CLAIMS

1. An apparatus comprising:

a container arranged to hold proteins, cells, or small molecules;

a resonant sensor embedded in or on the container, the resonant sensor having an inductive element and a capacitive element, the container and the resonant sensor structured such that, when a concentration of the proteins, cells, or small molecules in the container changes, dielectric permittivity and conductivity of the proteins, cells, or small molecules contributes to capacitance of the resonant sensor to affect a resonant frequency shift of the resonant sensor, the resonant sensor structured for contactless interrogation with no wired connection to the resonant sensor; and

a vector network analyzer arranged to measure an amount of signal power transmitted or absorbed through the resonant sensor, as a function of frequency, with the vector network analyzer arranged to interrogate the resonant sensor with no wired connection to the resonant sensor and to wirelessly receive signals from the resonant sensor to collect data reflecting resonant frequency of the resonant sensor over time.

2. The apparatus of claim 1, wherein the container includes a glass culture ware or a plastic culture ware.

3. The apparatus of claim 1, wherein the resonant sensor is embedded in an inner surface of the container.

4. The apparatus of claim 1, wherein the resonant sensor includes copper and polyimide with the copper epoxied side down in the container with the polyimide exposed to a medium in which the proteins, cells, or small molecules are disposed in the container.

5. The apparatus of claim 1, wherein the vector network analyzer is coupled to two antennas to interrogate the resonant sensor with no wired connection to the resonant sensor and to wirelessly receive signals from the resonant sensor.

6. A system comprising:

a container arranged to hold proteins, cells, or small molecules;

a resonant sensor embedded in or on the container, the resonant sensor having an inductive element and a capacitive element, the container and the resonant sensor structured such that, when a concentration of the proteins, cells, or small molecules in the container changes, dielectric permittivity and conductivity of the proteins, cells, or small molecules contributes to capacitance of the resonant sensor to affect a resonant frequency shift of the resonant sensor, the resonant sensor structured for contactless interrogation with no wired connection to the resonant sensor; and

a network analyzer arranged to measure an amount of signal power transmitted or absorbed through the resonant sensor with the network analyzer arranged to wirelessly interrogate the resonant sensor from outside the container with no wired connection to the resonant sensor and to wirelessly transmit data collected from the interrogation.

7. The system of claim 6, wherein the network analyzer is arranged to wirelessly interrogate the resonant sensor to collect scattering parameter data.

8. The system of claim 6, wherein the network analyzer is arranged to wirelessly transmit the collected data to a computer.

9. The system of claim 8, wherein the network analyzer is arranged to wirelessly transmit the collected data to the computer via Bluetooth protocol.

10. The system of claim 6, wherein the network analyzer is arranged to wirelessly transmit the collected data to a communication interface.

11. The system of claim 10, wherein the communication interface is arranged to transmit the data to a computer via a network.

12. The system of claim 6, wherein the network analyzer is a portable vector network analyzer.

13. A method comprising:

providing a container holding proteins, cells, or small molecules;

wirelessly interrogating, using a network analyzer outside the container, a resonant sensor embedded in or on the container to measure an amount of signal power transmitted or absorbed through the resonant sensor, the resonant sensor having an inductive element and a capacitive element, the container and resonant sensor structured such that, when a concentration of the proteins, cells, or small molecules in the container changes, dielectric permittivity and conductivity of the proteins, cells, or small molecules contributes to capacitance of the resonant sensor to affect a resonant frequency shift of the resonant sensor, the resonant sensor structured for contactless interrogation with no wired connection to the resonant sensor;

monitoring the resonant frequency of the resonant sensor from the interrogation at a number of different times; and

evaluating status of the proteins, cells, or small molecules from the monitored resonant frequency.

14. The method of claim 13, wherein evaluating the status includes determining the resonant frequencies as a function of optical density.

15. The method of claim 13, wherein interrogating the resonant sensor includes collecting scattering parameter data.

16. The method of claim 13, wherein the method includes transmitting data to a computer in response to interrogating the resonant sensor.

17. The method of claim 16, wherein transmitting the data to the computer includes using Bluetooth protocol.

18. The method of claim 13, wherein the method includes, in response to interrogating the resonant sensor, transmitting data to a computer via a network.

19. The method of claim 13, wherein the method includes:

interrogating the resonant sensor periodically from a portable vector network analyzer and collecting data from the interrogation;

transmitting the data to a computer; and

determining resonant frequencies for each data point and smoothing the data with an averaging window.

20. The method of claim 19, where the resonant sensor is interrogated every minute of a selected measurement period and the averaging window is a ten minute averaging window.

21. The apparatus of claim 1, wherein the apparatus includes one or more processors arranged to execute stored instructions to evaluate, from the data collected by the vector network analyzer, status of the proteins, cells, or small molecules from one or more changes in the resonant frequency of the resonant sensor.

22. The method of claim 13, wherein the method includes interrogating the resonant sensor at an interrogation frequency equal to or greater than 10 MHz.