CLAIMS

1. A sensor substrate comprising:

a base of silicon; and

a plurality of bars, each of the plurality of bars being formed of at least a first noble metal, the plurality of bars being disposed on a first area of the base in an array of units, each of the units including:

at least one long bar; and

at least one short bar, the short bar being shorter in length than the long bar,

wherein the array is a periodic array characterized by a surface enhanced infrared absorption (SEIRA) resonance in an infrared (IR) spectrum,

and wherein each of the plurality of bars includes at least one interface characterized by a surface enhanced Raman spectroscopy (SERS) resonance.

2. The sensor substrate as recited in claim 1, wherein the at least one interface is defined by one of: (i) a plurality of nanoholes distributed in the first noble metal, and (ii) a multi-layer structure disposed on the base, the multi-layer structure including a surface layer formed essentially of the first noble metal and at least one dielectric layer interposed between two metal layers.

3. The sensor substrate as recited in claim 2, wherein the at least one interface is characterized with a plasmonic resonance in a visible wavelength for SERS.

4. The sensor substrate as recited in claim 2 or claim 3, wherein the plurality of nanoholes are distributed in the first noble metal in any one of a repeated pattern and a random distribution, and wherein each of the at least one long bar and the at least one short bar is an elongate structure characterized by a width in a nanometer scale.

5. The sensor substrate as recited in claim 2 or claim 3, wherein the multi-layer structure comprises at least one dielectric layer disposed immediately adjacent the surface layer, and wherein the multi-layer structure includes at least one layer of a second metal alternating with at least one dielectric layer.

6. The sensor substrate as recited in claim 5, wherein the multi-layer structure comprises at least one metal-dielectric-metal structure disposed between the surface layer and the base.

7. The sensor substrate as recited in claim 5, wherein the multi-layer structure comprises at least one dielectric layer interposed between two metal layers, and wherein at least one of the two metal layers is formed of the first noble metal.

8. The sensor substrate as recited in claim 5, wherein the multi-layer structure comprises at least one dielectric layer interposed between two metal layers, and wherein at least one of the two metal layers is formed of the second metal.

9. The sensor substrate as recited in any one of claims 5 to 8, wherein first noble metal consists of gold.

10. The sensor substrate as recited in any one of claims 5 to 9, wherein the second metal consists of silver or aluminum.

11. The sensor substrate as recited in any one of claims 5 to 10, wherein each of the at least one dielectric layer is formed of silicon dioxide or aluminum oxide.

12. The sensor substrate as recited in claim 2 or claim 3, wherein the plurality of bars are formed by one of a top-down process and a bottom-up process to form the following structure: silicon / silver / silicon dioxide / silver / silicon dioxide / silver / silicon dioxide / gold, and wherein the base is formed of the silicon, and wherein the surface layer is formed of the gold.

13. The sensor substrate as recited in any one of claims 1 to 12, wherein the array comprises a grid array, and wherein each of the units is disposed in a respective corner of the grid array.

14. The sensor substrate as recited in any one of claims 1 to 13, wherein the sensor substrate is simultaneously operable for SERS sensing and SEIRA sensing.

15. The sensor substrate as recited in any one of claims 1 to 14, further comprising a thin film disposed on a second area of the base, the thin film being a planar piece of a metal operable for surface plasmon resonance (SPR), and wherein the thin film is formed of any one of the group consisting of: gold, nickel-silver, and silver, and wherein the sensor substrate is simultaneously operable for SERS sensing, SEIRA sensing, and SPR sensing.