CLAIMS:

1. A method of amplifying a nucleic acid molecule and quantify amplification thereof, with a polymerase chain reaction (PCR) or a loop-mediated isothermal amplification (LAMP), through bulk heating a biological enzymatic reaction mixture in solution containing

- a nucleic acid template,
- a polymerase enzyme, and
- chemically modified nanoparticles comprising nanorods of metal, having photo-thermal properties, to promote said PCR or said LAMP, comprising:
    a) irradiating said chemically modified nanoparticles with an activation light beam from a continuous wave laser, a LED light source, or a combination thereof, to provide excitation for a period of time to activate said photo-thermal properties of said chemically modified nanoparticles, such that said chemically modified nanoparticles release heat sufficient to provide said heating to the whole reaction mixture in solution and promote said PCR or said LAMP, and
    b) irradiating said biological enzymatic reaction mixture, during an annealing step, an elongation step, or both, with an ultraviolet (UV) light source and measuring a transmission change in UV light transmission therefrom to quantify amplification of said nucleic acid template, wherein said irradiating is for a duration and at an intensity sufficient to measure a free nucleotide concentration therein, while avoiding inhibition of amplification of said nucleic acid molecule.

2. The method of claim 1, wherein said PCR is a reverse transcriptase (RT) PCR, or said LAMP is a RT LAMP.

3. The method of claim 1, wherein the metal is selected from the group consisting of Au, Ag, Pd, Pt, Fe, Cu, Al, and Zn.

4. The method of claim 3, wherein said metal is gold.

5. The method of any one of claims 3 - 4, wherein said nanoparticles are gold nanorods.

6. The method of any one of claims 1 to 5, wherein said photo-thermal properties comprise a localized plasmon resonance at a surface of the chemically modified nanoparticles,

and said activation light beam has a wavelength corresponding to said localized plasmon resonance.

7. The method of any one of claims 1 to 6, wherein said chemically modified nanoparticles are chemically modified by a chemical compound that prevents the inhibition of an active site of said polymerase enzyme.

8. The method of claim 7, wherein the chemical compound that prevents the inhibition of the active site of said polymerase enzyme is polyethylene glycol.

9. The method any one of claims 1 to 8, wherein the step of irradiating comprises adjusting a power of said activation light beam to regulate temperature of said biological enzymatic reaction mixture in solution through controlled heat release from said chemically modified nanoparticles.

10. The method of any one of claims 1 to 9, wherein said continuous wave laser is a compact laser.

11. The method of claim 10, wherein said compact laser is a fibre-coupled laser, a vertical-cavity surface-emitting laser (VCSEL), or a combination thereof.

12. The method of claim 10, wherein said compact laser is a VCSEL.

13. The method of any one of claims 10 - 12, wherein said activation light beam from said compact laser is provided from a distance of ≤ 5 mm from said biological enzymatic reaction mixture.

14. The method of claim 13, wherein said activation light beam from said compact laser is provided from a distance of from ~~about~~ 1 mm to ~~about~~ 5 mm from said biological enzymatic reaction mixture.

15. The method of claim 13, wherein said activation light beam from said compact laser is provided from a distance of from ~~about~~ 3 mm to ~~about~~ 5 mm from said biological enzymatic reaction mixture.

16. The method of claim 13, wherein said activation light beam from said compact laser is provided from a distance of ~~about~~ 5 mm from said biological enzymatic reaction mixture.

17. The method of any one of claims 1 to 16, further comprising a step of monitoring said bulk heating.

18. The method of claim 17, wherein monitoring said bulk heating is performed with an infrared thermometer.

19. The method of any one of claims 1 to 18, wherein said monitoring is during annealing step.

20. The method of any one of claims 17 to 18, wherein said monitoring is during said elongation step.

21. The method of any one of claims 1 to 20, wherein said duration is from ~~about~~ 10 ms to ~~about~~ 1000 ms, preferably 30 ms.

22. The method of claim 20, wherein said intensity is from ~~about~~ 0.5 to ~~about~~ 1 mW.

23. The method of any one of claims 1 - 22, wherein said UV light source emits light having a wavelength of from ~~about~~ 175 nm to ~~about~~ 350 nm.

24. The method of any one of claims 1 - 22, wherein said UV light source emits light having a wavelength of from ~~about~~ 240 nm to ~~about~~ 350 nm.

25. The method of any one of claims 1 - 22, wherein said UV light source emits light having a wavelength of from ~~about~~ 260 nm to ~~about~~ 280 nm.

