



**2009 European Wearable Energy Harvesters
Technology Innovation Award**



“We accelerate growth”

2009 European Wearable Energy Harvesters Technology Innovation Award

Award Description

Frost & Sullivan's Technology Innovation Award is bestowed upon a company (or individual) that has carried out new research, which has resulted in innovation(s) that have or are expected to bring significant contributions to the industry in terms of adoption, change, and competitive posture. This award recognizes the quality and depth of a company's research and development program as well as the vision and risk-taking that enabled it to undertake such an endeavor.

Research Methodology

To choose the award recipient, Frost & Sullivan's analyst team tracks innovation in key hi-tech markets. The selection process includes primary participant interviews and extensive primary and secondary research via the bottom-up approach. The analyst team shortlists candidates based on a set of qualitative and quantitative measurements. The analysts also consider the pace of research and technology innovation, and the significance or potential relevance of the innovation to the overall industry. The ultimate award recipient is chosen after a thorough evaluation of this research.

Measurement Criteria

In addition to the methodology described above, there are specific criteria used to determine the final rankings. The recipient of this award has excelled based on one or more of the following criteria:

- Significance of the innovation(s) in the industry, and across industries (if applicable).
- Potential of the products of innovation(s) to become industry standard(s).
- Competitive advantage of innovation vis-à-vis other related innovations.
- Impact (or potential impact) of innovation(s) on company or industry mind share and/or company bottom line.
- Breadth of intellectual property related to the innovation(s), that is, patents, scientific publications, and papers in peer-reviewed journals.



Frost & Sullivan's 2009 European Technology Innovation Award in the field of wearable energy harvesters goes to Holst Centre/imec for its wearable electrocardiograph energy harvesting solution, which provides tens of microwatts of energy per square centimeter for modules with 3 x 4 cm dimensions. Due to its convenience of use, self powering, and low maintenance, this has opened the way for a wide range of commercial and personal solutions. Holst Centre and imec achieved this result within the R&D program on Micropower Generation and Storage.

Company Background

Holst Centre is an independent open-innovation R&D centre that develops generic technologies for Wireless Autonomous Transducer Solutions and for Systems-in-Foil. A key feature of Holst Centre is its partnership model with industry and academia around shared roadmaps and programs. It is this kind of cross-fertilization that enables Holst Centre to tune its scientific strategy to industrial needs.

Holst Centre was set up in 2005 by imec (Flanders, Belgium) and TNO (The Netherlands) with support from the Dutch Ministry of Economic Affairs and the Government of Flanders. It is named after Gilles Holst, a Dutch pioneer in Research and Development and first director of Philips Research.

Located on High Tech Campus Eindhoven, Holst Centre benefits from the state-of-the-art on-site facilities. Holst Centre has over 150 employees from around 25 nationalities and a commitment from over 20 industrial partners.

Imec performs world-leading research in nano-electronics. Imec leverages its scientific knowledge with the innovative power of its global partnerships in ICT, healthcare and energy. Imec delivers industry-relevant technology solutions. In a unique high-tech environment, its international top talent is committed to providing the building blocks for a better life in a sustainable society.

Imec is headquartered in Leuven, Belgium, and has offices in Belgium, the Netherlands, Taiwan, US, China and Japan. Its staff of more than 1,650 people includes over 550 industrial residents and guest researchers. Imec's intensive research activity resulted in more than 300 valuable patents covering such technologies as nomadic embedded systems, wireless autonomous transducer solutions, biomedical electronics, photovoltaics, organic electronics, and gallium arsenide power electronics.

Technology Relevance in the Market Place

Wearable devices are an affirmation of the human tendency to try and make common devices much more convenient to use. This approach not only refers to watches, phones, or music players, but also in regards to medical devices and health monitoring systems. Pacemaker systems have evolved from huge operation units, which were placed on a trolley next to the patient, to the small and internal self sustainable solutions. A similar idea stimulated the development of wearable health monitoring systems at Holst Centre. Their prototype wearable self powered electrocardiography system has helped pave the way for novel health monitoring systems.

Technology Overview & Innovative Features

Wearable devices that operate using the body's heat have been in use for several years. So far, small thermoelectric energy generators have proven their capability to power small personal devices such as watches without needing an external power source. Recently, Holst Centre and imec have developed miniaturized health monitoring systems, which consumes heat from the human body in order to operate. The key component of this device is the

thermoelectric material, in most cases bismuth telluride, that converts human body heat into electric current. Once this device is placed close to the body, it generates electricity that is further accumulated in an energy storage system. The electricity capacitor subsequently powers the autonomous wearable electrocardiography (ECG) system. The thickness of the system components does not exceed 6.5 mm and can be easily integrated into fabric. Once installed, the system requires no technical maintenance.

The demonstrated energy harvesting solution provides tens of microwatts of energy per square centimeter for modules with 3 x 4 cm dimensions. In this specific application, the energy harvesting module efficiency was sufficient to operate the wearable ECG using fourteen units integrated in a shirt and occupying less than 1.5% of its total area. The device operation was tested in indoor and outdoor conditions with outdoor clothes worn on and off. During energy harvesting, the power management unit of the presented system uses the ASIC converter to charge two 2.4V batteries, which are powering the second stage dc/dc converter supplying the ECG unit. In all cases, the system performance was sufficient to operate the ECG. The whole unit is fortified against the mechanical stress that would accidentally destroy the fragile thermopiles of the energy harvester. The shock protection, made of thermally isolating material, is placed between the radiator and the hot end of the device (exposed to the source of a heat). It was found that this protection facilitates even washing the device in laundry with a drying cycle of 1,000 rpms.

Interestingly, the developed product is service free for its entire life and user activity is only limited to the need of wearing it. Once placed close to the body the device starts itself and monitors the patient's health. The personal devices, which couldn't be made portable due to their large sizes or high power requirements, are now developed in the form of easy to wear and care gadgets. This approach is not only valid for monitoring systems but for the whole wide group of personal appliances that could be integrated in clothes or personal equipment such as mobiles, watches, etc. Most personal devices still consume large amounts of energy that cannot be provided by currently available energy harvesting solutions. However, increasing efficiencies of energy harvesters, such as the system developed by Holst Centre and imec for health monitoring systems, could enable the fabrication of a wide range of self sustainable personal solutions in the future.

Conclusion

Frost & Sullivan's 2009 European Technology Innovation Award recognizes Holst Centre/imec for its unique wearable energy harvesting technology based on its unique design platform. Holst Centre and imec will continue to miniaturize health monitoring devices such as this one, that allow for efficient and easy monitoring of human health with a.o. electrocardiograph units, which was not possible in the past.

About Best Practices

Frost & Sullivan Best Practices Awards recognize companies in a variety of regional and global markets for demonstrating outstanding achievement and superior performance in areas such as leadership, technological innovation, customer service, and strategic product development. Industry analysts compare market participants and measure performance through in-depth interviews, analysis, and extensive secondary research in order to identify best practices in the industry.



About Frost & Sullivan

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