

Project news

Scientists working at the **National Physical Laboratory** have developed a new model to deliver the maximum power output for piezoelectric energy harvesters. The results were published in a new *paper* in Applied Physics Letters. Their research showed that the typical arrangement for piezoelectric energy harvesters, where the entire length of the cantilever is covered with piezoelectric material, is counterproductive.



Figure 1. Macro sized piezoelectric energy harvesting cantilever

In fact the researchers calculated that the charge redistribution across the cantilever creates an internal loss of power of up to 25 percent of potential output. To counter this, the team showed that more energy can be converted if the beam is only covered with piezoelectric for two thirds of its length.

Dr. Ernst Lenz and colleagues from the **Physikalisch-Technische Bundesanstalt** presented their work addressing the lack of reference materials for traceable measurements of thermoelectric properties (see previous e-newsletter) at two conferences last month. At *DPG-Frühjahrstagung 2012* in Berlin and at a DFG – Workshop entitled '*Measurement of thermoelectric properties on nanostructured materials*' Dr Lenz presented findings from the research project carried out in collaboration with the Institute of Materials Research at the German space centre.

Their presentations focused on the search for traceable reference materials for Seebeck coefficients for thermoelectric generators in the temperature range of 300 K to 900 K. A metallic nickel copper alloy (CuNi44) and a semiconducting iron disilicide ($\text{Fe}_{0.95}\text{Co}_{0.05}\text{Si}_2$) were presented as two possible reference materials. A relative uncertainty of about 5 percent for the Seebeck coefficient was demonstrated through an improved measurement system achieved by using gold/platinum thermocouples and a Pt-100 thermometer.

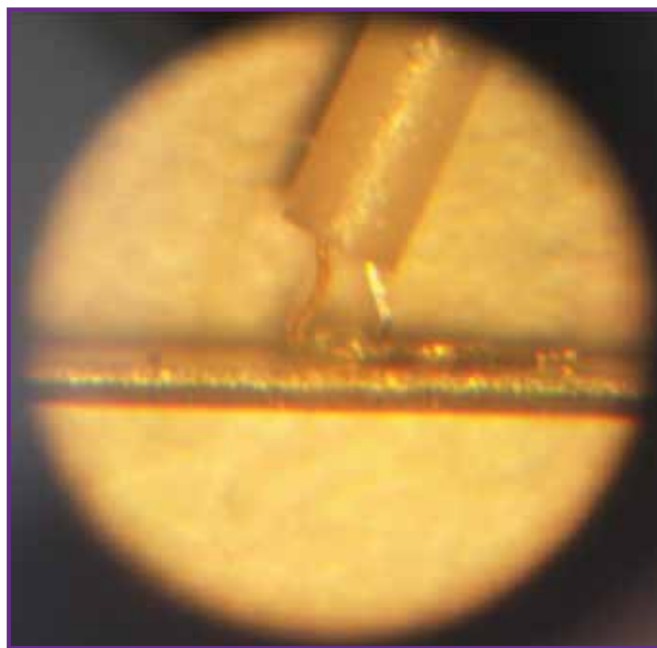


Figure 2. Spot welding of TC to sample for testing optimal heat coupling to sample

In May, the PTB researchers will present a poster on the research at *ICMOVPE-XVI*, the 16th International Conference on Metal Organic Vapor Phase Epitaxy (ICMOVPE-XVI) in Korea.

Visit our blog at <http://emrp-metrology-for-enery-harvesting.blogspot.com>

Project news

In June, Dr Paul Weaver and colleagues from the **National Physical Laboratory** will submit a paper to the *2nd TYC Energy Materials Workshop and Tutorial*, hosted at Kings College, London. The paper looks at the use of piezoelectric materials to harvest energy at a range of length scales from large scale vibrational harvesters, through micro-scale cantilevers down to nano-structured piezoelectric materials as well as techniques for measuring energy harvesting performance.

The 2nd TYC workshop on energy materials aims to bring together experimentalists, theorists and computational scientists working on charge transfer with a focus on organic semiconductors, dye-sensitised solar cells, semiconducting oxides and thermo-electrics.

After over a year and half handling the EMRP work on behalf of the **National Physical Laboratory**, Professor Markys Cain will be handing over to his



Fig 3. Dr Paul Weaver

colleague Dr Paul Weaver. Prof Cain will continue to work on the project in a research capacity with Dr Weaver and colleagues. NPL have also announced Dr Louise Brown as the new EMRP Project Manager and a new member of the technical team, Peter Woolliams.

At the end of March, Dr Alexandre Bounouh from the **Laboratoire National d'Essais** attended the 2nd National Symposium on Recovery and Energy Storage for Autonomous Systems in Grenoble. Dr Bounouh shared his development of a traceable measurement technique to determine both resonant frequency and damping parameters of MEMS based energy harvesters (EH) or more generally of micro and nanoelectromechanical systems.

Upcoming events

Dr Mauro Zucca from the **Istituto Nazionale di Ricerca Metrologica** will give a talk at the *2012 International Magnetism Conference* in Vancouver which runs from the 7th to the 12th of May. Dr Zucca will present on hysteretic modelling of electrical micro-power generators based on the Villari effect.

Dr Mark Stewart from the **National Physical Laboratory** will be presenting on Metrology in Energy Harvesting to *IDTechEx Energy Harvesting & Storage Europe* which runs from 15th-16th May in Berlin.