26. The method of any one of claims 1 - 22, wherein said UV light source comprises a plurality of UV light source, configured to irradiate a plurality of nucleic acid sample.

27. The method of any one of claims 1 to 26, wherein said transmission change in UV light transmission is measured with a photodetector.

28. The method of any one of claims 1 to 27, wherein UV light from said UV light source is focused through an optical lense, a light pipe, or a combination thereof.

29. The method of any one of claims 27 to 28, wherein UV light from said UV light source is focused through a light pipe onto said photodetector.

30. The method of any one of claims 1 to 31, wherein said method is performed in real-time.

31. A system for performing a polymerase chain reaction (PCR) or a loop-mediated isothermal amplification (LAMP) of a nucleic acid molecule and quantify amplification thereof, the system comprising:

a) at least one nucleic acid sample containing
   - a nucleic acid template,
   - a polymerase enzyme, and
   - chemically modified nanoparticles comprising nanorods of metal, having photo-thermal properties, to promote said PCR or said LAMP;

b) a thermal cycler in thermal communication with said at least one nucleic acid sample;

c) a continuous wave laser<u>, a LED light source, or a combination thereof,</u> configured to irradiate said at least one nucleic acid sample and provide excitation for a period of time to activate said photo-thermal properties of said chemically modified nanoparticles;

d) an ultraviolet (UV) light source configured to irradiate said at least one nucleic acid sample;

e) a photodetector configured to measure the transmission changes in UV light absorbance from said at least one nucleic acid sample,

f) a processor for analyzing said change transmission changes in UV light transmission and quantify amplification of said nucleic acid template.

32. The system of claim 31, wherein said UV light source is a UV light emitting diode (LED).

33. The system of any one of claims 31 - 32, wherein said UV light source emits light having a wavelength of from ~~about~~ 175 nm to ~~about~~ 350 nm.

34. The system of any one of claims 31- 32, wherein said UV light source emits light having a wavelength of from ~~about~~ 240 nm to ~~about~~ 350 nm.

35. The system of any one of claims 31- 32, wherein said UV light source emits light having a wavelength of from ~~about~~ 260 nm to ~~about~~ 280 nm.

36. The system of any one of claims 31- 35, wherein said system comprises a plurality of UV light source, configured to irradiate a plurality of nucleic acid sample.

37. The system of any one of claims 31- 35, wherein said system comprises a plurality of photodetector, configured to measure absorbance from a plurality of nucleic acid sample.

38. The system of any one of claims 31 to 37, wherein UV light from said UV light source is focused through an optical lense, a light pipe, or a combination thereof.

39. The method of claim 38, wherein UV light from said UV light source is focused through a light pipe onto said photodetector.

40. The system of any one of claims 31- 39, wherein the metal is selected from the group consisting of Au, Ag, Pd, Pt, Fe, Cu, Al, and Zn.

41. The system of claim 40, wherein said metal is gold.

42. The system of any one of claims 40 - 41, wherein said nanoparticles are gold nanorods.

43. The system of any one of claims 31 to 42, wherein said photo-thermal properties comprise a localized plasmon resonance at a surface of the chemically modified nanoparticles, and said activation light beam has a wavelength corresponding to said localized plasmon resonance.

44. The system of any one of claims 31 to 43, wherein said chemically modified nanoparticles are chemically modified by a chemical compound that prevents the inhibition of an active site of said polymerase enzyme.

45. The system of claim 44, wherein the chemical compound that prevents the inhibition of the active site of said polymerase enzyme is polyethylene glycol.

46. The system of any one of claims 31 to 45, further comprising a thermometer for monitoring bulk heating of said at least one nucleic acid sample.

47. The system of claim 46, wherein said thermometer is an infrared thermometer.

48. The system of any one of claims 31 to 47, wherein said continuous wave laser is a compact laser.

49. The system of claim 48, wherein said compact laser is a fibre-coupled laser, a vertical-cavity surface-emitting laser (VCSEL), or a combination thereof.

50. The system of claim 48, wherein said compact laser is a VCSEL.

51. The system of any one of claims 31 - 50, wherein said activation light beam from said compact laser is provided from a distance of ≤ 5 mm from said biological enzymatic reaction mixture.

52. The system of claim 51, wherein said activation light beam from said compact laser is provided from a distance of from ~~about~~ 1 mm to ~~about~~ 5 mm from said biological enzymatic reaction mixture.

