# TECHNICAL INSIGHTS

## SENSOR

## TECHNOLOGY ALERT

12th June 2015

## 1. X-RAY IMAGING COULD HELP IMPROVE ENERGY STORAGE

Lithium-ion has been the fastest growing and most promising battery chemistry. Normally, the energy density of lithium ion is twice that of the usual nickel-cadmium chemistry, with potential for higher energy densities. Lithium-ion is a low maintenance type of battery technology. No scheduled cycling is needed to increase the life of such batteries. The self-discharge is less than half that of nickel-cadmium and lithium-ion cells can cause relatively minimal harm when disposed of.

However, lithium-ion is fragile, and for safe operation, a protection circuit becomes necessary. The protection circuit built into each pack can limit each cell's' peak voltage during charge and prevents the voltage from becoming too weak upon discharge. The maximum charge and discharge current on most packs are confined to between 1 C and 2C. Lithium-ion batteries are susceptible to aging (often fail after two or three years), can be expensive to manufacture, and are not a fully mature technology.

In a development that could improve the energy storage of, for example portable electronics or electric microgrids, researchers at the University of Wisconsin-Madison and Brookhaven National Laboratory have developed an innovative X-ray imaging technique for the purpose of viewing and studying the electrochemical reactions in lithium-ion rechargeable batteries that contain a new iron fluoride material. Iron fluoride has potential to boost the amount of energy stored three-fold compared to that a conventional lithium-ion battery is able to store.

By accounting for background signals that would otherwise confuse the image, the researchers were able to accurately view and measure, at the nanoscale, the chemical changes iron fluoride experiences in the storage and

 

discharge of energy. Through examining the iron fluoride transformation in batteries at the nanoscale, the new X-ray imaging method pinpoints each individual reaction, which allows for understanding the occurrence of capacity decay. Analysis of X-ray data on this level allowed for tracking the electrochemical reactions with greater accuracy than in previous methods, and led the scientists to deduce that the performance of iron fluoride improves when it has a porous microstructure.

The study also provided some preliminary insights pertaining to the issue that iron fluoride battery materials do not discharge as much energy as they take in, thereby reducing energy efficiency.

The research could generate approaches for maximizing the cycling performance and efficiency of iron fluoride lithium-ion battery materials, which would further the development of large-scale renewable energy storage technologies for electric cars and microgrids. The X-ray technique could also prove useful in understanding other solid-state transformations that are an essential aspect in various technologies. Such knowledge would help improve several industrial processes, for instance, preparing inorganic ceramics or thin-film solar cells.

The research was supported by the US Department of Energy Basic Energy Sciences and a seed grant from the Wisconsin Energy Institute. The synthesis of the battery materials was supported by National Science Foundation Division of Materials Research.

Details: Dr. Song Jin, Professor of Chemistry, University of Wisconsin-Madison, 1101 University Avenue, Madison, WI 53706. Phone: +1-608-262-1562. E-mail: jin@chem.wisc.edu

## 2. ACOUSTIC CONTROL OF SMARTPHONES

Touchscreen interfaces have become the most preferred and widely used technology for controlling smartphones or other mobile devices. Touchscreens can facilitate ease of use and intuitive tactile responses and interactions with respect to such mobile devices.

Projected capacitive touch screens have supplanted resistive touch screens in high-volume consumer electronics applications (mobile phones, tablet computers, digital cameras, MP3 players, and so on). Unlike conventional capacitive touch technology, projected capacitive touch technology is able to

 

sense input from a stylus or gloved finger. Projected capacitive touch screens can offer better multi-touch performance, durability, optical clarity, and a more intuitive user interface. Capacitive touch screens are using in-cell technology to eliminate a layer by having the capacitors inside the touch screen. This technique enables more direct contact with the content displayed and more responsive interaction.

However, touch screens have had certain limitations as an interface for mobile devices.

For example, touchscreens are not as accurate in navigating applications as the traditional mouse and physical buttons. It can be easier to select small interface elements with a cursor than with fingers, particularly when one holds the mobile device with one hand and uses the thumb to operate an application. Touchscreen keyboards can have small buttons and an inadequate tactile response, which can impede user satisfaction.

Moreover, the screen itself can be disrupted as a result of interaction with the touch screen. Applications requiring a great deal, and different types, of button input or requiring the display of a considerable and varied amounts of information may not be efficiently addressed using touch screens.

In work supported by Disney Research, researchers at Carnegie Mellon University and Disney Research have developed what is termed "Acoustruments," which can offer an innovative, inexpensive alternative to touch screens in the form of physical knobs, sliders and other mechanisms that can be easily added to mobile devices.

