No.59, 4th Quarter 2009

ITRI TODAY

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ITRI Honored with Wall Street Journal Technology Innovation Award and R&D 100 Award

In 2009 ITRI has added more prestigious international awards to its growing collection of prizes for innovative R&D and technology applications. In October, ITRI accepted the Wall Street Journal Technology Innovation Award for fleXpeaker, a technology for paper-thin flexible loudspeakers technology. Earlier this year, ITRI won an R&D 100 Award for STOBA, a technology to ensure ultimate lithium-ion battery safety. These awards not only serve to affirm ITRI's status as a leading research institute for technology development and commercialization, they also help raise its international profile visibility and help bring in attract more business opportunities and attract partners.

fleXpeaker™

ITRI's fleXpeaker, which won the Technology Innovation Award top prize in the category of Consumer Electronics, is the world's thinnest, lightest and most flexible speaker. It combines arrays of tiny, bendable speakers to produce high-fidelity speaker systems of almost any size using standard inkjet printing on substrates of paper or plastic and thin metal. FleXpeaker was selected for the award from more than 500 total entries which were judged by an expert panel for technology innovation as well as application and commercialization potential.

Despite its simple structure, which consists of a vibration film sandwiched

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SOURCE:EOL/ITRI & Scenario Lab

Flexio, an ultra-thin and light portable radio, won a 2009 Red Dot Award for its combination of fleXpeaker with a flexible solar cell.

between two layers of metal with paper or metal with plastic, fleXpeaker offers good sound quality. In mid- to high-range frequencies (250Hz – 20KHz, where the vast majority of 3C products operate), the sound quality is better than conventional speakers. The team is working to improve performance in lower frequency range, but in this it is up against physical limits (for applications requiring more bass, fleXpeaker systems will likely incorporate a more traditional subwoofer).

FleXpeaker offers many advantages over traditional speakers. It is environment-friendly, as it can be made from recyclable and/or biodegradable layers of paper and metal, and its power consumption is only 10% that of conventional moving-coil loudspeakers due to its much higher sound generation efficiency. In addition, it is designed to be manufactured using roll-to-roll production. This not only substantially lowers unit costs, but also makes it relatively easy to adjust sound quality for various applications by changing the size of sound cavities in the structure by adjusting the inkjet printing scheme used for the construction of the spacer layer.

As far as choice of substrate, the thin metal layer (necessary to receive the audio signal) can be combined with paper or plastic layers depending on the application. In general, paper substrate may be used for disposable applications because it is less robust than plastic but is lower in cost and recyclable. Either substrate allows fleXpeaker to be cut with scissors into any shape.

Application Flexibility

Because fleXpeaker is flexible in size, lightweight and consumes little power,it can be embedded into almost any application environment to meet space-saving, ornamental, or other design requirements. It is envisioned that fleXpeaker will be widely applied in various 3C and entertainment products such as flat-screen televisions, MP3s, cameras, and so on, making them even lighter and slimmer while extending battery life. Other applications may include advertising and signage, such as on billboards, in shopping malls, or for public announcement systems in locations such as train stations. Through special integration technology, fleXpeaker can

also be incorporated into clothing and consumer packaging, in industrial anti-noise earphones, or in medical devices.

One of the first applications to emerge is Flexio, a small and light portable radio that combines a flexible solar cell and fleXpeaker. ITRI also won 2009 Red Dot Award for Flexio, and prototypes will be displayed for a year at the Red Dot design museum in Singapore. In addition, ITRI is working with a local carmaker on car audio systems, while several companies are in the process of licensing the technology to develop their own applications, including for buildings, 3C products, and more.

A New Approach

According to Mr. Chang-Ho Liou of the Division of Nanoelectronic Technology, Electronic and Optoelectronic Research Laboratories (EOL) of ITRI, the R&D which led to fleXpeaker commenced in 2003. ITRI was working on flexible displays, and a flexible speaker was desirable to create a flexible audio-video system. It was determined very early that the flexible speaker should use automated roll-to-roll manufacturing, because it greatly lowers costs and increases application flexibility. The requirements for thinness and flexibility forced the team (initially just Mr. Liou and his boss, Dr. Ming-Daw Chen) to throw away conventional ideas about loudspeaker structure and start from the basics of acoustics.

They experimented with many approaches, structures and materials. For example, plastic with transparent metal, a combination commonly found in touch screens, was tried but abandoned because transparent metal is expensive. It was not until 2005 that they tried using thin metal foil with paper. It took just a few minutes to throw together the materials and confirm that a vibration material between two foil-paper layers could indeed function as a speaker, but the road from that eureka moment to the Technology Innovation Award was paved with countless hours of hard work. Fortunately, the materials involved were cheap and readily available, and Mr. Liou recalls with a smile that at times their work resembled inventors tinkering in a workshop more than scientists working in cutting edge R&D facilities.

fleXpeaker Commercialization

ITRI has filed a system of patent applications in multiple countries on several aspects of the fleXpeaker technology,

SOURCE: EOL/ITRI

Thin and bendable, fleXpeaker also offers excellent sound quality.

