CLAIMS

The invention claimed is:

1. A system, comprising:

a flow path containing a fluid in which a chemical reaction is occurring;

at least one integrated computational element configured to optically interact with the fluid and thereby generate optically interacted light; and

at least one detector arranged to receive the optically interacted light and generate an output signal corresponding to a characteristic of the chemical reaction.

2. The system of claim 1, further comprising an electromagnetic radiation source that emits electromagnetic radiation that optically interacts with the at least one integrated computational element and the fluid.

3. The system of any of the preceding claims, wherein the characteristic of the chemical reaction is a concentration of one or more reagents in the fluid.

4. The system of claim 3, wherein the one or more reagents in the fluid comprises at least one substance selected from the group consisting of barium, calcium, manganese, sulfur, iron, strontium, chlorine, paraffins, waxes, asphaltenes, aromatics, saturates, foams, salts, particulates, sand, and any combinations thereof.

5. The system of claim 3, wherein the one or more reagents in the fluid comprises at least one substance selected from the group consisting of acids, acid-generating compounds, bases, base-generating compounds, biocides, surfactants, scale inhibitors, corrosion inhibitors, gelling agents, crosslinking agents, anti-sludging agents, foaming agents, defoaming agents, antifoam agents, emulsifying agents, de-emulsifying agents, iron control agents, particulate diverters, salts, fluid loss control additives, gases, catalysts, clay control agents, chelating agents, corrosion inhibitors, dispersants, flocculants, scavengers, lubricants, breakers, delayed release breakers, friction reducers, bridging agents, viscosifiers, weighting agents, solubilizers, rheology control agents, viscosity modifiers, pH control agents, hydrate inhibitors, relative permeability modifiers, diverting agents, consolidating agents, fibrous materials, bactericides, tracers, probes, nanoparticles, tetrakis hydroxymethyl phosphonium sulfate (THPS), glutaraldehyde, benzalkonium chloride,

algal/fungal/bacterial deposits, imidazoline derivatives, quaternary ammonium salts, alkaline zinc carbonate, amines, and any combinations thereof.

6. The system of any of the preceding claims 1, wherein the characteristic of the chemical reaction is a concentration of a product resulting from the chemical reaction.

7. The system of any of the preceding claims, wherein the characteristic of the chemical reaction comprises at least one substance selected from the group consisting of a chemical composition, an impurity content, a pH level, a temperature, a viscosity, a density, an ionic strength, a total dissolved solids measurement, a salt content measurement, a porosity, an opacity measurement, a bacteria content, and any combinations thereof.

8. The system of any of the preceding claims, further comprising a signal processor communicably coupled to the at least one detector for receiving the output signal, the signal processor being configured to determine the characteristic of the chemical reaction.

9. The system of any of the preceding claims, further comprising an electromagnetic radiation source that emits electromagnetic radiation, wherein the at least one detector is a first detector and the system further comprises a second detector arranged to detect the electromagnetic radiation and thereby generate a compensating signal indicative of electromagnetic radiating deviations.

10. The system of claim 9, further comprising a signal processor communicably coupled to the first and second detectors, the signal processor being configured to receive and computationally combine the output and compensating signals in order to normalize the output signal and determine the characteristic of the chemical reaction.

11. The system of any of the preceding claims, wherein the flow path comprises at least one structure selected from the group consisting of a flowline, a pipeline, a hose, a process facility, a storage vessel, a tanker, a railway tank car, a transport barge or ship, a separator, a contactor, a process vessel, and any combinations thereof.

12. A method of monitoring a fluid, comprising:

containing the fluid within a flow path, the fluid having a chemical reaction occurring therein;

optically interacting at least one integrated computational element with the fluid, thereby generating optically interacted light; and

producing an output signal based on the optically interacted light that corresponds to a characteristic of the chemical reaction.

13. The method of claim 12, further comprising optically interacting electromagnetic radiation emitted from an electromagnetic radiation source with the fluid.

14. The method of claim 13, further comprising reflecting the electromagnetic radiation off of the fluid or transmitting the electromagnetic radiation through the fluid.

15. The method of claim 12, 13, or 14, wherein producing the output signal further comprises:

receiving with at least one detector the optically interacted light; and

generating with the at least one detector an output signal corresponding to a characteristic of the chemical reaction.

16. The method of claim 15, further comprising:

receiving the output signal with a signal processor communicably coupled to the at least one detector; and

determining the characteristic of the chemical reaction with the signal processor.

17. The method of claim 15, wherein the at least one detector is a first detector, the method further comprising:

receiving and detecting with a second detector at least a portion of the electromagnetic radiation;

generating with the second detector a compensating signal indicative of radiating deviations of the electromagnetic radiation source; and

computationally combining the output signal and the compensating signal with a signal processor communicably coupled to the first and second detectors, whereby the characteristic of the chemical reaction is determined.

18. The method of claim 12, 13, 14, 15, 16, or 17, wherein the characteristic of the chemical reaction comprises a concentration of one or more reagents in the fluid.

19. The method of claim 18, wherein the one or more reagents in the fluid comprises at least one selected from the group consisting of barium,

calcium, manganese, sulfur, iron, strontium, chlorine, paraffins, waxes, asphaltenes, aromatics, saturates, foams, salts, particulates, sand, and any combinations thereof.

