

PROJECT SUMMARY

The overall objective of this project is to develop a lightweight, easy-to-use, stable, on-chip nano-plasmonic SPR-based urine protein assay cartridge (PAC) (see Figure 1) capable of detecting trace amounts of proteins in urine samples. Such a PAC may not only be used for accurate early-diagnosis of proteinuria, a syndrome indicating potentially serious health problems and/or progressive kidney failure, but also act as a technological backbone to developing a proteomics device for screening protein levels in body fluids (urine, blood and saliva).

Figure 1 displays a schematic of the overall detection modality and illustrates the product concept. The PAC design is based on several innovations that make on-chip, label-free urine protein detection possible, including: (a) a new nano-plasmonic chip technology that enables concurrent detection of multiple urine proteins with extremely high detection sensitivity; (b) a novel microfluidic system that offers unique features over conventional analytical methods, such as small volumes (nano/microliters), and straightforward, maintenance-free operation. In its ultimate embodiment, the plasmonic assay system will be an automated, hand-portable sensor allowing for sensitive detection of characteristic urine proteins. The rapid, accurate, reagent-free assessment of astronaut health in a miniaturized, inexpensive, on-chip format with minimal logistic requirements (in particular for urinalysis or blood analysis) is well suited to microgravity space environments.

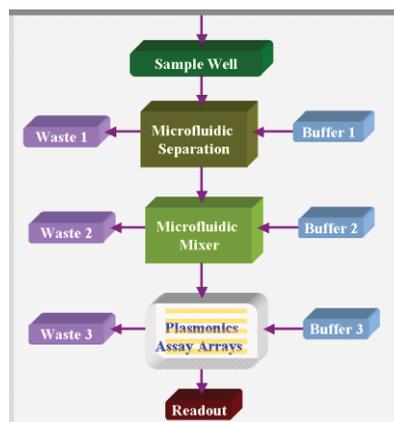


Figure 1. On-chip Nano-plasmonic PAC Component Block Diagram

Technical Activities and Progress: During Phase II course, we planned four major work areas which are: 1) optimization and identification of the nanostructures for sensor chip, 2) microfluidics development, 3) device (protein assay cartridge, PAC) integration and prototype development. To this end, we have accomplished most of the technical tasks listed in the three areas, specifically, sensitive nanoslit and nanoledge structure have been identified and fabrication method also developed; Both the microfluidic components and integrated microfluidics have been developed with assistance of CFD-multiphysics computational tool for design, the functions of microfluidic components or integrated cartridge for sample dilution, preparation have been tested, validated experimentally. Finally, while the reproducibility of the biosensor for albumin detection is a challenge, an integrated PAC cartridge, along with surface modification for protein detection, have been developed, and demonstrated for avidin-biotin binding. Future work is needed to develop a more controllable process for antibody immobilization at the nanoslit/ledge sensing structures and provide more reproducible detection of urine protein, albumin.

Intellectual Property: With the Phase II effort, a new concept for nanoplasmonic sensing with nanofluidic control has been developed and a patent was filed on 01/11/2010. Listed inventors are Jianjun Wei (CFDRC), Sameer Singhal (CFDRC), David H. Waldeck (University of Pittsburgh), Matthew Kofke (University of Pittsburgh), the patent is entitled “Nanoscale Surface Plasmonics Sensors with Nanofluidic Control”, and publication number is 2011/0168559. Leveraging this concept, a SBIR Phase I proposal was submitted to NIH/NCI for early cancer biomarker screening and for an award; the Phase I project was completed on Sept. 30th, 2011.

Publications and Presentations: The NASA project has made a few peer-reviewed publications in paper, conference proceedings, abstract or presentations, which are listed below:

- Jianjun Wei, Matthew Kofke, Madu Mendis, Hongjun Song, Sameer Singhal, David Waldeck, An In-Plane Nanofluidic Nanoplasmonics-Based Platform for Biodetection, *Proceedings of the ASME 2012 3rd Micro/Nanoscale Heat & Mass Transfer International Conference*, MNHMT2012, March 3-6, **2012**, Atlanta, Georgia, USA
- Wei, J.J.; Rexus, M.; Kofke, M.; Wang, Y.; Singhal, S.; Waldeck, D.H., Nano-plasmonics Sensing and Integration with Microfluidics for a Lab-on-chip Biosensor, *Proc. of TechConnect World Conference & Expo 2011*, 1-4
- J. J. Wei, M. Kofke, S. Singhal, and D. H. Waldeck, Transmission SPR of Gold Nanoslit and Ultrasensitive Detection of Proteins, *IEEE Xplore*, **2010**, 1-4
- J. J. Wei; M. Kofke, M. Rexus, S. Singhal, J. Sullivan, and D. H. Waldeck, Nano-plasmonics based sensing and integration with microfluidics for a lab-on-chip biosensor? *The 2010 International Chemical Congress of Pacific Basin Societies (Pacifichem 2010)*, Honolulu, Hawaii, USA, December 15 - 20, **2010**
- J. J. Wei, M. Kofke, S. Singhal, M. Rexus, J. Sullivan, and D. H. Waldeck, Nanoplasmonics-based Ultrasensitive Biological Sensing System, *International Symposium on Spectral Sensing Research (ISSSR)*, Springfield, Missouri, June 21-24, **2010**.
- J. J. Wei, M. Kofke, S. Singhal, and D. H. Waldeck, Transmission SPR of Gold Nanoslit and Ultrasensitive Detection of Proteins, *the 4th International Conference on Bioinformatics and Biomedical Engineering (iCBBE)* Chengdu, China, June 18-20, **2010**.
- J. J. Wei, D. H. Waldeck, Y. Wang, M. Kofke, K. Pant, and S. Sundaram, A Novel Plasmonics-Based Nanotechnology for a Label-Free, On-Chip Biosensor, *ISSSR*, Hoboken, NJ, **2008**

Commercialization Activities and Progress: A summary of commercialization activities and progress are included in this report. Potential customers have been identified according to the technology applications. Commercialization models are proposed according to CFDRC’s experiences and capability. Potential other IP protections are listed. Both the recent NASA and Non-NASA customer activities are reviewed. Future potential customer and commercialization activities have been proposed.