TOXIN DIAGNOSTICS – DEVELOPMENT OF NOVEL, FIELDABLE TECHNOLOGIES TO DIAGNOSE TOXIN EXPOSURE

Chip-scale Photonic Integrated Circuit Sensor To Monitor Biomarkers And Diagnose Toxin Exposures

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Photonic Integrated Circuit (PIC) technology offers a pathway to create multiple analyte sensors in a single highly manufacturable chip-scale form factor. They can enable the early warning of both chemical and biological threat exposure in the local environment as well as monitor human health, potentially in a discrete wearable form factor. Biomarker quantities present in blood, sweat, and other bodily fluids can be tracked to alert of immune response, indicate the type of illness or injury, and track recovery. Collections of toxins and pathogens could also be quantified in a low SWaP-C handheld diagnostic aid for use in resource constrained field situations.

Utilizing a refractive index PIC (RI-PIC) sensing mechanism coupled with a multitude of specific analyte capture sorbent materials, many analytes across a multiplexed array of sensors can be detected and quantified at once. We have established manufacturable means of enrobing exposed optical waveguides from a commercially available (AIM Photonics) domestic PIC fabrication service with our sorbents. When analytes adsorb in the coatings of each waveguide sensor in an array, their optical index of refraction shifts. We have implemented a variety of on-chip components exceptionally sensitive to this index shift and have shown they can ignore a strong interference from temperature deviations to achieve detection limits down to fM concentrations. Detection limits will vary across analytes, capture materials, sensor design, and sample collection approaches and we are poised to explore the limit of any analyte and medium.

We have investigated custom molecularly imprinted polymer (MIP) sorbents to capture chemical threat simulants and demonstrated aqueous detection; vapor and aerosol detection of chemical analytes will be investigated next. Our PIC devices can also support non-MIP sorbents as well as biocapture materials based on synthetic peptides, aptamers, and antibodies to detect a wide variety of chemicals from small molecules to proteins. We have built the expertise to rapidly (~ 2 weeks) create new synthetic peptide capture materials tailored to capture emerging biological threats. The process could be adapted to small molecules as well.

Detection currently requires benchtop equipment and a trained operator. However, the platform already includes integrated optical detectors, and we are working to integrate light sources and interface electronics on-chip with COTS microcontrollers for data analysis off-chip. All to keep future deployable unit SWaP-C as low as possible.