Shear Horizontal Surface Acoustic Wave Microsensor for Class A Viral and Bacterial Detection

LABORATORY DIRECTED RESEARCH & DEVELOPMENT

Sandia National Laboratories

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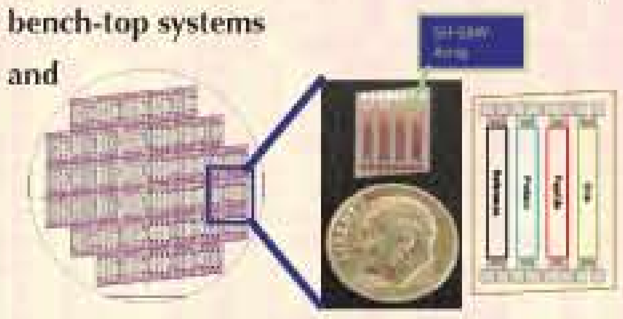
Project Goal: to deliver a prototype SH-SAW sensor array detection with reusable surfaces and the elimination of non-specific binding for multi-analyte detection of Category A bioagents.

SH-SAW Array for Detection of Multiple Class A BW Agents

Problem

Currently there are no commercial sensor systems that can provide autonomous detection of a reasonable, number of bioagents in a small system.

- Bio Watch and JBPDS both require verification via PCR in the laboratory
- Most commercial systems are bench-top systems
- Need for improved sensitivity and lower detection limits
- Need for stable and robust ligands

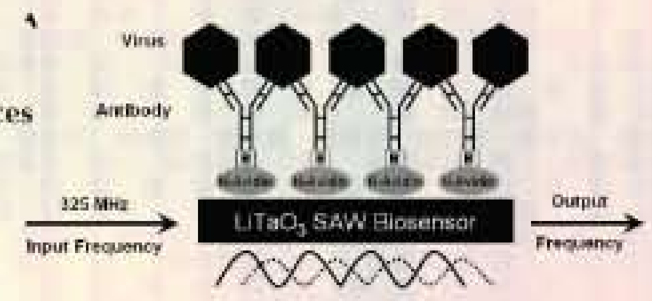


40 sensor arrays / 4 in. wafer

Approach

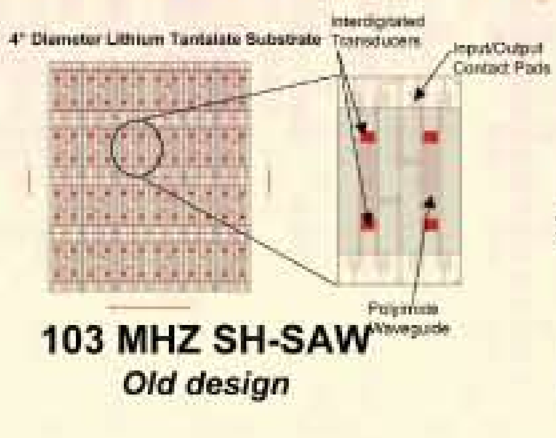
Currently there are no commercial sensor systems that can provide autonomous detection of a reasonable, number of bioagents in a small system.

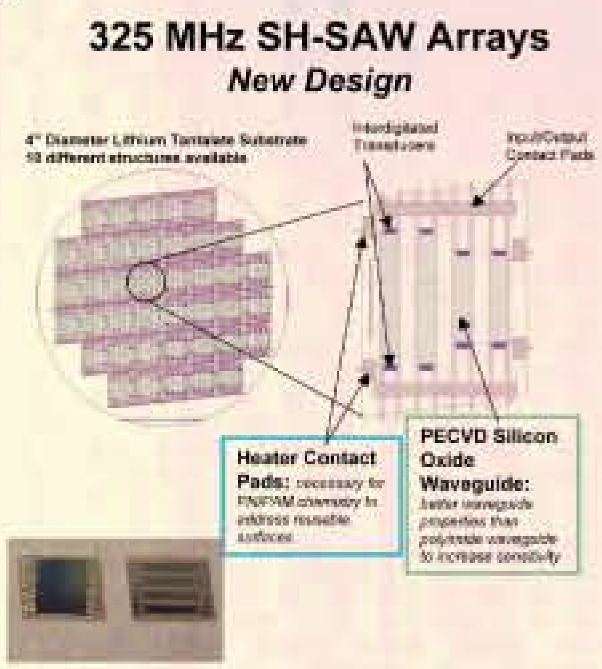
- Develop arrays of sensors to detect multiple agents
- Use of flexible capture probes (antibodies, peptides, or DNA) to selectively capture
- antigen (virus, bacteria, toxin)
- Design higher operating frequency devices to improve sensitivity and detection
- Enable heating capabilities to allow for reusable surfaces
- Make peptides stable to high temperatures and resistant to proteases



Results

Fabricated 325 MHz SH-SAW arrays





Layout of 325 MHz SH-SAW delay-line arrays on 4" diameter $LiTaO_3$ wafer. Each delay line consists of an input and output transducer with contact pads. A heater metallization is also added to the acoustic path for testing at varying temperatures.

Results

Developed Fluidics Interface and Electrical Readout System for Array

Fluidic Interface:

- Fabricated fluidic cells for the unheated and heated SH-SAW arrays.
- The outer dimensions of both the static and fluidic cells are 25 mm x 25 mm x 18 mm and interchangeable in the acquisition system.
- Fluid connections are made via 1/16" tubing.
- Fluidic cells are fabricated from polyetheretherketone (lightweight, chemically resistant, biocompatible).

SH-SAW DAQ Box in Level 3 Facility

Battery powered DAQ and integrated SH-SAW Detection system

Readout:

- The detection system is based on the AD8302, which converts differential signal magnitude (ΔM) and phase shift ($\Delta\partial$) to DC voltages.
- The DC level outputs are processed using an op-amp design implemented to permit on-board data processing prior to A/D conversion.

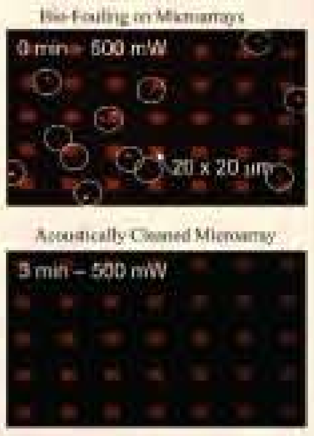
Developed Peptides for Category A Viral Hemorrhagic Fever Agents

Acoustic Removal of Nonspecific Protein Fouling

Nonspecific binding is a universal problem that reduces sensitivity and specificity of biosensors

We developed an acoustic approach for removal of nonspecific protein fouling

- Acoustic excitation (green arrows) removes nonspecifically bound proteins for cleaning
- The removal is monitored using a second pair of transducers perpendicular to the excitation (blue arrows)



Detection Data

Impact

- Handheld prototype bio-identification system has been developed that is adaptable to many deployment scenarios.
- Small, near-real-time, multi-sensor system for bioagents in complex samples:
  - Specific and sensitive identification for spores, bacteria, protein, and viruses has been demonstrated in the presence of interferents and complex backgrounds.
  - Multiplex identification has been demonstrated.

Potential Use

- Discussions with Smiths Detection and Constellation Technologies
- Applicable to needs of intelligence communities, police agencies, medical, environmental agencies, NIH, DARPA, military

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NNSA National Nuclear Security Administration

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