Metrology for energy harvesting
European Metrology Research Programme

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Project news

TEG test Rig

NPL have designed and built a system to characterise commercial thermoelectric generators (TEGs). It uses an absolute method for the measurement of heat flow to determine the Seebeck Coefficient, Output Power and Efficiency.

The rig has been designed specifically with commercial modules in mind – those measuring 40 x 40mm or 47 x 47mm can be fully characterised from room temperature to 200°C.

It was recently presented to a group of thermoelectric industry experts and received very positive feedback. NPL are now working in collaboration with the University of Glasgow to further develop the design of this test rig. In future the rig will improve accuracy of measurement and widen the temperature range in which to test these TEGs.

Harman method

ZT, the dimensionless-figure-of-merit of a thermoelectric material is often used to characterise its performance. It is a function of a number of material properties: the Seebeck coefficient, the electrical conductivity (or resistivity) and the thermal conductivity. The Harman technique is an entirely electrical method to determine ZT, without independent measurement of thermal conductivity.

NPL has designed a Harman set-up, using a four probe technique to characterise a wide range of thermoelectric materials from thin films to bulk samples.

Industrial Advisory group

NPL recently held a very successful industrial advisory group meeting on thermoelectric materials with leading UK companies and academics. Demand for measurement and standards were expressed by a number of industry representatives present with applications ranging from IT heat management to cars.

STOP PRESS - Energy Harvesting for Structural Monitoring - A Roadmap to New Research Challenges

The Energy Harvesting Network (EMN) has published a roadmap identifying the next generation of research challenges in energy harvesting.

The report is designed to inform funding agencies of emerging areas of science and engineering that will need support over the next 10 years. It aims to act as a catalyst for bringing together multidisciplinary teams to develop proposals that tackle these research challenges.

Visit our blog at http://tinyurl.com/MetrologyForEH

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Project news – event updates

Rolls-Royce, the UK's global power systems company has expressed an interest in joining the the EMRP Energy Harvesting project's industrial user group. The interest followed a presentation from NPL's Markys Cain at **IDTECHEX 2011** in Munich in June. The event was attended by over 300 representatives from industry and venture capitalists.

After giving his presentation, Markys was invited to give the same talk to a larger number of Rolls Royce employees as part of the monthly online RR WEBEX series of presentations. Dr Cain's invite to Europe's largest event on energy harvesting & storage followed an interview with IDTechEx's technology analysts, Harry Zervos which resulted in some great media coverage for the project.

There was further interest in the project at **EMF 2011** (the European Meeting on Ferroelecrricty) in Bordeaux in June. NPL's Markys Cain was invited to present on the work of the EMRP to an audience of over 200 academic delegates working across dielectrics, ferroelectrics, piezos and multiferroics. Markys made a number of potential new contacts and will start to follow up with them to share more information on the project and its research shortly.

PTB's Torsten Funck presented on the Metrology for Energy Harvesting project at **IMEKO-MI2011** – The international symposium on metrological infrastructure, environmental and energy measurement in Croatia in June. The event was attended by 60 people, mainly from NMIs and accreditation bodies. Torsten also attended **Metrologie 2011** – the 15th international congress on metrology in Paris last month where he presented to 800 delegates from over 50 countries on metrology for non sinusoidal signals appearing in energy harvesting applications. A wide range of attendees included metrologists, representatives from industry, laboratories and national institutes, specialists from the health sector, manufacturers of metrological equipment, academics and researchers.

Some of Europe's key players in nano-ferroelectrics heard from energy harvesting researchers from NPL at the **International Symposium on Integrated Functionalities** in Cambridge (31 July - 4 August 2011). Three papers from the Metrology for Energy Harvesting project were presented to an audience of over 250, mostly academic attendees.
These looked at:

- In-situ real time structural response of a ferroelectric to an applied external electric field of varying frequency
- Energy loss in piezoelectric energy harvesting cantilevers
- Lead-free ferroelectric heterostructures for energy storage technologies

Copies of all three papers can be downloaded from the ISIF website. Some of the new energy harvesting technologies presented throughout the symposium will be included in the next EMRP blog.

Upcoming events

VDI-Fachtagung Messunsicherheit
8-9 Nov 2011
Erfurt, Germany

Technology World
16-17 Nov 2011
London, UK

Energy Harvesting and Storage USA 2011
15-16 Nov 2011
Boston, USA

3rd Energy Harvesting Research Theme Workshop
2 Dec 2011,
Southampton, UK

View from industry:

Roy Freeland, CEO, Perpetuum

Perpetuum is a UK-based global leader in vibration energy harvesting. It engineered, produced and commercialized the world's first practical electromagnetic vibration harvesting micro-generator delivering the power required to transmit large amounts of autonomous wireless sensor data reliably from remotely monitored assets.