53. The system of claim 51, wherein said activation light beam from said compact laser is provided from a distance of from ~~about~~ 3 mm to ~~about~~ 5 mm from said biological enzymatic reaction mixture.

54. The system of claim 51, wherein said activation light beam from said compact laser is provided from a distance of ~~about~~ 5 mm from said biological enzymatic reaction mixture.

55. The system of any one of claims 31 to 54, wherein said system provides real-time information ~~about~~ amplification of said nucleic acid template.

56. The system of any one of claims 31 to 55, wherein said PCR is a reverse transcriptase (RT) PCR, or said LAMP is a RT LAMP.

57. A method of amplifying a nucleic acid molecule, with a polymerase chain reaction (PCR) or a loop-mediated isothermal amplification (LAMP), through bulk heating a biological enzymatic reaction mixture in solution containing

- a nucleic acid template,
- a polymerase enzyme, and
- chemically modified nanoparticles comprising nanorods of metal, metallic coated organic nanotubes, or a combination thereof, having photo-thermal properties, to promote said PCR or said LAMP, comprising:
    a) irradiating said chemically modified nanoparticles with an activation light beam from a compact continuous wave laser, a compact LED light source, or a combination thereof, to provide excitation for a period of time to activate said photo-thermal properties of said chemically modified nanoparticles, such that said chemically modified nanoparticles release heat sufficient to provide said heating to the whole reaction mixture in solution and promote said PCR or said LAMP;
    b) quantify amplification by irradiating said biological enzymatic reaction mixture, during an annealing step, an elongation step, or both, with an UV light source and measuring a transmission change in UV light transmission therefrom to quantify amplification of said nucleic acid template, wherein said irradiating is for a duration and at an intensity sufficient to measure a free nucleotide concentration therein, while avoiding inhibition of amplification of said nucleic acid molecule;
    wherein said chemically modified nanoparticles are nanorods of metal.

~~58. The method of claim 59, further comprising step b):~~

~~b) quantify amplification by irradiating said biological enzymatic reaction mixture, during an annealing step, an elongation step, or both, with an ultraviolet (UV) light source and measuring a transmission change in UV light transmission therefrom to quantify amplification of said nucleic acid template, wherein said irradiating is for a duration and at an intensity sufficient to measure a free nucleotide concentration therein, while avoiding inhibition of amplification of said nucleic acid molecule;~~

~~wherein said chemically modified nanoparticles are nanorods of metal.~~

~~59~~58. The method of claim 57, wherein the metallic coated organic nanotubes are selected from the group consisting of carbon nanotubes coated with a metal and multiwalled carbon nanotubes coated with or decorated with a metal.

~~60~~59. The method of any one of claims 57 - ~~59~~58, wherein the metal is selected from the group consisting of Au, Ag, Pd, Pt, Fe, Cu, Al, and Zn.

~~61~~60. The method of claim ~~60~~59, wherein said metal is gold.

~~62~~61. The method of any one of claims ~~60~~ 59 - ~~61~~60, wherein said nanoparticles are gold nanorods.

~~63~~62. The method of any one of claims 57 to ~~62~~61, wherein said photo-thermal properties comprise a localized plasmon resonance at a surface of the chemically modified nanoparticles, and said activation light beam has a wavelength corresponding to said localized plasmon resonance.

~~64~~63. The method of any one of claims 57 to ~~63~~62, wherein said chemically modified nanoparticles are chemically modified by a chemical compound that prevents the inhibition of an active site of said polymerase enzyme.

~~65~~64. The method of claim ~~64~~63, wherein the chemical compound that prevents the inhibition of the active site of said polymerase enzyme is polyethylene glycol.

~~66~~65. The method any one of claims 57 to ~~65~~64, wherein the step of irradiating comprises adjusting a power of said activation light beam to regulate temperature of said biological enzymatic reaction mixture in solution through controlled heat release from said chemically modified nanoparticles.

~~67~~66. The method of any one of claims 57 to ~~66~~65, wherein said compact continuous wave laser is a fibre-coupled laser, a vertical-cavity surface-emitting laser (VCSEL), or a combination thereof.

~~68~~67. The method of claim ~~67~~66, wherein said compact laser is a VCSEL.

~~69~~68. The method of any one of claims ~~67~~ 66 - ~~68~~67, wherein said activation light beam from said compact continuous wave laser is provided from a distance of ≤ 5 mm from said biological enzymatic reaction mixture.

~~70~~69. The method of claim ~~69~~68, wherein said activation light beam from said compact continuous wave laser is provided from a distance of from ~~about~~ 1 mm to ~~about~~ 5 mm from said biological enzymatic reaction mixture.