Drawing inspiration from wind instruments, the researchers have devised mechanisms such as pluggable plastic tubes and other structures for connecting a smart phone’s speaker and microphone. This would allow for acoustic control of the device by changing sounds as they pass through the system. The Acoustruments could provide key enhancements in the functionality and capabilities of a smart phone, such as proximity sensing or pressure sensing. The researchers noted that plastic acoustruments could be made quickly and inexpensively, since no electrical circuitry is involved.

Potential or promising applications for the Acoustruments include the use of smart phones to control toys, appliances, robots, virtual reality displays, where the technology could provide enhanced interaction or control of the smart phone without distractions. Other applications can include interactive dolls,

 

smart phone cases capable of sensing being placed on a table or being hand carried, alarm clocks with on/off and snooze buttons.

Acoustruments function similarly to wind instruments. The smartphone speaker generates ultrasonic frequencies that are inaudible to individuals. Any interactions that block, open holes or change the length or diameter of the plastic tubes that connect the speaker to the microphone will alter the acoustic signal.

Details: Scott Hudson, Professor, Human-Computer Interaction Institute, School of Computer Science, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213. Phone: +1-412-268-2429. E-mail: scott.hudson@cs.cmu.edu

## 3. WIRELESS FIELD MONITORING SOLUTION

Sensors, transmitting data wirelessly, are increasingly enabling more precise, efficient management of crops and irrigation. The use of sensors can allow more detailed, real-time information about the condition of soil in different areas of a farm. This capability can allow farmers to optimize cultivation, fertilization, and water-use based on the condition of the soil at different sections of the farm.

Furthermore, the ability to wirelessly transmit data about soil condition, such as soil moisture content, can save farmers considerable time compared to having to go into the fields to read soil moisture meters.

Sensors are enabling precision agriculture, which facilitates more efficient use of resources that are adapted to local field conditions. The ability to collect and quickly disseminate detailed information about, for example, environmental factors and soil status allows farmers to make more informed decisions, which can conserve resources and improve crop yield.

Wireless sensors in precision agriculture have assisted in such areas as spatial data collection, precision irrigation, variable-rate technology and providing data to farmers.

In spatial data collection, mobile field data acquisition systems, for example, have been developed to collect data for crop management and spatial-variability studies. Data collected included soilwater availability, soil compaction, soil fertility, biomass yield, leaf area index, leaf temperature, leaf

 

chlorophyll content, plant water status, local climate data, insect-disease-weed infestation, grain yield, and so on.

Precision irrigation systems have included distributed, remotely controlled, and automatic irrigation systems in which sensor data was communicated via a LAN (local area network). Examples of implementation of variable rate technology include automated fertilizer applicator systems for tree crops that consisted of an input module for GPS (global positioning system) and real-time sensor data acquisition, a decision module for calculating the optimal quantity and spread pattern for a fertilizer, and an output module to control the fertilizer application rate, along with Bluetooth communications.

US-based gThrive Inc. is now offering its convenient, cost-effective gThrive wireless sensing solution that can provide growers with crucial information for water, fertilizer, and pest management. Data about moisture, temperature, salinity, and sunlight conditions in the fields can be viewed on one's smart phone. The solution helps automate irrigation and fertigation (the application of fertilizer with water). It is geared toward helping farmers to better manage their energy, water, and fertilizer consumption, which would reduce costs and environmental impact and improve yield and profit margins.

The gThrive is a field monitoring solution that collects data through wireless, portable gStakes; relays the data through a gLink base station from the gStakes to the cloud; and includes a smart phone application to enable users to access the information with ease. The gStakes can monitor key parameters: soil moisture, soil electrical conductivity, soil temperature, sunlight, and air temperature.

The gStakes communicate with each other and with the gLink base station over a proprietary radio link. The gLink connects to the Internet over a Wi-Fi network or uses the cellular telephone network. The user can access data from the company's secure servers over the Internet, via a computer, smart phone or tablet.

The gThrive solution provides capabilities such as real-time graphs of field data; reduction of water and pumping cost; the use of less amounts of fertilizer; monitoring of soil salinity; ability to adjust the condition of the worst sections of the field so they become more productive; awareness of when the root zone is sufficiently warm to seed, plant, fertilize or control pests; ability to

 

identify irrigation problems in real time; and the capacity to monitor frost conditions in different climate conditions within the field.

Details: Brian Mellea, Vice President, Marketing, gThrive Inc., 3945 Freedom Circle, Suite 540, Santa Clara, CA 95054. Phone: +855-474-8474. E-mail: brian.mellea@gthrive.com.

## 4. RECENT PATENTS IN THE FIELD OF 3D IMAGE SENSORS

Three-dimensional (3D) image sensors are able to capture depth information to provide a 3D image. 3D vision systems have strong application potential in robotics and, most importantly, gaining much traction because of applications in the consumer electronics domain such as gesture recognition, gaming and many others.

