Washington University in St. Louis
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LOW-COST, FLEXIBLE PAPER SUBSTRATE FOR SENSITIVE TRACE CHEMICAL AND BIOLOGICAL DETECTION USING SERS (SURFACE ENHANCED RAMAN SCATTERING)

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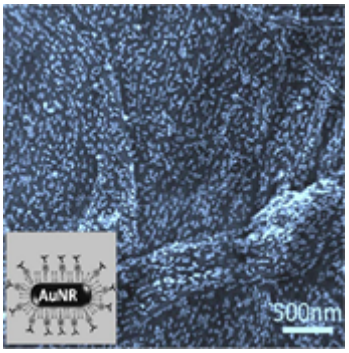
Technology Description

Researchers in Prof. Srikanth Singamaneni's laboratory have developed a patented, low-cost, flexible substrate designed to improve sample collection and enhance analyte detection with surface enhanced Raman scattering (SERS) or localized surface plasmon resonance (LSPR) assays. This cellulose substrate (common laboratory filter paper) filled with gold nanorods easily conforms to real-world surfaces so that samples can be collected through simple and effective dipping or swabbing. This results in better sorption than conventional rigid substrates (silicon, aluminum, glass) with a detection limits down to a few picograms and high dynamic range over areas as large as a few square centimeters. Furthermore, the gold nanorods can be functionalized with antibodies or other molecules to create plasmonic biosensor paper. This substrate is compatible with existing SERS instruments and could be readily combined with other assays for label-free detection in chemical or biological sensors. End-user applications of this technology include water quality monitoring, diagnostics or hazardous material detection.

Related technologies:

- Simple, stable plasmonic biosensors for point-of-care diagnosis of cardiac arrest and other conditions (WUSTL Technology T-014923)
- Plasmonic biosensors with built-in artificial antibodies (WUSTL Technology T-013772)



SEM images of paper substrate adsorbed with gold nanorods conjugated to antibodies

Stage of Research

The inventors demonstrated detection of less than 150pg of analyte spread over a 4cm^2 surface. They also demonstrated that their bioplasmonic paper (paper adsorbed with gold-antibody conjugates) can detect trace kidney cancer biomarkers in biological samples (urine) down to a concentration of 10 ng/mL.

Applications

- **Label-free detection** – substrate for surface enhanced Raman scattering (SERS)/localized surface plasmon resonance (LSPR) with end user applications such as:
  - chemical sensors in water quality monitoring or explosive detection
  - biological sensors for quantifying analytes or complex mixtures
  - diagnostics for measuring/quantifying disease biomarkers
  - consumer-based hazardous material detection

Key Advantages

- **Extremely low detection limit and large dynamic range:**
  - flexible paper substrate conforms to real-world surfaces for improved sample collection
  - paper has inherently high analyte sorption with excellent wicking properties
  - paper-based LSPR substrate has detection limit on par or better than conventional rigid substrates using similar plasmonic nanostructures for biomarker detection
- **Versatile chemical and biological sensing platform:**
  - compatible with existing SERS instruments
  - enables multiplex detection and multimarker biochips
  - can be efficiently combined with conventional bioassays and separation techniques
- **Low-cost, scalable fabrication:**
  - manufactured using relatively simple wet chemistry
  - compatible with conventional printing
  - cellulose-based substrate is naturally abundant, safe, recyclable and inexpensive

Patents:

- Label-free detection of renal cancer (U.S. Patent No. 9,410,949)
- Additional patent applications pending

Publications

- "Bioplasmonic paper–based assay for perilipin-2 non-invasively detects renal cancer" Hu, R.; Gupta, R.; Wang, Z.; Wang, C.; Sun, H.; **Singamaneni, S.**; Kharasch, E. D.; Morrissey, J. J.* *Kidney Int.*, **2019,** 96, 1417-1421.
- "Multiplexed Charge-Selective Surface Enhanced Raman Scattering based on Plasmonic Calligraphy" Tian, L.; Tadepalli, S.; Farrell, M.; Liu, K.-K.; Gandra, N.; Pellegrino, P.; Singamaneni, S.* *J. Mater. Chem. C* **2014**, *2*, 5438-5446.
- "Multifunctional Analytical Platform on a Paper Strip: Separation, Pre-concentration and Sub-Attomolar Detection" Abbas, A.; Brimer, A.; Slocik, J. M.; Tian, L.; Naik, R. R.; **Singamaneni, S.*** *Anal. Chem.*, **2013**, *85*, 3977-3983.
- "Bioplasmonic Paper as a Platform for Detection of Kidney Cancer Biomarkers" Tian, L.; Morrissey, J M.; Kattumenu, R.; Gandra, N.; Kharasch, E. D**.; Singamaneni S**.* Anal. Chem., **2012**, 84, 9928-9934.

- "Paper Based SERS Swab for Rapid Trace Detection on Real-world Surfaces" Lee, C. H.; Tian, L.; **Singamaneni S.*** *ACS Appl. Mater. Interfaces* **2010**, *2*, 3429-3435.

Related Web Links - Soft Nanomaterials Laboratory