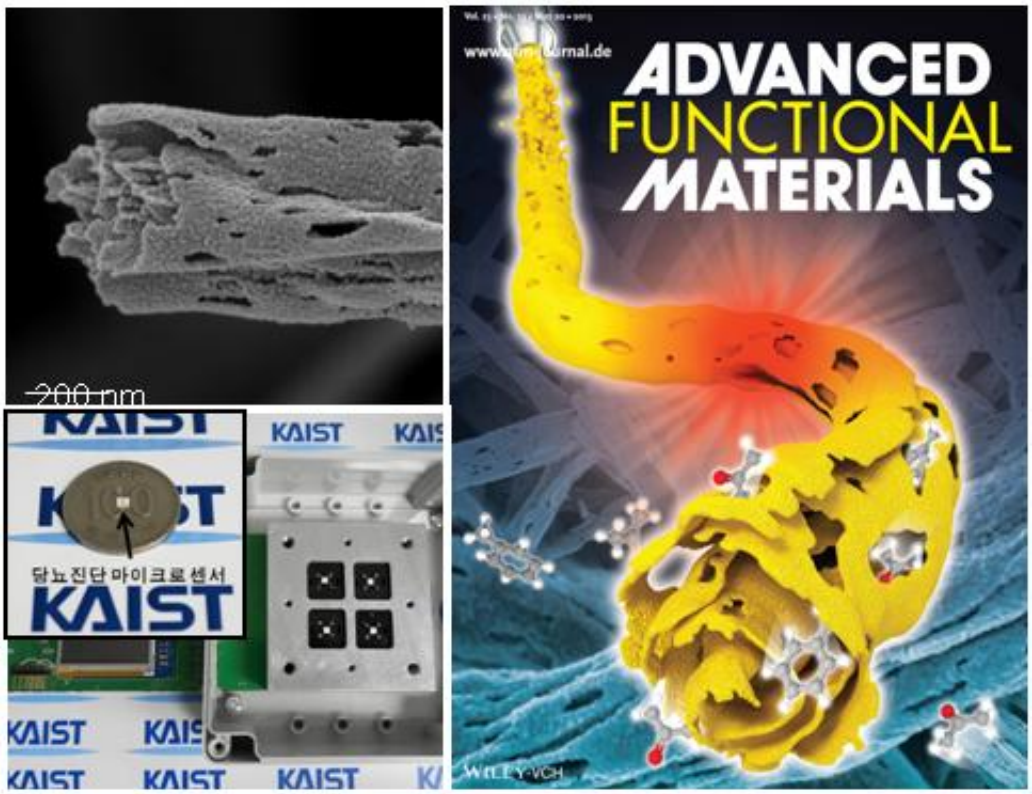
Nanofiber sensor detects diabetes or lung cancer faster and easier

June 11 2013



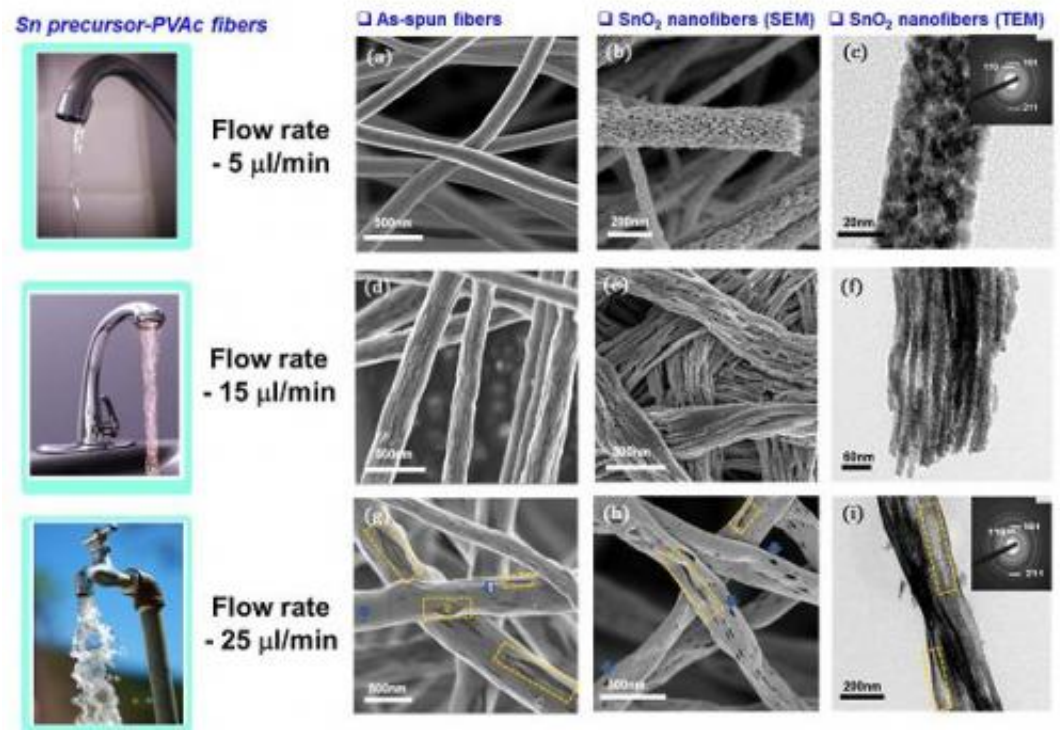
Clockwise from left to right: left upper shows a magnified SEM image of a broken thin-wall assembled SnO2 fiber. Left below is an array of breath sensors (Inset is an actual size of a breath sensor). The right is the cover of *Advanced Functional Materials* (May 20th issue) in which a research paper on the development of a highly sensitive exhaled breath sensor by using SnO2 fibers is published. Credit: KAIST

