University of Minnesota

nanoTECHNOLOGY news

from the University of Minnesota

Fall 2017

Handheld Protein Biomarker Detection
Zepto Life Technology

Beginning from work in Professor Jian-Ping Wang's group at University of Minnesota, Zepto Life Technology is building a handheld protein biomarker detection platform with integrated microfluidics which has great potential for the final development of simple, rapid, automatic and cost-effective point-of-care testing (POCT).

Many epidemiologic studies have indicated that D-dimer and C-reactive protein (CRP) can be used as reliable biomarkers of most cardiovascular diseases, and some *in vitro* diagnostic kits including the two biomarkers for assessing cardiovascular risk have been successfully commercialized.

Biologically functionalized giant magnetoresistive (GMR) sensors paired with biologically functionalized magnetic nanoparticles (MNPs) sensitively and specifically detect protein biomarkers such as human D-dimer and CRP (Fig 1a-d). The scalability of highly dense sensor array on one chip and robust solution spotting endow GMR attractive features such as multiplex detection of protein biomarkers at medically relevant sensitivities in a convenient hand-held and battery powered form.

The versatile set of tools from the Minnesota Nano Center including CVD, PVD, RIE Etcher and Photolithography Stepper along with characterization tools allows Zepto Life Technology to fulfill their goals.

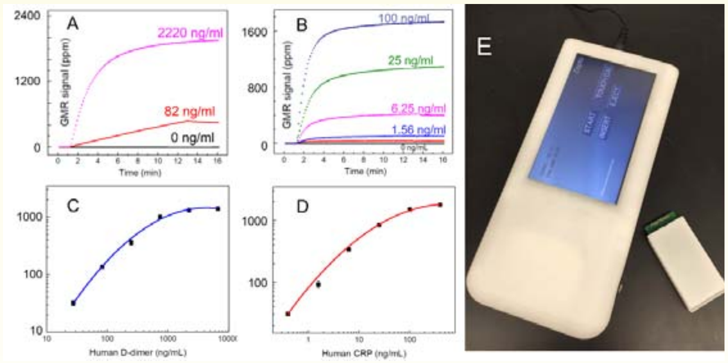

Fig 1: Typical binding curves in real time for human D-dimer (a) and CRP (b). Calibration curves for human D-dimer (c) and CRP (d) detection by GMR biosensor. (e) A disposable testing cartridge is equipped with GMR sensors and microfluidic interface. The cartridge connects to a handheld biosensing system which monitors the GMR sensors while flowing sample and reagents above.

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Please visit Professor Wang's biosensing group on the web for relevant publications: http://www.nanospin.umn.edu/magnetic-biosensing

REMINDER: If your work uses the Minnesota Nano Center, please add the following in the acknowledgements section of any publications: "A portion of this work was carried out in the Minnesota Nano Center which receives partial support from the NSF through the NNCI program."

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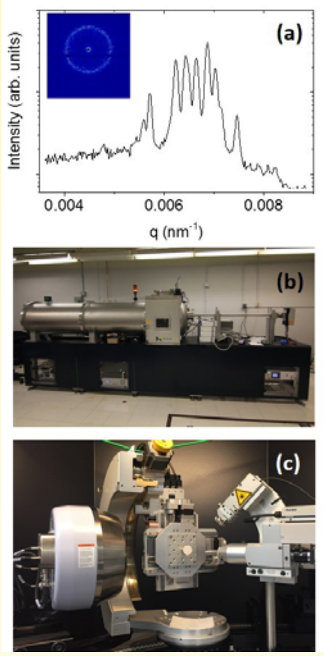
CharFac Director, Greg Haugstad

The CharFac / Imaging Center / NMP (IPRIME) workshop held on Aug. 28-29 attracted about 80 attendees, half from industry. The event included 12 talks on advanced characterization methods and a corresponding number of demos (limited in capacity to 25 industrial attendees). Feedback from this event has been positive but we appreciate more. We continue to strategize on how to promote usage of our most advanced capabilities. One idea is to have a staff poster session where interested parties can engage in fruitful discussions with the staff, including more drill-down into individual research problems. And we intend to have more focused events themed for example around scanning probe methods or X-ray scattering.

Speaking of which, we are thrilled to announce three transformational developments in our X-ray scattering (XRS) laboratories (please contact Dr. Javier Garcia-Barriocanal, javigb@umn.edu):

First, the installation of a new Xenocs Ganesha X-ray scattering system in CharFac was completed in August, and first users have received training. (See figure, parts a-b.)



(a) Azimuthally integrated intensity pattern corresponding to a Frank Kasper sigma (ó) phase measure in a block copolymer; sample courtesy of the Frank Bates group. The inset shows the full 2D scattering pattern of the polymer sample. (b) The Ganesha instrument installed at the CharFac. (c) The D8 Discover microdiffractometer with new eulerian-cradle sample goniometer (center) and Vantec 2D detector (left).

This system explores scattering angles ranging from 10^{-4} to 90 degrees, with maximum angular resolution of 10^{-4} degrees. Thus the Ganesha probes a real-space scale ranging from Angstroms (i.e., crystallography) to approximately 600 nm. Its exceptional operating modes take advantage of the latest technology in 2D detection, X-ray source intensity and "scatterless" slits. The Ganesha combines the longest synchrotron-style SAXS+WAXS beamline for the home laboratory with the highest level of flexibility and functionality. It further allows *in-operando* measurements under controlled temperature, atmosphere and sample deformation.

