BASIC: Biological Agent Sensing Integrated Circuit

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As biological warfare becomes more of a threat, detection mechanisms are being developed to detect hazardous agents in the environment to prevent massive outbreaks. Since airborne clouds of bacteria or viral agents are nearly invisible and odorless, people who inhale the harmful agents may not know until they fall ill days later. Currently, infection from pathogenic agents isn't detected until several people within a similar region show clinical signs or die. Many diseases caused by biological agents are treatable with antibiotics before the onset of symptoms, but after symptoms appear, victims may be beyond treatment. Biological sensors based on integrated circuits are being designed to test for the presence of a large group of potential bioterrorism agents (zoonotic microorganisms) in the environment. The system proposed is to be used for the rapid detection of a variety of biological agents. The basic system principle being used is the detection of electrical changes occurring at the surface of an integrated circuit based on the presence or absence of the agent in question.

A chip is specially constructed with electrical detection mechanisms in place, after which it is selectively loaded with biological agents specifically set up to cause detectable changes in the integrated circuits electrical behavior. A set of known magnetite-tagged bioterrorism agents will be used in an assay. Such tagged organisms will be used to load the antibody coated surface of the chip within the circuitry. Once all of the antigen binding surfaces are occupied by the tagged organisms, the chip will be exposed to environments where such organisms potentially exist. Through competition, some of the tagged organisms will be displaced by untagged organisms naturally present in the environment, thereby changing the electrical parameters of the chip. This change will be detected and used to identify and quantify organisms by on-chip digital circuitry.

The sensors use a novel detection mechanism to measure changes in the number of microorganisms at the surface of the chip. Magnetic as well as capacitive effects are measured to count the numbers of organisms present. Initial versions of the detector chip use a sensing inductor to determine the number tagged pathogens in the sample container. Varied amounts of magnetite attached to the pathogens inside the sensing inductor cause the inductance of the coil to change. Changes in the inductance are proportional to the number of magnetite-tagged pathogens that have been replaced by untagged pathogens present in the environment. A wide variety of types of organisms can be detected on the same integrated circuit utilizing the specificity of antibodies.

The design is such that no chemical processing is required once the chip is deployed. The goal is to have a stand-alone sensor that can be operational with no human intervention. We envision this device to be usable in either arrays of sensors distributed throughout an urban or battlefield environment, or as a personal detector worn by individuals.