Metrology for energy harvesting
European Metrology Research Programme

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Project news

Industry Meeting and Workshops, PTB, Germany

The Metrology for Energy Harvesting Project drew to a conclusion with a one day meeting at Physikalisch-Technische Bundesanstalt in Braunschweig, Germany at the end of August. Attended by representative from each of the seven project partners, industry and academia, Energy Harvesting: *A Metrological Approach* included in-depth briefings on a range of new tools and best practice for the measurement of energy harvesting performance. These included techniques focused on specific technologies such as piezoelectric, thermoelectric, electrostatic and magnetostrictive energy harvesting

Fig 1. Project partners line up outside PTB for the start of Energy Harvesting: A Metrological Approach

Project highlights presented included:

- New techniques and models to deliver the maximum power output for piezoelectric and other electro-mechanical energy harvesters
- Techniques for measuring energy coupling at the microscale, and the power requirements and outputs of Microelectromechanical systems (MEMS) devices
- Tools and models to measure electrical and thermal properties of nanomaterial harvesters and their coupling down to the nanoscale
- The first reference materials for measuring induced electric voltage within thermometric materials in response to temperature differences with temperature ranges up to 860K
- A test-rig able to measure the performance of magnetostrictive devices

Dr Paul Weaver from the National Physical Laboratory said "the work we present today will enable industry and consumers to reliably assess different EH technologies such as thermoelectric and vibrational harvesting devices. More accurate and standardised measurement will allow industry to lower costs and increase energy efficiency to make a stronger business case for applications in new sectors."

The meeting was followed by three workshops providing in-depth presentation and discussion of project achievements. The workshop webcasts are available for download *here*.

Visit our homepage at http://projects.npl.co.uk/energy_harvesting

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….And for the future

The project is now planning a new stream of work to deepen and broaden its research in energy harvesting. This set of next steps is laid out in a proposal that will be submitted to the EMRP and will take the progress made so far even closer to industry. Targets include developing techniques for measurement of energy harvesting performance as part of a system, support for the development of performance standards, further reducing uncertainties through improved measurement techniques, and bringing in new materials and technologies that are likely to impact on this area in coming years such as nano-structured materials and MEMS technologies.

As part of this proposal process, the project is looking to gather support from organisations that see the value of metrological research in this area. If you would like to add your name to the list of supporters, please contact *energy-harvesting@npl.co.uk*

Project news

New research by a team from the National Physical Laboratory was published last month looking at nanostructured piezoelectric energy harvesting devices, the outputs of which have commonly been measured through open-circuit voltage and/or short-circuit current.

However in their new *paper* in Energy & Environmental Science the team from NPL, in collaboration with researchers from Queen Mary, University of London, have shown that such measurements do not provide a complete picture of the output of these devices, and can be misleading when attempting to compare alternative designs

By comparing the performance of two ZnO nanorods the team showed that despite one showing an open-circuit voltage nearly three times lower than its compatriot, it still generated 150 times more power on an optimum load. As a result the paper's authors call for a more rigorous testing procedures in line with those used for more established technologies.

In July Dr Alex Bounouh and colleagues from Laboratoire national de métrologie et d'essais presented a poster at *IMEKO-TC* in Barcelona on electrostatic energy harvesters and methods to characterize them in terms of electromechanical properties. IMEKO-TC was the 19th Symposium Measurements of Electrical Quantities, attracting around 200 attendees. At the conference Dr Bounouh met a new project contact and supporter in Dr Hyung-Kew Lee from the Korea Research Institute of Standards and Science.

Ernst Lenz and colleagues from Physikalisch-Technische Bundesanstalt have accepted an invitation to speak at *SemiconNano 2013*, the 4th International Workshop on Epitaxial Growth and Fundamental Properties of Semiconductor Nanostructures. The conference will be held at Lake Arrowhead, California from the September 29th - October 4th. The title of the talk will be Semiconducting Thermoelectric Reference Material for Traceable Thermoelectric Measurements up to 650 K.

Dr Paul Weaver and colleagues from the National Physical Laboratory attended the 2013 IEEE International Symposium on the Applications of Ferroelectrics in Prague which looked at research and developments within fundamental materials, devices, and applications. The team presented a poster on their research into efficiency measurement in piezoelectric vibration energy harvesters.

The conference was attended by experts in ultrasonics, ferroelectrics, frequency control and time forum from around the world and saw the team from NPL make new project industry contacts from Bosch and ABB.

The UK is hosting PowerMEMS 2013 at the Royal Society in London, 3 – 6th December to look at micro and nanotechnology for power generation and energy conversion applications. The conference will feature energy harvesting, energy storage, power management and energy harvesting materials related research. The conference also includes the PowerMEMS School which is a 2 day short course on the fundamentals of energy harvesting technologies. Please visit the conference webpage *to find out more*.

View from industry:

Dr Tomasz Zawada, Engineering and Research Manager, Meggitt Sensing Systems

MEGGiTT
smart engineering for extreme environments

Who are Meggitt?