Second, we have finished an in-house design/installation of a custom refrigeration system that uses the cooling water of Shepherd Labs. The new cooling system significantly reduces energy consumption, maintenance, laboratory space and noise when compared to previous refrigeration systems (individual water chillers for each instrument). We thank Daniel Lundgren from Facilities Management for his invaluable help.

Third, we have installed a ¼ eulerian cradle (sample goniometer) in the D8 Discover microdiffractometer, which replaces an XYZ stage. The D8 Discover is also equipped with a state-of-the-art Vantec 500 2D detector, a significant improvement over the old Hi-Star multiwire detector. The new cradle opens the possibility of fast thin film analysis as well as texture and stress analysis. These applications together with phase identification, XRD mapping, crystallinity percentage, phase percentage, particle size and more make the D8 Discover a huge asset. (See figure, part c.)

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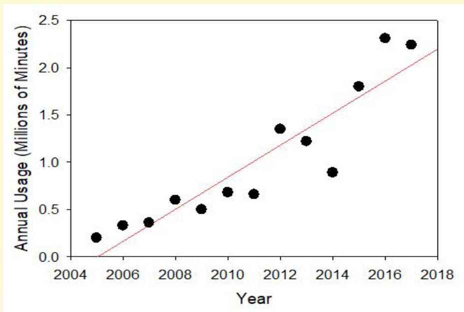
Greg Haugstad, Director

MINNESOTA nano CENTER news



One of the challenges facing MNC is meeting the increasing needs for usage of the facility. Usage is a tricky quantity to measure, but one way that we track it by equipment usage minutes. The graph at right shows our recent history. As you can see, usage minutes has increased dramatically over the last 15 years. Increasing equipment usage means that more equipment will require more maintenance more frequently. At the same time, many of our pieces of equipment are aging. Many of the components, like vacuum pumps and pressure gauges, are easily replaced when they wear out. The parts that are the most difficult to replace are those related to the control systems and software because they are machine-specific, and often upgraded by the vendors. Last summer a failure of the STS etcher caused four weeks of down time that was only fixed when a used part was found in Great Britain.

Over the last few years we have begun a program of replacing equipment control systems. Most recently we submitted a proposal to the Grant In Aid program to replace the controls on the STS. My thanks to Paul Crowell and Dan Frisbie for agreeing to serve as PI and co-PI. We will continue this process, replacing control systems that are in the 15+ year old range, to ensure that MNC remains a reliable resource for your work.

MNC Director
Stephen Campbell

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Processing Capability - ALD tools

Atomic Layer Deposition (ALD) systems allow very well controlled growth of extremely thin films, even over highly nonplanar structures such as nanopores, nanowires, and nanoparticles. Typical films are metal oxides, metal nitrides and metals. The process involves the sequential exposure of the substrate to two gases. The gases are chosen such that at least one of them saturates the surface at one monolayer of coverage and the process conditions are such that neither gas, by itself, will decompose to form a solid. After exposure to the first gas, the system is flushed, but one monolayer of this gas remains on the substrate where it can react with the second gas to form a monolayer of the desired film. The process is repeated until the desired film is grown.

The Fiji 200 Gen 2 PE-ALD system from UltraTech.

MNC has two ALD systems, a standard thermal tool with ozone as well as a plasma-enhanced tool (PE-ALD). The thermal ALD currently has source materials for the deposition of HfO_2, Al_2O_3, SiO_2, TiO_2, and ZnO. The PE-ALD tool uses a plasma instead of thermal energy to drive the process, and this allows depositions to be done at lower temperatures. This tool currently has these films: HfO_2, HfN_2, Al_2O_3, Al_2N_3, TiO_2, and TiN_2. Please contact us if you have interest in this capability.

New User Orientation

MNC is offering New User Orientation for new users twice each month. On the first Wednesday of every month, the session begins at 1:00pm, and on the third Thursday of the month the session begins at 10am. A MNC staff member provides a tour showing some of the safety related equipment and the gowning process used for the MNC cleanroom. There is also training on using Badger, the lab software. The safety training takes about one hour to complete, and must be done before users will be granted access to MNC facilities. See the ‘For New Users’ section of our website for complete information: www.mnc.umn.edu/newusers.php.

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Contact: Becky von Dissen at vondi001@umn.edu or 612-625-3069

Minnesota Nano Center and the National Nanotechnology Coordinated Infrastructure

The MNC is a state-of-the-art facility for interdisciplinary research in nanoscience and applied nanotechnology. The Center offers a comprehensive set of tools to help researchers develop new micro- and nanoscale devices, such as integrated circuits, advanced sensors, microelectromechanical systems (MEMS), and microfluidic systems. The MNC is also equipped to support nanotechnology research that spans many science and engineering fields, allowing advances in areas as diverse as cell biology, high performance materials, and biomedical device engineering.

In September 2015, the National Science Foundation funded the National Nanotechnology Coordinated Infrastructure (NNCI). MNC is part of this initiative, along with our partner facility at North Dakota State University. The NNCI aims to advance research in nanoscale science, engineering and technology by enabling NNCI sites to provide researchers from academia, small and large companies, and government with access to university user facilities with leading-edge fabrication and characterization tools, instrumentation, and expertise within all disciplines of nanoscale science, engineering and technology. The NNCI framework builds on the National Nanotechnology Infrastructure Network (NNIN), which enabled major discoveries, innovations, and contributions to education and commerce for more than 10 years.