PHOTOGRAPH BY FU-SHENG TZOU

Dr. Ming-Daw Chen (left) and Mr. Chang-Ho Liou (right) with other key members of the fleXpeaker team.

including the structure, the manufacturing process, some applications and some specially developed materials. One related patent has so far been granted, while papers have been published in the US Display Consortium, Society For Information Display, and other journals.

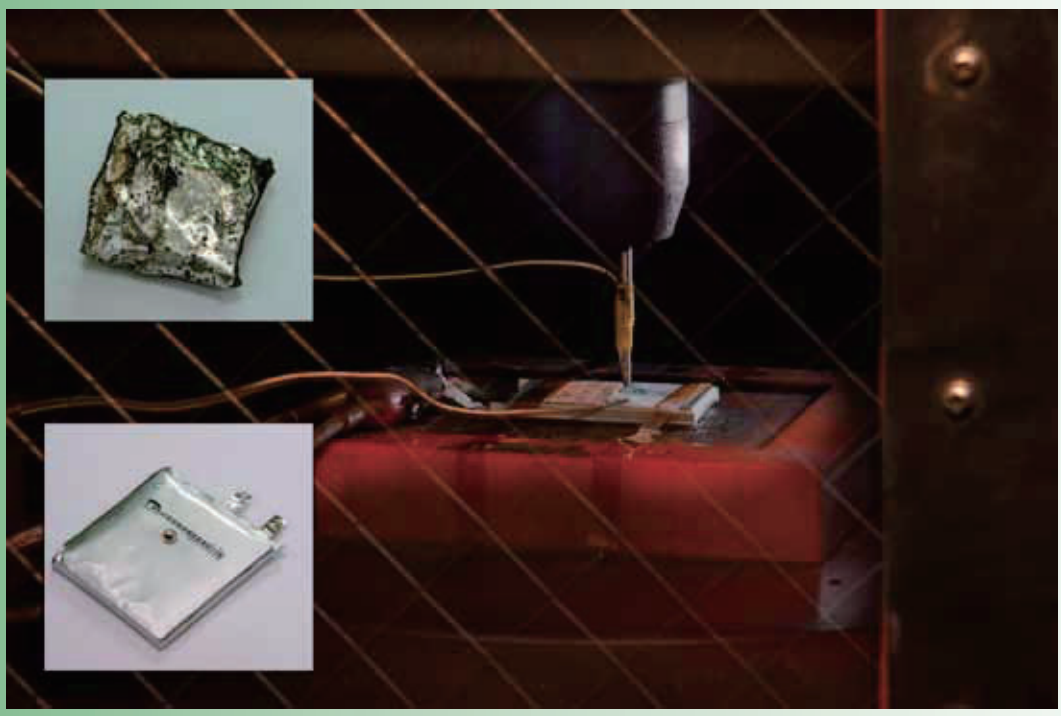
Negotiations are in progress with several interested parties regarding IP licensing and technology transfer. Under consideration is the possibility of spinning off a new company to make fleXpeaker loudspeakers; the spin-off would possibly be the same business to commercialize ITRI's flexible multimedia products including its flexible displays.

In the second or third quarter of 2010 pilot production is expected to begin, using ITRI's Flexible Electronics Pilot Laboratory to test feasibility of larger scale production.

STOBA Wins R&D100 Award

Making Lithium-Ion Batteries Safe

Because they are thin, light and high-powered, Lithium-Ion Batteries (LiB) are ubiquitous in 3C products, and are a focus for electric vehicles. However, their high power density means LiBs are vulnerable to overheat and explode after an internal short circuit, which can be caused by particulate contamination during manufacturing, improper heating or charging, or by piercing or other impact. When internal temperature rises too high the membrane separating positive and negative materials melts, resulting in massive current shorting, rapid thermal runaway (to temperatures over 600 degrees) and finally explosion. To prevent this, today's commercial batteries rely on the insertion of an insulating film between the each pair of opposite electrodes. This insulating separation film is good enough for normal battery use conditions, but when subjected to severe impact or penetration in an accident, the film is virtually useless in suppressing the explosive battery energy release.



PHOTOGRAPH BY FU-SHENG TZOU

Lithium ion batteries undergo piercing experiments to verify safety; (inset top) most LiBs without STOBA burn up and explode, but the battery with STOBA (bottom) does not.

Although the actual failure rate is quite low when it is considered that nearly 3 billion LiBs are manufactured every year, the potentially fatal consequences are too severe to ignore. Dr. Jing-Pin Pan, director of the Energy Storage Materials Division of ITRI's Material and Chemical Research Laboratories (MCL), points out that in order to power electric cars, LiBs will be even higher-powered and therefore more dangerous. On the other hand, if the critical safety issue is resolved, the batteries can be made more powerful.