Today's technological innovation enables smartphone users to diagnose serious diseases such as diabetes or lung cancer quickly and effectively by simply breathing into a small gadget, a nanofiber breathing sensor, mounted on the phones.

Il-Doo Kim, Associate Professor of Materials Science and Engineering Department at the Korea Advanced Institute of Science and Technology (KAIST), and his research team have recently published a cover paper entitled "Thin-Wall Assembled SnO2 Fibers Functionalized by Catalytic Pt Nanoparticles and their Superior Exhaled Breath-Sensing Properties for the Diagnosis of Diabetes," in an academic journal, *Advanced Functional Materials* (May 20th issue), on the development of a highly sensitive exhaled breath sensor by using hierarchical SnO_2 fibers that are assembled from wrinkled thin SnO_2 nanotubes.

In the paper, the research team presented a morphological evolution of SnO2 fibers, called micro phase-separations, which takes place between polymers and other dissolved solutes when varying the flow rate of an electrospinning solution feed and applying a subsequent heat treatment afterward.

The morphological change results in nanofibers that are shaped like an open cylinder inside which thin-film SnO2 nanotubes are layered and then rolled up. A number of elongated pores ranging from 10 nanometers (nm) to 500 nm in length along the fiber direction were formed on the surface of the SnO2 fibers, allowing exhaled gas molecules to easily permeate the fibers. The inner and outer wall of SnO2 tubes is evenly coated with catalytic platinum (Pt) nanoparticles. According to the research team, highly porous SnO2 fibers, synthesized by eletrospinning at a high flow rate, showed five-fold higher acetone responses than that of the dense SnO2 nanofibers created under a low flow rate. The catalytic Pt coating shortened the fibers' gas response time dramatically as well.



This is the microstructural evolution of SnO2 nanofibers as a function of flow rate during electrospinning. Credit: KAIST

The breath analysis for diabetes is largely based on an acetone breath test because acetone is one of the specific volatile organic compounds (VOC) produced in the human body to signal the onset of particular diseases. In other words, they are biomarkers to predict certain diseases such as acetone for diabetes, toluene for lung cancer, and ammonia for kidney malfunction. Breath analysis for medical evaluation has attracted much attention because it is less intrusive than conventional medical examination, as well as fast and convenient, and environmentally friendly, leaving almost no biohazard wastes.

Various gas-sensing techniques have been adopted to analyze VOCs including gas chromatography-mass spectroscopy (GC-MS), but these

techniques are difficult to incorporate into portable real-time gas sensors because the testing equipment is bulky and expensive, and their operation is more complex. Metal-oxide based chemiresistive gas sensors, however, offer greater usability for portable real-time breath sensors.

Il-Doo Kim said, "Catalyst-loaded metal oxide nanofibers synthesized by electrospinning have a great potential for future exhaled breath sensor applications. From our research, we obtained the results that Pt-coated SnO_2 fibers are able to identify promptly and accurately acetone or toluene even at very low concentration less than 100 parts per billion (ppb)."

The exhaled acetone level of diabetes patients exceeds 1.8 parts per million (ppm), which is two to six-fold higher than that (0.3-0.9 ppm) of healthy people. Therefore, a highly sensitive detection that responds to acetone below 1 ppm, in the presence of other exhaled gases as well as under the humid environment of human breath, is important for an accurate diagnosis of diabetes. In addition, Professor Kim said, "a trace concentration of toluene (30 ppb) in exhaled breath is regarded to be a distinctive early symptom of lung cancer, which we were able to detect with our prototype breath tester."

The research team has now been developing an array of breathing sensors using various catalysts and a number of semiconducting metal oxide fibers, which will offer patients a real-time easy diagnosis of diseases.

Provided by The Korea Advanced Institute of Science and Technology (KAIST)

Citation: Nanofiber sensor detects diabetes or lung cancer faster and easier (2013, June 11)