~~71~~70. The method of claim 69, wherein said activation light beam from said compact continuous wave laser is provided from a distance of from ~~about~~ 3 mm to ~~about~~ 5 mm from said biological enzymatic reaction mixture.

~~72~~71. The method of claim 69, wherein said activation light beam from said compact continuous wave laser is provided from a distance of ~~about~~ 5 mm from said biological enzymatic reaction mixture.

~~73~~72. The method of any one of claims 57 to ~~72~~71, further comprising a step of monitoring said bulk heating.

~~74~~73. The method of claim ~~73~~72, wherein monitoring said bulk heating is performed with an infrared thermometer.

~~75~~74. The method of any one of claims ~~73~~ 72 to ~~74~~73, wherein said monitoring is during annealing step.

~~76~~75. The method of any one of claims ~~73~~ 72 to ~~74~~73, wherein said monitoring is during said elongation step.

~~77~~76. The method of any one of claims 57 to ~~76~~75, wherein said duration is from ~~about~~ 10 ms to ~~about~~ 1000 ms, preferably 30 ms.

~~78~~77. The method of any one of claims 57 to ~~76~~75, wherein said intensity is from ~~about~~ 0.5 to ~~about~~ 1 mW.

~~79~~78. The method of any one of claims ~~58~~ 57 to ~~78~~77, wherein said UV light source emits light having a wavelength of from ~~about~~ 175 nm to ~~about~~ 350 nm.

~~80~~79. The method of any one of claims ~~58~~ 57 to ~~78~~77, wherein said UV light source emits light having a wavelength of from ~~about~~ 240 nm to ~~about~~ 350 nm.

~~81~~80. The method of any one of claims 5~~7~~8 - ~~78~~77, wherein said UV light source emits light having a wavelength of from ~~about~~ 260 nm to ~~about~~ 280 nm.

~~82~~81. The method of any one of claims ~~58~~ 57 - ~~78~~77, wherein said UV light source comprises a plurality of UV light source, configured to irradiate a plurality of nucleic acid sample.

~~83~~82. The method of any one of claims ~~58~~ 57 to ~~82~~81, wherein said transmission change in UV light transmission is measured with a photodetector.

~~84~~83. The method of any one of claims ~~58~~ 57 to ~~83~~82, wherein UV light from said UV light source is focused through an optical lense, a light pipe, or a combination thereof.

~~85~~84. The method of any one of claims ~~58~~ 57 to ~~84~~83, wherein UV light from said UV light source is focused through a light pipe onto said photodetector.

~~86~~85. The method of any one of claims 57 to ~~85~~84, wherein said method is performed in real-time.

~~87~~86. A system for performing a polymerase chain reaction (PCR) or a loop-mediated isothermal amplification (LAMP) of a nucleic acid molecule, the system comprising:

a) at least one nucleic acid sample containing
   - a nucleic acid template,
   - a polymerase enzyme, and
   - chemically modified nanoparticles comprising nanorods of metal, metallic coated organic nanotubes, or a combination thereof, having photo-thermal properties, to promote said PCR or said LAMP;

b) a thermal cycler in thermal communication with said at least one nucleic acid sample; ~~and~~

c) a compact continuous wave laser, a compact LED light source, or a combination thereof, configured to irradiate said at least one nucleic acid sample and provide excitation for a period of time to activate said photo-thermal properties of said chemically modified nanoparticles;

d) an ultraviolet (UV) light source configured to irradiate said at least one nucleic acid sample;

e) a photodetector configured to measure the transmission changes in UV light absorbance from said at least one nucleic acid sample, and

f) a processor for analyzing said change transmission changes in UV light transmission and quantify amplification of said nucleic acid template;

wherein said chemically modified nanoparticles are nanorods of metal,

for quantifying amplification of said nucleic acid.

~~88. The system of claim 87, further comprising~~

~~d) an ultraviolet (UV) light source configured to irradiate said at least one nucleic acid sample;~~

~~e) a photodetector configured to measure the transmission changes in UV light absorbance from said at least one nucleic acid sample, and~~

~~f) a processor for analyzing said change transmission changes in UV light transmission and quantify amplification of said nucleic acid template;~~

~~wherein said chemically modified nanoparticles are nanorods of metal,~~

~~for quantifying amplification of said nucleic acid.~~

~~89~~87. The system of claim ~~88~~86, wherein said UV light source is a UV light emitting diode (LED).

