

## Project news

Dr Ossi Hahtela and colleagues at **MIKES** in Finland are working on a new probe and setup for high temperature thermal conductivity measurements. The system is awaiting thorough testing with borofloat glass and silicon wafer samples, though preliminary results look good, at least at moderate temperatures. Once this final stage is completed and the results are in the group will start work on a research paper and conference presentation.



Fig 1. MIKES high temperature thermal conductivity measurements

Rado Lapuh and colleagues from the **Slovenski institut za kakovost in meroslovje** (SIQ) presented their new paper titled "Arbitrary waveform generator for simulation of energy harvesters" at the *Conference on Precision Electromagnetic Measurements (CPEM)* in Washington D.C at the start of July. The paper describes the development and construction of a digital arbitrary waveform generator used for simulations of energy harvesters. It is able to generate arbitrary signals that are common for different energy harvesters, including piezoelectric, thermoelectric and mechanical devices.

A successful mid-term (18 month) EMRP project meeting was held at the National Physical Laboratory in the UK and was attended by all consortium partners. The significant progress made during the first half of the project was reviewed and plans set for the second half of the project. The next Project meeting will take place in Torino on November 20 and 21.

In May researchers from the **National Physical Laboratory** attended the *IDTechEx Europe Energy Harvesting and Storage Conference* in Berlin. Dr Mark Stewart and colleagues presented a well-received talk on NPL's vibrational energy harvesting work, titled "Improving Energy Harvester Performance Through Metrology" to the 320 delegates.

The conference was primarily attended by individuals and organisations new to the energy harvesting market but interested to look at its current state. There were some interesting market forecasts from analysts at IDTechEx who predicted the thermoelectric market could be worth \$750 million by 2022, and piezoelectrics, \$775 Million by the same year.

Dr Stewart also reported interest in the project and its work from industry figures such as *ARVENI*, a French high tech start up working in wireless sensor networks and *Ibule* a South Korean photonics company.

In the UK, members of the Electronics, Sensors and Photonics Knowledge Transfer Network provide a *summary* of the conclusions from the conference.

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

# Project news

Dr. Ernst Lenz and colleagues from the **Physikalisch-Technische Bundesanstalt** were in South East Asia for two conferences presenting their research on traceable thermoelectric measurements of seebeck coefficients.

In May they attended *ICMOVPE-XVI*, the 16th International Conference on Metal Organic Vapor Phase Epitaxy. A paper to accompany their poster on seebeck coefficients in the temperature range from 300K to 900K has been submitted to the International Journal of Thermophysics.

In June they presented a second poster at the *International Conference on Optical, Optoelectronic and Photonic Materials and Applications* in Japan. This focused on Seebeck coefficient of  $\beta$ -Fe<sub>0.95</sub>Co<sub>0.05</sub>Si<sub>2</sub> and Ge in the temperature range of 300K to 850K. At the conference Dr Ernst Lenz developed new contacts from the University of Surrey, Osaka Prefecture University and the University of Electro-Communications in Tokyo. A paper to accompany their poster containing data of the previously mentioned semiconductors as well as PbTe has been submitted to *physica status solidi (c)*.

Researchers at the **National Physical Laboratory** have developed a novel 3-axis broadband shaker for MEMS device testing. This integrates a vibration source with a scanning laser Doppler vibrometer (LDV) which allows you to relate the complex mechanical response of the MEMS device to the mechanical input and the harvested energy output. The miniaturised 3-axis piezoelectric vibrator provides wideband excitation and can operate in vacuum (required for some MEMS devices).

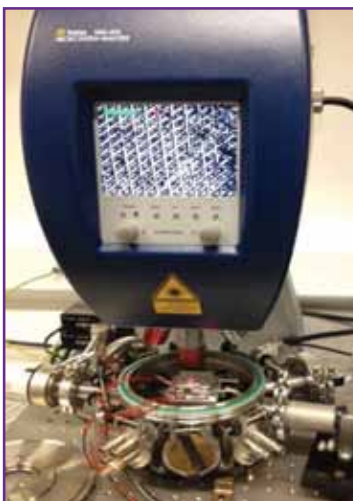


Fig 2. Three-axis broadband shaker for MEMS device testing

In June the team from the **National Physical Laboratory** presented recent collaborative work from the project to the *Thomas Young Centre workshop on Energy Materials*, held at King's College. The workshop was intended to foster an active dialogue and collaboration between experiment and theory in academia and industry.

NPL presented its new work on the metrology of energy harvesting using thermoelectric and piezoelectric materials, the development of high energy density materials for electrical energy storage and the symbiosis between experiment and modelling in the development of new materials and metrology.