20. The method of claim 18, wherein the one or more reagents in the fluid comprises at least one substance selected from the group consisting of acids, acid-generating compounds, bases, base-generating compounds, biocides, surfactants, scale inhibitors, corrosion inhibitors, gelling agents, crosslinking agents, anti-sludging agents, foaming agents, defoaming agents, antifoam agents, emulsifying agents, de-emulsifying agents, iron control agents, particulate diverters, salts, fluid loss control additives, gases, catalysts, clay control agents, chelating agents, corrosion inhibitors, dispersants, flocculants, scavengers, lubricants, breakers, delayed release breakers, friction reducers, bridging agents, viscosifiers, weighting agents, solubilizers, rheology control agents, viscosity modifiers, pH control agents, hydrate inhibitors, relative permeability modifiers, diverting agents, consolidating agents, fibrous materials, bactericides, tracers, probes, nanoparticles, tetrakis hydroxymethyl phosphonium sulfate (THPS), glutaraldehyde, benzalkonium chloride, algal/fungal/bacterial deposits, imidazoline derivatives, quaternary ammonium salts, alkaline zinc carbonate, amines, any derivatives thereof, and any combinations thereof.

21. The method of claim 12, 13, 14, 15, 16, 17, 18, 19, or 20, wherein the characteristic of the chemical reaction comprises a concentration of a product resulting from the chemical reaction.

22. The method of claim 12, 13, 14, 15, 16, 17, 18, 19, 20, or 21, wherein the characteristic of the chemical reaction comprises a characteristic selected from the group consisting of a chemical composition, an impurity content, a pH level, a temperature, a viscosity, a density, an ionic strength, a total dissolved solids measurement, a salt content measurement, a porosity, an opacity measurement, a bacteria content, and any combinations thereof.

CLAIMS

The invention claimed is:

1. A system, comprising:

a flow path provided within a wellbore and containing a fluid in which a chemical reaction is taking place, wherein the fluid comprises at least one of a reagent and a product associated with the chemical reaction;

at least one integrated computational element arranged in an optical train to optically interact with the fluid in the flow path and thereby generate optically interacted light, the at least one integrated computational element comprising a plurality of thin film layers deposited on an optical substrate;

at least one detector arranged in the optical train following the at least one integrated computational element to receive the optically interacted light and generate an output signal corresponding to a characteristic of the chemical reaction occurring within the fluid; and

a signal processor communicably coupled to the at least one detector for receiving the output signal, the signal processor being programmed to determine the characteristic of the chemical reaction based on the output signal.

2. The system of claim 1, further comprising an electromagnetic radiation source arranged in the optical train, the electromagnetic radiation source emitting electromagnetic radiation that optically interacts with at least one of the at least one integrated computational element and the fluid.

3. The system of claim 1, wherein the characteristic of the chemical reaction is a concentration of the reagent in the fluid and the signal processor is further programmed to determine the concentration of the reagent in the fluid.

4. The system of claim 3, wherein the reagent in the fluid comprises at least one substance selected from the group consisting of barium, calcium, manganese, sulfur, iron, strontium, chlorine, paraffins, waxes, asphaltenes, aromatics, saturates, foams, salts, particulates, sand, and any combinations thereof.

5. The system of claim 3, wherein the reagent in the fluid comprises at least one substance selected from the group consisting of acids, acid-generating compounds, bases, base-generating compounds, biocides, surfactants, scale inhibitors, corrosion inhibitors, gelling agents, crosslinking agents, anti-sludging agents, foaming agents, defoaming agents, antifoam agents, emulsifying agents, de-emulsifying agents, iron control agents, particulate diverters, salts, fluid loss control additives, gases, catalysts, clay control agents, chelating agents, corrosion inhibitors, dispersants, flocculants, scavengers, lubricants, breakers, delayed release breakers, friction reducers, bridging agents, viscosifiers, weighting agents, solubilizers, rheology control agents, viscosity modifiers, pH control agents, hydrate inhibitors, relative permeability modifiers, diverting agents, consolidating agents, fibrous materials, bactericides, tracers, probes, nanoparticles, tetrakis hydroxymethyl phosphonium sulfate (THPS), glutaraldehyde, benzalkonium chloride, algal/fungal/bacterial deposits, imidazoline derivatives, quaternary ammonium salts, alkaline zinc carbonate, amines, and any combinations thereof.

6. The system of claim 1, wherein the characteristic of the chemical reaction is a concentration of the product resulting from the chemical reaction and the signal processor is further programmed to determine the concentration of the product resulting from the chemical reaction.

7. The system of claim 1, wherein the signal processor is further programmed to determine the characteristic of the chemical reaction when the characteristic of the chemical reaction comprises at least one substance selected from the group consisting of a chemical composition, an impurity content, a pH level, a temperature, a viscosity, a density, an ionic strength, a total dissolved solids measurement, a salt content measurement, a porosity, an opacity measurement, a bacteria content, and any combinations thereof.

8. The system of claim 1, further comprising an electromagnetic radiation source arranged in the optical train and emitting electromagnetic radiation, wherein the at least one detector is a first detector and the system further comprises a second detector arranged to detect the electromagnetic radiation and thereby generate a compensating signal indicative of electromagnetic radiating deviations.

9. The system of claim 8, wherein the signal processor communicably coupled to the first and second detectors, the signal processor being programmed to receive and computationally combine the output and compensating signals in order to normalize the output signal.

10. The system of claim 1, wherein the flow path comprises at least one structure selected from the group consisting of a flowline, a storage vessel, a separator, a contactor, a process vessel, and any combinations thereof.