~~90~~88. The system of any one of claims ~~88~~ 86 - ~~89~~87, wherein said UV light source emits light having a wavelength of from ~~about~~ 175 nm to ~~about~~ 350 nm.

~~91~~89. The system of any one of claims ~~88~~ 86 - ~~90~~88, wherein said UV light source emits light having a wavelength of from ~~about~~ 240 nm to ~~about~~ 350 nm.

~~92~~90. The system of any one of claims ~~88~~ 86 - ~~90~~88, wherein said UV light source emits light having a wavelength of from ~~about~~ 260 nm to ~~about~~ 280 nm.

~~93~~91. The system of any one of claims ~~88~~ 86 - ~~92~~90, wherein said system comprises a plurality of UV light source, configured to irradiate a plurality of nucleic acid sample.

~~94~~92. The system of any one of claims ~~88~~ 86 - ~~93~~91, wherein said system comprises a plurality of photodetector, configured to measure absorbance from a plurality of nucleic acid sample.

~~95~~93. The system of any one of claims ~~88~~ 86 to ~~94~~92, wherein UV light from said UV light source is focused through an optical lense, a light pipe, or a combination thereof.

~~96~~94. The method of claim ~~95~~93, wherein UV light from said UV light source is focused through a light pipe onto said photodetector.

~~97~~95. The system of claim ~~87~~86, wherein the metallic coated organic nanotubes are selected from the group consisting of carbon nanotubes coated with a metal and multiwalled carbon nanotubes coated with or decorated with a metal.

~~98~~96. The system of any one of claims ~~87~~ 86 - ~~97~~95, wherein the metal is selected from the group consisting of Au, Ag, Pd, Pt, Fe, Cu, Al, and Zn.

~~99~~97. The system of claim ~~98~~96, wherein said metal is gold.

~~100~~98. The system of any one of claims ~~98~~ 96 - ~~99~~97, wherein said nanoparticles are gold nanorods.

~~101~~99. The system of any one of claims ~~87~~ 86 - ~~100~~98, wherein said photo-thermal properties comprise a localized plasmon resonance at a surface of the chemically modified nanoparticles, and said activation light beam has a wavelength corresponding to said localized plasmon resonance.

~~102~~100. The system of any one of claims ~~87~~ 86 - ~~101~~99, wherein said chemically modified nanoparticles are chemically modified by a chemical compound that prevents the inhibition of an active site of said polymerase enzyme.

~~103~~101. The system of claim ~~102~~100, wherein the chemical compound that prevents the inhibition of the active site of said polymerase enzyme is polyethylene glycol.

~~104~~102. The system of any one of claims ~~87~~ 86 - ~~103~~101, further comprising a thermometer for monitoring bulk heating of said at least one nucleic acid sample.

~~105~~103. The system of claim ~~104~~102, wherein said thermometer is an infrared thermometer.

~~106~~104. The system of any one of claims ~~87~~ 86 to ~~105~~103, wherein said compact continuous wave laser is a fibre-coupled laser, a vertical-cavity surface-emitting laser (VCSEL), or a combination thereof.

~~107~~105. The system of claim ~~106~~104, wherein said compact laser is a VCSEL.

~~108~~106. The system of any one of claims ~~106~~ 104 - ~~107~~105, wherein said activation light beam from said compact laser is provided from a distance of ≤ 5 mm from said biological enzymatic reaction mixture.

~~109~~107. The system of claim ~~108~~106, wherein said activation light beam from said compact laser is provided from a distance of from ~~about~~ 1 mm to ~~about~~ 5 mm from said biological enzymatic reaction mixture.

~~110~~108. The system of claim ~~108~~106, wherein said activation light beam from said compact laser is provided from a distance of from ~~about~~ 3 mm to ~~about~~ 5 mm from said biological enzymatic reaction mixture.

~~111~~109. The system of claim ~~108~~106, wherein said activation light beam from said compact laser is provided from a distance of ~~about~~ 5 mm from said biological enzymatic reaction mixture.

~~112~~110. The system of any one of claims ~~87~~ 86 to ~~111~~109, wherein said system provides real-time information ~~about~~ amplification of said nucleic acid template.

~~113~~111. The method of any one of claims 57 to ~~86~~85, wherein said PCR is a reverse transcriptase (RT) PCR, or said LAMP is a RT LAMP.

~~114~~112. The system of any one of claims ~~87~~ 86 to ~~113~~110, wherein said PCR is a reverse transcriptase (RT) PCR, or said LAMP is a RT LAMP.