Dates for your diary

Energy Management Seminar

17-19 April
Italy

Intermag 2012

7-11 May
Vancouver

ICMOVPE-XVI

20-25 May
Busan, Korea

Energy Harvesting & Storage Europe 2012

15-16 May
Berlin, Germany

SK2012

19-20 June
Southampton, UK

Zeropower

3-4 July
Glasgow, Scotland

Conference on Precision Electromagnetic Measurements

1-6 July
Washington DC, USA

View from industry:

Rob van Schaijk, R&D Manager Sensors & Energy Harvesters, Holst Center



The Holst Center is an independent open-innovation R&D centre set up by IMEC, a world-leading micro-electronics research organisation based in Belgium, and TNO, an independent research institute based in the Netherlands.

What do you do at the Holst Centre?

We operate between the worlds of academia and industry. Our work includes delivering complete technologies that can be transferred instantly into commercial applications, as well as more fundamental work closer to the academic community looking at issues like material properties. Our industrial partners include large semi-conductors manufacturers as well as multinational electronics firms such as Panasonic, Samsung and Phillips.

Whilst the Holt centre employs only around 150 people, the IMEC group includes an additional 2,000 people working in neighbouring Belgium.

What is your role?

Since 2007, I have worked as a principal researcher and program manager in the micropower program. At the moment I manage the group developing sensors and energy harvesters, primarily for applications in autonomous wireless sensor systems.

How long has the institute been interested in energy harvesting?

The institute started in 1984 – but only in the last 10 years have we focused on energy harvesting technology. Now have around 15 people working on energy harvesters.

How did you see initially see the application of energy harvesting?

10 years ago energy harvesting was very much seen as an academic pursuit. At that time we looked at

all the different types of energy sources that could be harvested and which ones were feasible from a commercial perspective.

How have these perceptions changed since then?

Very soon after the expectations around energy harvesters and the hype of what they could deliver started to grow. As it turns out much of this expectation was over the top - especially in the consumer technology fields such as mobile phones.

Our feasibility assessment period saw us concentrate initially on vibrational, radio frequency, solar and thermal energy sources however, the rapid maturity of the thermal and solar sector, with lots of quality new products entering the market has seen the focus on these decrease from an R&D point of view.

I think generally for us there has been a move away from the more fundamental research and investigation as the industry has matured and commercial partners are increasingly aware of what they want and the capabilities this technology provides.

What do you see is the next step?

To grow out of niche industrial markets into more main stream commercial and maybe even consumer markets. We see applications like smart buildings as major growth areas in the coming years and you will see more and more autonomous sensors in offices powered by light, temperature differences and radio frequency energy transfer. We also expect applications in smart packaging with energy harvesting devices included as part of the product. In machine monitoring and automotive applications one will see an increasing use of vibrations to harvest energy.

What do you see as the major barrier to further commercial success of energy harvesting?

Cost is always going to be a major issue when it comes to making energy harvesting a commercial success. There are production methods which reduce costs but these are only applicable to systems which require large volumes of sensors.

Before energy harvesters can spread across more commercial, and especially consumer focused sectors, manufacturers need to demonstrate larger volume production at low cost whilst still offering the reliability which their customers want. There are some successful examples such as the light button – however at present this is a rare exception.

One way to make the products more cost effective in terms of wireless monitoring would be to better match what you can produce in terms of power output with the needs of the sensor. I believe overcoming this will be pivotal in terms of competing with battery options and breaking the consumer market.

Are there sectors worth exploring which offer more immediate growth opportunities for energy harvesting?

Sectors where cost is not an issue might offer more immediate opportunities for growth such as monitoring the health of high precision parts where the risk of failure is so high that manufactures look primarily for reliability over significant time frames. Here wireless micro-sensors powered by harvesters could monitor the health of engines, looking out for signs of fatigue and wear on parts.

Another issue to exploit is accessibility. In jet engines, wind turbines and other heavy machinery, the difficulty and effect on operations of changing batteries or repairing faulty wiring makes wireless sensory networks a legitimate alternative.

There is also the pressure in certain sectors of increasing environmental regulation. With stricter penalties companies are more reluctant to use batteries because of the cost of recycling them.

How do you see the benefits of metrology to the energy harvesting sector?

As a research institute we are not so much involved in the production and testing phase of product development where we believe metrology to be most important, however we still appreciate its relevance for the wider market interest and confidence in the

technology. Nowadays you see a lot of companies presenting harvesters but there is no way of comparing them.

From our point of view we are particularly interested in the more fundamental issues metrology can solve such as comparisons between material properties which affect us more at the R&D level as we are constantly looking at new materials for energy harvester design.

There is also interest in attempts to standardise energy harvesters – especially around the connectors and information on specs. Many industrial parties are involved in the ISA 100 Wireless Committee, looking at standardisation for industrial applications.

What are you working on at the moment?

We are focusing on tire system monitoring as part of the evolution towards a more intelligent tire. At present only the pressure in a tire is measured but companies would like to monitor more parameters like forces. The 'intelligent' tire could measure tire integrity and pressure, the road condition, or even the driving style of the driver. In this environment battery replacement is not sustainable or practical and is an example of where energy harvesting and autonomous wireless sensor network can provide a solution which could increase driver safety whilst reducing fuel consumption.

How do you see the health of the European Energy harvesting market?

Europe does very well in the development of these products in terms of successful start ups and there is always lots of world leading research taking place.

What is more of a concern is its ability to convert this research base into commercial products. I believe there are certainly lessons that can be learnt from other technologies and how commercial advantage has been lost to rival industrial regions in Asia.

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

This project is funded by the EMRP and national metrology research programmes.

