

Wearable Sized Raman Spectrometers For SERS (Surface Enhanced Raman Spectroscopy)

Bring laboratory-level spectroscopic analysis to you!

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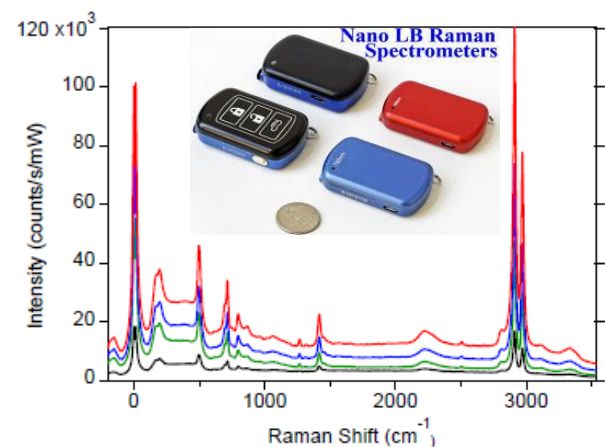
APPLICATION NOTE

Background

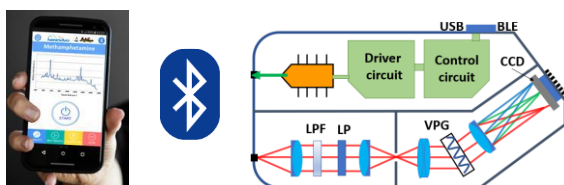
Wearable Surface-Enhanced Raman Spectroscopy (SERS) has advanced remarkably over the past decade, driven by breakthroughs in materials science, nanotechnology, flexible electronics, and real-time data analytics. It's impressive to see how wearable SERS has evolved—from the early, bulky, and non-portable prototypes to today's highly integrated, lightweight, and truly wearable systems available in 2025.

BaySpec's SERS technology in a collaboration with Professor Keisuke Goda's research group at the University of Tokyo, with their work focusing on developing advanced Surface-Enhanced Raman Spectroscopy (SERS) for applications like sample collection-free sensing. Goda's lab has developed innovative SERS substrates and techniques, which BaySpec then integrates into their portable and wearable Raman spectrometers. The collaboration aims to create practical, high-performance SERS sensors for diverse fields such as drug detection, food safety, and health monitoring. Combining Goda's advanced SERS substrate technology with BaySpec's hardware and manufacturing expertise this creates highly sensitive, reliable, and portable SERS devices. This includes a focus on "sample collection and preparation-free" SERS,

BaySpec is a spectral sensing company that designs and manufactures instruments, such as portable spectrometers, and integrates new technologies like the innovative SERS substrates from Goda's lab. BaySpec has commercialized these technologies, which are used in portable devices like the BaySpec SERS Readers.



Every year, millions of individuals with substance use disorders (SUD)—an estimated 35 million in the United States—do not receive necessary treatment due to significant barriers within the diagnostic process. Rapid confirmatory testing is needed to overcome the urgent need of SUD diagnosis and treatment, BaySpec Inc. together with Baylor University have developed a concept palm-held surface-enhanced Raman spectroscopy (SERS) sensing and analysis system with cloud-based machine-learning analysis to detect a broad spectrum of drug residues and their metabolite products. BaySpec and Baylor are working on to have a quantitative, portable sensing solution for point-of- need SUD diagnosis and treatment with



high performance and minimal cost and resource requirements. This quantitative, multi-drug detection instrument measures fentanyl and other opioid analgesics such as, morphine, codeine, heroin, amphetamine, xylazine and other synthetic derivatives from noninvasively collected biofluid samples, especially from saliva and urine. The SERS sensing and analysis system is enabled by two disruptive technologies: 1) miniaturized palm-held Raman spectrometers with 10 \times reduced cost and high industry standard that is developed by BaySpec Inc. 2) ultra-sensitive and uniform diatom photonic crystal SERS substrates with machine-learning analysis for quantitative multiplex drug detection, led by Prof. Alan Wang at Baylor University.

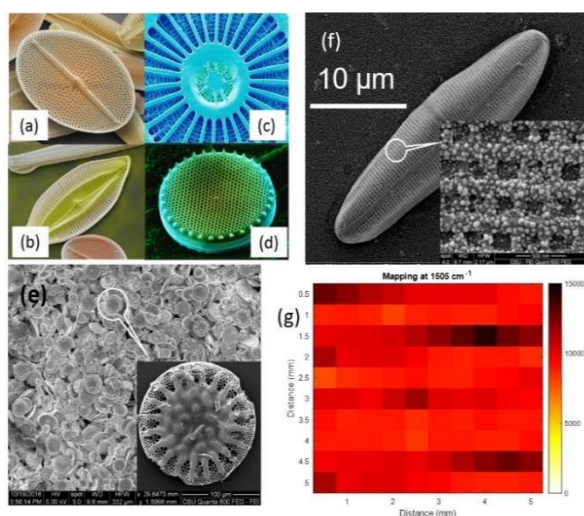


Fig. 2 SEM images of (a-d) diatom species with different photonic crystal frustules; (e) diatomaceous earth and single diatom frustule; (f) Our diatom SERS substrate; (g) R6G signals of 5x5mm² diatomaceous SERS substrate.

The system addresses an unmet need for rapid drug detection from non-invasive test samples, lowering the barrier for diagnosis and treatment of substance use disorder (SUD), a major public health concern. Development of a portable, miniaturized spectrometer that does not compromise efficiency is innovative. The combination of uniform diatom photonic crystal surface enhanced Raman spectroscopy (SERS) substrates with machine learning analysis is an innovative strategy for quantitative multi-drug detection. This wearable Surface-Enhanced Raman Spectroscopy Sensing and Analysis

System is for Point-of-Need Substance Use Disorders, Diagnosis and Treatment. a miniaturized palm-held/wearable surface-enhanced Raman spectroscopy system combined with machine learning analysis to detect opioids and other drug residues and metabolites in non-invasively collected samples proof-of-concept. With extraordinarily high reproducibility or substrate-to-substrate, spot-to-spot, sample-to-sample, and time-to-time consistency in SERS spectrum (which is not possible with traditional metal-based SERS) due to the absence of "electromagnetic hot spots" by making the entire surface of the substrate "chemically hot", high durability due to no oxidization, and high compatibility to biomolecules due to its fluorescence quenching capability.

Combine with the BaySpec's SERS reader – a mini wearable analyzer, which provide a full analytics solution. SERS readers feature proprietary miniaturized optics, highly efficient detector, and maximum sensitive with ultrafast acquisition. The full fingerprint coverage and high resolution delivers the best-in-class performance in a variety of applications, from detection of illicit drugs, toxic industrial chemicals (TICs), pesticides, urine drug testing, microplastic detection, chemical warfare agents, biological warfare agents, explosives, infectious disease sensing and many other detection applications.



Figure 1: Belt Wearable Raman with 630nm, 645nm, 785nm, 810nm and 830nm Excitations.

The technology developed through this collaboration with Goda and Baylor University

offer a wide range of applications, including the detection of illicit drugs, pesticides, explosives, and biomarkers in sweat and saliva.

In summary, we have proof-of-concept demonstration of a field-deployable, low-cost, point-of-need sensing technology that can lower the barriers to diagnosis and treatment at any stage of the patient journey through SUD. Future research will include: 1) large-scale, cost-effective production of the instrument and diatom-SERS substrates; 2) perfection of the MKL algorithms to identify more drug residues and improve quantification accuracy; and 3) collaboration with potential users. If successful, we will create a disruptive, life-saving sensing technology which will bring treatment directly to the patient.