What is STOBA?

MCL's Deputy General Director Alex Peng explains that STOBA (Self-Terminated Oligomer with Branched Architecture) is a hyper-branched polymer with a unique characteristic: under increased temperature, STOBA grows in volume and structural complexity. STOBA is added to the lithium battery to form a protective film that provides two lines of defense. When the battery heats excessively (>150 ºC) due to external impact or piercing, the end points of the STOBA polymer's branched structure react together to form a cross-linking three-dimensional network which acts as a physical barrier insulating the anode and cathode, decreasing ionic conductivity and suppressing thermal runaway. At the same time, STOBA efficiently scavenges free radicals and suppresses oxygen release to shut down the combustion process. The combination of these two effects virtually eliminates the risk of explosion.

Apart from resolving the battery safety issue, STOBA has other outstanding characteristics. It is relatively inexpensive to mass produce, so STOBA does not raise battery cost very much. Also, STOBA does not affect the battery performance during normal use, and actually improves performance at higher operating temperatures common to many compactly designed 3C products, extending the high temperature recycle life by more than 20%.

Commercialization

STOBA technology has already passed the mandatory shorting and piercing experiments more stringent than the international safety standard. Presently, it is the only technology to fundamentally resolve the lithium battery safety issue. Six articles have been published in various

PHOTOGRAPH by HUNG-MOU TSAI

Dr. Jonq-Min Liu, General Director of ITRI's Material and Chemical Research Labs (MCL), congratulated his outstanding team and thanked them for their hard work on STOBA development.

professional journals, while a system of about 30 patent applications has been filed in multiple countries on a dozen different subject matters for the STOBA battery technology, with four patents granted so far.

STOBA is expected to be used in smaller 3C batteries starting in 2010, with seven companies having already signed contracts, and more in negotiations. Although many international manufacturers have expressed interest in STOBA, priority is being given to local companies. The next step is to apply it in bigger batteries for electric vehicles, where performance needs are stronger and safety requirements even more difficult. STOBA may also have application outside the area of Li-ion batteries, for example, in fuel cells.

Origin and Development

Dr. Pan explained that he had worked with a similar material in the 90s when he was in the IC packaging industry. Because of its chemical composition this material can withstand heat, and his original idea was to adapt it as a gel for application in Polymer Lithium Batteries. As his MCL team worked, however, they realized that the material could solve the internal short circuit problem for LiBs. However, LiB chemistry is extremely complex and difficult to study – when a substance is added to the battery, for example, it is hard to determine where it went or what effects it caused. In early tests the team found they could delay the explosion by several seconds – not a solution, but an indicator of potential that was noticed by ITRI management, and more resources were dedicated to the project.

After the effective structure of STOBA was discovered, the next challenge was to mass produce it efficiently. With early yields only around 30%, the team spent over a year working late every night on pilot production, confident they were on the edge of a breakthrough – yet frustratingly unable to find it. Finally, Dr. Pan brought in an old colleague with systems analysis expertise to analyze the negative results and suggest promising directions for exploration. Deputy General Director Peng adds that the overall diversity of perspectives on the

team, including experts in chemistry, battery materials, analysis, testing, and so on, was a key factor in the successful development of STOBA.

Dr. Chang-Rung Yang, a manager in MCL's Advanced Thin Battery unit, recalls that the team entered the R&D 100 competition in 2008 – and did not win. He admits they were a little surprised, but they shrugged their shoulders and carried on with the research. "A year ago we knew that it worked, but we didn't really understand how it worked," he explains. "After another year working with the material, we have gained a much deeper understanding, so now we know how to adapt it to get optimal results for different applications."

Wider Benefits

Taiwan's LiB battery industry currently has about 3-5% of the market, trailing far behind the leaders Japan, Korea, and China. To expand market share, local companies need to find an entry point, and STOBA provides just that. Safety is a universal value, something customers everywhere are willing to pay for. Therefore, it presents a chance for Taiwan to leapfrog from its trailing position into the driver's seat. Dr. Pan adds that STOBA could have wider benefits to other industries beyond the battery market. Most 3C products consist of some IC, a display, and a battery. Taiwan is already a leader in the first two – if it can shore up its weakness in the battery sector, this can benefit its many 3C manufacturers.

Another emerging industry being promoted by Taiwan's government is LiB for electric vehicles including bikes, motorcycles, and LEVs. Taiwan is in many ways an ideal environment to establish an electric vehicle ecosystem, with its densely populated urban environment, strengths in electric motors, controller IC, and system integration, as well as several large scooter manufacturers. A strong battery technology foundation greatly improves the chance for Taiwan to realize its ambition to be a world leader in electric vehicles.

SOURCE: ITRI

STOBA will benefit not only the battery industry but also the 3C and electric vehicle sectors.