Three-dimensional machine vision is employed in robotics to enable a better sense of the environment in robots. To navigate and survey a particular region, 3D image sensing can be employed for mapping the area with high efficiency and accuracy. The key enabling technologies of 3D image sensing are laser detection and ranging, time-of-flight, stereovision and laser scanners.

The number of patents published in 3D image sensing is increasing every year, which reiterates the growing interest in the field and increasing possibilities of application in the near and medium terms. Three dimensional image sensors are expected to have a high impact in consumer electronics devices as companies try to incorporate gesture recognition capabilities into different devices, ranging from home entertainment (e.g., TV remote controls) to smart phones, tablets, gaming, and so on. Most of the top assignees such as, Samsung, LG, and Sony are based in the APAC region.

Three dimensional image sensors have key opportunities to be employed in semi-autonomous and fully autonomous vehicles for security and defense applications. Three dimensional image sensors have the capability for convergence with various technologies, such as, machine vision, LED, cameras, and software processing.

A recent patent in 3D image sensors (CN103925879), assigned to Hefei Institutes of Physical Science, Chinese Academy of Sciences, uses a 3D image sensor for indoor robot vision hand-eye calibration.

 

| Title | Publication Date/Publication Number | Assignee | Inventor | Abstract |
|---|---|---|---|---|
| Indoor robot vision hand-eye relation calibration method based on 3D image sensor | 16.07.2014; CN103925879 | Hefei Institutes of Physical Science, Chinese Academy Of Sciences | Kong Lingcheng | The invention provides an indoor robot vision hand-eye relation calibration method based on a 3D image sensor. The method comprises the following steps: S1, marking a plurality of marking points on hand grabbing tail end joints of a robot, acquiring point cloud image information of the hand grabbing tail end joints through the 3D vision sensor of the robot, and acquiring a plurality of sets of three-dimensional coordinate values relative to a visual sensor coordinate system; S2, acquiring the three-dimensional coordinate values of the multiple marking points of the hand grabbing tail end joints under the world coordinate system through an external three-dimensional measurement device, wherein the values are acquired through an arm-base coordinate system of the robot; S3, acquiring the coordinate values through the step S1 and the step S2 and obtaining a hand-eye calibration array. The indoor robot vision hand-eye relation calibration method based on the 3D image sensor simplifies the calibration process, the measurement precision is high, and the requirement for indoor robot hand-eye calibration can be effectively met. |
| System and method for fabricating a 3D image sensor structure | 22.05.2014; US20140138752 | Taiwan Semiconductor Manufacturing Company, Ltd. | Kao Min-Feng | A system and method for fabricating a 3D image sensor structure is disclosed. The method comprises providing an image sensor with a backside illuminated photosensitive region on a substrate, applying a first dielectric layer to the first side of the substrate opposite the substrate side where image data is gathered, and applying a semiconductor layer that is optionally polysilicon, to the first dielectric layer. A least one control transistor may be created on the first dielectric layer, within the semiconductor layer and may optionally be a row select, reset or source follower transistor. An intermetal dielectric may be applied over the first dielectric layer; and may have at least one metal interconnect disposed therein. A second interlevel dielectric layer may be disposed on the control transistors. The dielectric layers and semiconductor layer may be applied by bonding a wafer to the substrate or via deposition. |
| 3D image sensor and method of fabricating same | 23.04.2014; KR1020140047934 | Samsung Electronics Co. Ltd. | Lee, Kwang Min | Provided are a 3D image sensor and a method of fabricating the same. In the 3D image sensor, because the thickness of a second transmission gate and the gate insulating layer of a drain gate is thinner than that of other gate insulating layers, the operation voltage of the second transmission gate and the drain gate can be lowered. Thereby, the power consumption of the 3D image sensor can be reduced. COPYRIGHT KIPO 2014 |
| 3D-stacked backside illuminated image sensor and method of making the same | 26.03.2014; CN103681703 | Taiwan Semiconductor Manufacturing Co. Ltd. | Chao Calvin Yi-Ping | A stacked image sensor and method for making the same are provided. The stacked image sensor includes an upper chip with a pixel array thereon. The second chip includes a plurality of column circuits and row circuits associated with the columns and rows of the pixel array and disposed in respective column circuit and row circuit regions that are arranged in multiple groups. Inter-chip bonding pads are formed on each of the chips. The inter-chip bonding pads on the second chip are arranged linearly and are contained within the column circuit regions and row circuit regions in one embodiment. In other embodiments, the inter-chip bonding pads are staggered with respect to each other. In some embodiments, the rows and columns of the pixel array include multiple signal lines and the corresponding column circuit regions and row circuit regions also include multiple inter-chip bonding pads. |