## Dates for your diary

### Conference on Thermoelectrics

9-12 July  
Aalborg, Denmark

### Polymers for Energy Harvesting

29 July  
London, UK

### Energy Harvesting & Storage USA

7-8 Nov  
Washington DC, USA

### The Energy Event

11-12 September  
Birmingham, UK

### Intelligent Building Systems

26-27 September  
Paris, France

# View from industry:

## Gerhard Span, Chief Technology Officer, O-Flexx



*O-Flexx Technologies is a German technology company that specialises in the field of thermoelectric generators.*

### What does O-Flexx do and what is your role within the organisation?

We are working towards manufacturing thermoelectric generators on thin films. Our technology will allow our clients to harvest electrical energy from a greater number of heat sources by exploiting differences in temperature based on the Seebeck effect. By using a thin film in-plane we are looking to maintain a large thermo electric efficiency and a high packing density.

My role as Chief Technology Officer sees me responsible for all the technology that goes into our products. Though we are still in a developmental phase we are working towards a scalable solution that works as well for small temperatures differences as for much higher thermal fluxes. We have sold our first devices this year.

### When did you personally first come across energy harvesting technology?

Energy harvesting was the starting idea for me to move into thermoelectrics. The roads in the Alps close to where I lived can be very shady and can freeze, but in summer the same spot will be closer to 60 or 70 degrees Celsius. That got me thinking whether road large surface could be used as a collector and store of thermal energy. I wasn't really focusing on markets at the beginning but just wanted to find out why this type of technology wasn't available.

### What is O-flexx's interest in energy harvesting?

Energy harvesting was a focus from the beginning as it's a major market for thermoelectrics. The high thermal resistance of our products means we can work with smaller amounts of heat, making them very suited for energy harvesting.

Today most of the enquires we receive for products are in the field of energy harvesting with potential customers looking to generate not just milliwatts and microwatts, but up to half a watt of power from temperature differences.

Though energy harvesting is not our sole focus we believe we have a concept which works in both in this world and for general electrically production.

### What sectors are you seeing interest from?

We have many diverse customers getting in contact with us but we are only eight people so we have to focus on markets that look particularly promising. At present we are working with heating system manufacturers as well as companies interested in monitoring devices for steel production.

The energy harvesting market is a collection of niches which tends to limit how much money you can generate if you make your products too specific. We are looking for products that can be applied across these applications and even up to larger scale energy generation. We believe we are close to achieving this.

### Are you noticing increased customer interest in EH technologies?

I would say people are certainly becoming aware that solutions exist and that you can use small amounts of freely available energy to power sensors. There's a number of reasons for this.

The market situation for thermoelectric generators is favourable. In the long run, the costs of fossil fuels will keep increasing whilst at the same time more and more countries will encourage the adoption and development of renewable energies.

You also have the arguments around the replacement of batteries which costs a lot and you have to send someone to replace them, often in dangerous environments with the risk of explosions or highly radioactive environments.

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

Everything comes down to cost. You can have a solution that is technically perfect, but if the cost is not there you don't have a business. To overcome these challenges requires a better understanding of what customers need and is easily installable.

I believe the markets for energy harvesting technology will remain niche for the moment because the materials required for industrial-scale use have yet to prove sufficiently efficient in converting thermal into electrical energy. Also the technology required to manufacture thermoelectric generators and modules has not yet reached the point where production costs are low enough to allow rollout of mass market applications.

I think there will always be an element of 'niceness' to the energy harvesting industry as you are unlikely to ever get one product which works in 60-70 % of the market. Instead you need to maximise the application of any product you produce to make yourself commercially competitive.

### Are there any industrial sectors where energy harvesting might play a greater role in the future?

Energy harvesting can make production processes more reliable and cheaper. For example we are now getting enquires from steel plants looking for energy sources to monitor the temperature of their furnaces. These opportunities are very promising for our technology but will require some development to enable them to work at these exceptionally high temperatures.

Wind turbines are also being looked at as a potential market. Here reliability, reducing the need for human intervention and maintenance, is a major issue, especially for the offshore sites which are less accessible.

In the future carmakers will also be confronted with far stricter legislation with regard to CO<sub>2</sub> reductions, for example. Thermoelectric generators offer a simple way of supplying power within modern motor vehicles without using additional fuel and reducing the requirement for maintenance.

### What is the relevance of metrology for EH to your company?

Metrology is very important, particularly because we are dealing with heat. Unfortunately up to now we have found little metrology reference material concerning small flux heat exchange. As a result we have had to run simulations and do our own calculations to measure our heat flux. It's a major resource issue for a small company like ours because it consumes time from other areas of the business we need to grow, and in most cases the error barriers we produce are too large for commercial confidence anyway.

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

The most beneficial thing for us would be a flexible standard for thermal heat flux measurement. Nobody in the market today trusts heat flux measurements and yet the low heat fluxes we are interested in are not represented by the standards currently being worked on as part of the project.

We are also interested in more basic material science such as the measurement of thermal conductivities. Right now we have ranges of figures we can choose from which vary by up to 1 order of magnitude and because you have to do the measurement yourself your customers have to trust you.

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

I notice in Europe a lot of the basic research is being done and yet the majority of the products are coming to the market from the USA, Korea, and Japan. It's clear we are missing out on commercialising our basic research.



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



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