Meggitt is a FTSE 100 global engineering company employing over 11,000 people worldwide. We operate primarily in the aerospace, energy and defence sectors with a special interest in the engineering and manufacture of sensor materials and systems.

What is your role?

I am in charge of research and development within *Meggitt's Sensing Systems* business unit, which is based in Denmark. The unit was previously a separate company called Ferroperm Piezoceramics before it was merged with Meggitt in 2008. Its focus is producing piezoelectric materials for both components and devices. Our primary markets are for use in medical ultrasounds, underwater acoustics, flow meters, accelerometers and the new emerging energy harvesting sector.

In general we operate in the high end of the market producing high value-added products. We can achieve this through having the best stability of materials in the industry, allowing us to offer high level guarantees of batch to batch variation, usually within 5% and resulting from very strict performance testing methods.

Though a leading manufacturer of products we are also very much active in externally funded research under EU funded FP7, FP6 and FP5 projects, working with a variety of different academic partners as well as customers.

What is your interest in energy harvesting?

Energy harvesting is still an emerging concept and technology but we are very much interested in the potential applications of piezoelectricity. Whilst we are not limited to this one area, we see it as one of our core business for the time being.

As part of this programme we have taken part in a nationally funded project called *ELBA* with the *Danish Technical University*, and *Vestas* the world's biggest producer of wind turbines. This collaboration aims to develop wireless sensor network powered solely with energy harvesting and no batteries.

As part of ELBA we have combined piezoelectric PZT thick films with MEMS processes. We have successfully produced a number of prototypes based on millimetre-scale energy harvesting devices which is major interest to us from a development point of view.

It is in the powering of wireless sensors where we see the biggest benefits for our customers. Wind energy is a nice example of a potential market where a power supply for autonomous monitoring is a key concern as companies like Vestas try to make the business case for bigger turbines within more off-shore locations.

How long have you been interested in energy harvesting?

The interest started 10 years ago with the realisation that the technology in ultra-low energy electronics was in place. I joined Meggitt in Denmark six years ago and right at the start it was one of the topics that really caught my attention. Very soon we started setting up some of our first research projects including Elba.

What challenges to adoption do you see within potential and existing markets?

Technical challenges around creating good output, reliability and functionality remain an area of focus however right now the business challenges with energy harvesting are often a lot bigger than the technical ones. Today you can create a reliable product that works in real world environments but

View from industry

there are still challenges to wrap these technologies within the functionality that will work in particular market where there is significant demand.

This is why we are so keen to get prototypes out there into the market so customers can see the potential for themselves and start to make business plans that incorporate energy harvesting.

To help them further we need to provide the whole infrastructure to support energy harvesting in the form of an energy management service. This cuts out the need for customers to do their own research and trials, allowing them to introduce our devices straight away.

The elements for this supporting case are starting to fall into place. The next step is to go out and find the right application and put this growing business case to them. It partly comes down to a customer education exercise, talking to potential buyers about the benefits of energy harvesting and then working with them to find the right solution for them.

Where do you think energy harvesting technology has potential for growth in the future?

Wireless sensor networks for monitoring application are still the major interest from our commercial point of view. The ultimate goal here is the aerospace industry market, though first it has to be proven in less demanding markets which is why the energy market is proving more fruitful at the moment. The automotive sector is another area of interest for energy harvesting however issues like price and volume are affecting uptake.

How would you describe Metrology's importance to energy harvesting?

I think it's a really very important –there is no doubt about it. The way people compare the performance of devices currently out there, with each university and company seemingly having their method, there is a lot of confusion.

I see metrology as the enabler for progress and the current lack of it in this sector is one of the major inhibiting factors as customer cannot see the true value of the products or the potential savings and efficiencies offered by the technology. This is why projects like this are a must. The timing is good as well, just as a number of new products are starting to come onto the market.

Are there any areas within the metrology of energy harvesting that you would like to see further research?

We are still at a stage where even the basics are not well established and I don't think everyone has the same understanding of the fundamentals. We can discuss details such as multisource energy harvesting which will present an important challenge to overcome but the major principles such as what numbers we need to measure to make a decent approximation of output and performance are not there yet.

Where do you feel that European capability ranks in terms of developing innovative EH products?

One way of comparing this is to look at the number of patents in the area of energy harvesting. The US is certainly number one in this respect and ahead by some way. Whilst this doesn't show everything it does suggest we in Europe are lagging behind when it comes to the commercial exploitation of the basic research we conduct. The situation is reminiscent of the story of nanotechnology where Europe was way ahead in terms of research but the knowledge created was transferred to Asia and the US who have benefited commercially.

Upcoming events

Intelligent Building Systems
25 - 26 September
CNIT, Paris *www.ibs-event.com*

SemiconNano 2013
29 September - 4 October
Lake Arrowhead, California *www.physik.tu-berlin.de*

ENSSys 2013
14 November
Rome, Italy *www.enssys.org*

PowerMEMS 2013 3-6 Dec
London, England *www.powermems.org*

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We welcome feedback, opinion and suggested articles. Please send your comments to paul.weaver@npl.co.uk and james.romero@proofcommunication.com