| Title | Publication Date/Publication Number | Assignee | Inventor | Abstract |
|---|---|---|---|---|
| Pixel unit of 3D CMOS image sensor | 29.01.2014; CN103545334 | Shanghai Integrated Circuit Research & Development Center | Chen Jiayin | PURPOSE: A 3D image sensor and an electronic system including the same are provided to improve performance by vertically laminating a color filter and an organic photoconductive conversion layer for sensing depth information. CONSTITUTION: A unit pixel(100) includes a color filter(150) and an infrared sensing part. The color filter selectively absorbs visible light and converts the light into electricity. A readout circuit reads out the image information sensed from a pixel array. An infrared sensing part includes a first electrode(141), a second electrode(142), and an organic photoconductive conversion layer(130). The organic photoconductive conversion layer is formed between the first electrode and the second electrode. The visible light passes through the organic photoconductive conversion layer, and infrared light is selectively absorbed for photoelectric conversion. COPYRIGHT KIPO 2013 null |
| 3D imaging apparatus and a control method thereof, capable of acquiring a 3D image without mechanical or optical synchronization, by photographing an external image in 3D using one lens and one sensor | 08.08.2013; KR1020130088688 | Samsung Electronics Co. Ltd. | Cho, Dae Woo | PURPOSE: A 3D imaging apparatus and a control method thereof are provided to be used as various usages related with the imaging apparatus, by photographing a 3D image without increasing volume or production cost, by being comprised in an image display apparatus. CONSTITUTION: One lens (110) receives an optical signal about an external image. An imaging device (120) converts the inputted optical signal into an electric signal. An image signal processor (130) acquires two electric signals corresponding two external images having binocular parallax from the electric signal respectively, and converts the acquired two electric signals into digital signals. An image encoder (140) converts the digital signal into a predetermined image format. COPYRIGHT KIPO 2013 null [Reference numerals] (110) Lens; (120) Imaging device; (130) Image signal processor; (131) Binocular disparity application unit; (140) Image encoder |
| 3D image sensor capable of increasing a dynamic range | 10.10.2012; KR1020120110614 | Schwertner, Heiko | Schwertner, Heiko | PURPOSE: A 3D image sensor is provided to polarize received light reflected from a subject, thereby reducing interference effects due to external light. CONSTITUTION: A light source module(300) irradiates transmitting light onto a subject. A lens module(400) polarizes the received light, which is reflected from the subject, by the transmitting light. The lens module provides the polarized received light. A sensing unit(100) converts the polarized received light into electrical signals. COPYRIGHT KIPO 2013 null |

**Exhibit 1 lists some of the patents related to 3D image sensors.**

*Picture Credit: Frost & Sullivan*

## 5. TECHVISION 2015

The TechVision program is the premier offering of Technical Insights, the global technology innovation-, disruption-, and convergence-focused practice of Frost & Sullivan. TechVision embodies a very selective collection of emerging and disruptive technologies that will shape our world in the near future. This body of work is a culmination of thousands of hours of focused effort put in by over 60 global technology analysts based in six continents.

A unique feature of the TechVision program is an annual selection of 50 technologies that are driving visionary innovation and stimulating global growth. The selected technologies are spread across nine Technology Clusters that represent the bulk of R&D and innovation activity today. Each Cluster represents a unique group of game-changing and disruptive technologies that attract huge investments, demonstrate cutting-edge developments, and drive the creation of new products and services through convergence.

Our technology analysts regularly collect deep-dive intelligence on several emerging and disruptive technologies and innovations from around the globe. Interviews are conducted every day with innovators, technology developers, funders, and others who are a part of various technology ecosystems. The respondents are spread across public and private sectors, universities, research institutions, and government R&D agencies. Each technology is rated and compared across several parameters, such as global R&D footprint, year of impact, global IP patenting activity, private and public funding, current and emerging applications, potential adoption rate, market potential, and so on. This organic and continuous research effort spread across several technologies, regions, organizations, applications, and industries is used to generate an annual list of Top 50 technologies that have the maximum potential to spawn innovative products, services, and business models.

Furthermore, we analyze several possible convergence scenarios where two or more of the Top 50 technologies can potentially come together to disrupt, collapse, and transform the status quo. Driven by IP interactivity emanating from each of the top technologies, a whole range of innovative business models, products, and services will be launched at unprecedented speed in the future. We have come up with over 25 such unique convergence scenarios.

 

The Top 50 technologies we have selected for TechVision 2015 have the power to drive unique convergence and catalyze wide-scale industry disruptions. Frost and Sullivan's TechVision program empowers you with ideas and strategies to leverage the innovations and disruptive technologies that can drive the transformational growth of your organization.

**Rajiv Kumar**
Senior Partner

**For more information contact:**
techvision@frost.com

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