How long has Perpetuum been interested in energy harvesting?

Perpetuum was spun out from Southampton University in 2004 as a venture capital backed SME. It followed several years of research looking for ways to power sensors embedded in structures.

Our principal aim was to take the developments made in academia into devices that could be used in real world applications. For many years there were people doing research in this area but paying little attention to the sources of energy that are actually out there and available to be harvested.

What is the relevance of metrology for EH to Perpetuum?

It comes down to customers knowing what they are getting. It's vital they have a reliable way of comparing the output of different devices in their own particular environment and are able to predict power output of harvesters in real world situations.

Trust is key in this sector and consumers' trust has been affected by a number of spurious performance claims from developers that have failed to materialise. We need a way to stop and challenge these charlatans and remove any credibility given to their claims from the start through a set of standard measurement criteria that are recognised by both the industry and its market as an essential badge of approval. This is where metrology plays its part.

Do you come across these types of claims often and what is their effect on the wider industry?

Too often you find yourself at a conference where a team make bold claims around a world record output. But when you look at the lab conditions it has been achieved in, there is no relevance to real world applications. Claimants are using vibration levels that in a pipe or a machine would be past breaking point. You don't need sensors to tell you your equipment is in trouble under those conditions.

It easy to laugh at some of the wilder claims but they are tarring the whole industry with the same brush. Even after a recent Nokia announcement was withdrawn, there were people on online forums describing energy harvesting technology as questionable and overhyped – this must change.

Better metrology will help create a sensible base for comparison which can be used by a reasonably educated user to see through these farcical claims.

Are you noticing increased customer interest in EH technologies?

There certainly seems to be a greater appreciation of the wide variety of energy sources in the industrial setting. End users are increasingly reluctant to use batteries wherever possible because of concerns over their reliability and the cost of changing them.

In the early days you had precision instrumentation trials using wireless sensor networks with a battery life of two or three years. Now with these products in the market and in place, buyers are looking beyond that to a sustainable fit and forget solution. What users want is reliability and minimal maintenance over timescales of 15-20 years. This removes the cost of a new battery and the logistical costs of replacing it, as well as ensuring plant reliability.

I have heard of an extreme example of the cost of replacing the battery running into more than a million dollars because they had been installed undersea and required a submersible to recover and replace. The "fit and forget" benefit is driving demand for energy harvesting as the optimum solution for powering wireless sensing.

Are there any other driving forces behind this growth?

There are a lot of potentially hazardous environments like those found in petrochemical plants where an aim of management is to reduce the amount of man time spent in hazardous zones as much as possible. Here the benefits of an autonomously powered wireless networks are obvious.

We are beginning to see users wanting the widest possible use of wireless networks. People appreciate that they work but if they are going to use them across the whole plant, there must be an acceptable power source and that it is where the demand for energy harvesting has grown.

What do you see as the main challenges for EH devices?

We have to make sure that there is a solution for a very high proportion of industrial opportunities. Already it is getting to the point where in almost every location where you might want to stick a sensor, you have an energy harvesting device on offer - whether it is vibration, thermal or light powered. There are also solutions such as RF transmitted power where none of these are available.

A key for future success will be the development of good interchangeability. So if you have a plant and are looking to install sensors at various locations you can order a combination of thermal harvesters, vibrational harvesters and solar panels, arrange them to suit your plant, and have them all power the sensor network.

We have recently developed a device for users which tells you instantly whether a location in the plant offers you sufficient vibrational energy to power a sensor based on the particular spec of our harvesting devices. It is this type of user focused thinking that the sector as a whole must have to take the industry forward.

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

Europe is probably at the forefront of the market at present in the main areas – particularly in thermal and vibrational with the likes of ourselves and Micropelt. Solar is a little bit more difficult but one of the guys at the forefront is G24 who, though tied to the US, are now based in Wales.

This position is based on a strong research capability backed by Governmental and EU financial support. Many of the major research centres for this technology are based here in Europe and it is good to see the expertise and creativity that we have here.

What do you feel are/will be the main benefits or potential of energy harvesting technologies?

It's not the ultimate green product and we are not going to save the world directly from global warming with the milliwatts being generated by these low power harvesters. However, we are saving the world a lot of battery waste whilst making industry processes far more efficient at a lower capital cost.

Also by providing a way to reliably monitor major industrial machinery and processes, we are reducing the amount of human interaction with hazardous zones, improving safety associated with a wide range of industrial activities and giving more control to those that manage them.

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

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