein the mid infrared (MIR) source is a blackbody or a mid infrared (MIR) laser.

7. The mid infrared (MIR) detection system according to claim 5 or claim 6,
wherein the first wavelength is 806 nm and the second wavelength is 980 nm.

8. The mid infrared (MIR) detection system according to any one of claims 5 to 7, further comprising:

the mid infrared (MIR) source.

9. The mid infrared (MIR) detection system according to any one of claims 5 to 8, further comprising:
a first lens configured to direct the mid infrared (MIR) light from the mid infrared (MIR) source to the film;
a beam splitter; and
a second lens;
wherein the beam splitter is configured to direct the near infrared (NIR) light from the near infrared (NIR) source to the second lens; and
wherein the second lens is configured to direct the near infrared (NIR) light from the beam splitter to the film.

10. The mid infrared (MIR) detection system according to claim 9, further comprising:
a third lens configured to direct the emission of the first wavelength and the emission of the second wavelength from the film to the detector.

11. The mid infrared (MIR) detection system according to any one of claims 5 to 10,
wherein the detector is a spectrometer.

12. The mid infrared (MIR) detection system according to any one of claims 5 to 11, wherein the detector comprises a bandpass filter.

13. A method of forming a film, the method comprising:

forming one or more types of nanostructures with one or more types of ligands bonded to the one or more types of nanostructures;

wherein the one or more types of nanostructures comprise neodymium (Nd) and ytterbium (Yb); and

wherein a ratio of a molar concentration of neodymium (Nd) to a molar concentration of ytterbium (Yb) is more than 1 : 1.

14. A method of forming a mid infrared (MIR) detection system, the method comprising:

forming a film comprising:

one or more types of nanostructures; and

one or more types of ligands bonded to the one or more types of nanostructures;

arranging a near infrared (NIR) source configured to provide near infrared (NIR) light to the film; and

providing a detector;

wherein the one or more types of nanostructures comprise neodymium (Nd) and ytterbium (Yb);

wherein a ratio of a molar concentration of neodymium (Nd) to a molar concentration of ytterbium (Yb) is more than 1 : 1;

wherein the detector is configured to determine a first emission at a first wavelength from the film when the film is under radiation of only the near infrared (NIR) light, and a second emission at the first wavelength from the film when the film is under radiation of both the near infrared (NIR) light and mid infrared (MIR) light, the mid infrared (MIR) light from a mid infrared (MIR) source; and

wherein the detector is further configured to determine a first emission at a second wavelength from the film when the film is under radiation of only the

near infrared (NIR) light, and a second emission at the second wavelength from the film when the film is under radiation of both the near infrared (NIR) light and the mid infrared (MIR) light.

15. A method of operating a mid infrared (MIR) detection system, the method comprising:

providing only near infrared (NIR) light using a near infrared (NIR) source to a film and determining a first emission at a first wavelength and a first emission at a second wavelength from the film using a detector; and

providing the near infrared (NIR) light using the near infrared (NIR) source and mid infrared (MIR) light using a mid infrared (MIR) source to the film and determining the second emission at the first wavelength and the second emission at the second wavelength from the film using the detector;

wherein the film comprises:

one or more types of nanostructures; and

one or more types of ligands bonded to the one or more types of nanostructures;

wherein the one or more types of nanostructures comprise neodymium (Nd) and ytterbium (Yb); and

wherein a ratio of a molar concentration of neodymium (Nd) to a molar concentration of ytterbium (Yb) is more than 1 : 1.