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Energy System of the Future to be Demonstrated in Orkney

Written by AZoCleantech Apr 4 2019

The first phase of a new £28.5 million project to create a Virtual Energy System (VES) in Orkney, Scotland, has been launched to digitally link distributed and intermittent renewable generation to flexible demand.

Wind turbines in Orkney (Credit Colin Keldie, courtesy of Solo Energy)

The ReFLEX (Responsive Flexibility) Orkney project will demonstrate a first-of-its-kind Virtual Energy System (VES) interlinking local electricity, transport, and heat networks into one controllable, overarching system.

The project aims to create a 'smart energy island', demonstrating the energy system of the future, which will reduce and eventually eliminate the need for fossil fuels.

The project is funded by UKRI through the Industrial Strategy Challenge Fund.

Energy and Clean Growth Minister, Claire Perry said:

"What we are seeing here on Orkney is a test bed for the energy system of the future. These smart systems are a key part of our modern Industrial Strategy and will provide cheaper, greener and more flexible access to energy for everyone. What we learn from these innovations could one day be rolled out across the UK and exported around the world and we'll be able to say it was 'Made in Orkney'."

Led by the European Marine Energy Centre (EMEC), the ReFLEX Orkney project brings together an expert consortium of Orkney-based partners – Solo Energy, Aquatera, Community Energy Scotland, Heriot-Watt University and Orkney Islands Council – as well as multi-national energy company Doosan Babcock.

Electricity, transport and heat powered by local renewable energy generation, will be coupled with flexible energy demand balancing the intermittency of renewables.

At the heart of the project is the demonstration of flexible energy balancing technologies. For example, the project aims to deploy:

- Up to 500 domestic batteries;
- Up to 100 business and large-scale batteries;
- Up to 200 Vehicle-to-Grid (V2G) chargers;
- Up to 600 new electrical vehicles (EVs);
- An island community-powered electric bus and e-bike integrated transport system;
- Up to 100 flexible heating systems; and
- A Doosan industrial-scale hydrogen fuel cell.

Solo Energy will implement their FlexiGrid software platform enabling smart monitoring and control of the flexible technologies to charge during periods of peak local renewable generation, and release stored energy during times of peak demand.

These technologies will be introduced under attractive leasing type finance and novel ways of ownership that avoid the end user requiring major capital investment.

This pioneering project will help Orkney maximise the potential of its significant renewable generation capabilities, help to ensure higher quality and more affordable energy services, as well as further lowering the county's carbon footprint by decreasing reliance on imported carbon-intensive grid electricity from the UK mainland.

Once demonstrated and proven in Orkney, it is expected that the VES model and associated integrated energy service supply framework will be replicated in other areas across the UK and internationally, building long term export opportunities for the ReFLEX project partners and helping to create more flexible and renewable-based energy systems.

UK Government Minister Lord Duncan said:

"Scotland is at the forefront of smart energy which is key to the UK Government's modern Industrial Strategy. With £14.3 million of UK Government funding going to the ReFLEX project in Orkney, we are helping to establish the Scottish Islands as an energy powerhouse.

"We need cheaper, cleaner and flexible energy and Orkney will be at the heart of this."

Rob Saunders, Deputy Challenge Director, Prospering from the Energy Revolution, UK Research and Innovation said:

"We all need energy systems that are cheaper, cleaner and consumer-friendly. We have a great opportunity with the ReFLEX project to show just how innovation can deliver this energy ambition for the future. Supported by the Industrial Strategy Challenge Fund, ReFLEX can drive investment, create high-quality jobs and grow companies with export potential."

On behalf of the ReFLEX Orkney project partners, Neil Kermode, Managing Director at EMEC said:

"We're delighted that UKRI have funded this project. This new model will demonstrate how we can better interact with, own and manage our integrated energy systems locally, both at individual and community level.

"50% of the project is being funded privately indicating the appetite that exists within the partners to make this project work. Orkney has already demonstrated high commitment for local sustainable energy solutions and the county is well on its way to decarbonising each aspect of the energy system.

"The target for Orkney is to have a negative carbon footprint and this pioneering project will build upon the existing local energy system, local infrastructure and local expertise, to

accelerate this transition to a fully sustainable and flexible energy system."

Partner quotes:

Mark Hamilton from Solo Energy said: *"Orkney has unique energy challenges that make the island the perfect place to demonstrate this cutting edge new technology. With more renewable generation than the local grid can use, and a constrained connection to the mainland, new battery and software can help balance the gird locally.*

"The ReFLEX Orkney project will be a world-leading example of how energy storage and flexible demand can enable a full transition to a low-cost 100% renewable future by solving the intermittency problem. We can have all the wind and solar farms we want but unless we have the means to store and balance renewables we will never fully wean ourselves off fossil-fuels and get to the root of the climate change problem. Orkney is a perfect location to demonstrate how high levels of local renewable generation combined with intelligent flexible demand can deliver full energy autonomy and lower consumer energy bills."

Gareth Davies, Managing Director of Aquatera said: *"This project reflects the long-term strategic commitment that the project partners have shown to delivering a more sustainable and improved energy system in Orkney that can then act as a model for other parts of the UK and indeed other places in the world. We see this as a truly transformational opportunity to establish a better and progressive relationship between energy customers and their local energy systems.*

"Over the last few years Aquatera has taken a much more proactive role in pro-active energy project development at home in Scotland and in places such as the Philippines and Singapore – this ReFLEX project offers a major impetus to that strategy."

Nicholas Gubbins, CEO of Community Energy Scotland said: *"This brilliant news is built on the high level of collaboration between enabled communities and energy innovators in Orkney. A successful partnership that has started to show how we can supply and manage local energy in a more sustainable and equitable way, and, with this project, we all have an outstanding opportunity to further test and develop the new, fairer, and better future models of ownership and value systems pioneered by communities like those in Orkney.*

"Community Energy Scotland is proud to have helped incubate and knit these wide-ranging interests together so far, and to continue to play a key role in allowing development under ReFLEX Orkney. There is so much here that can be relevant to support grass-roots resilience in other communities, other parts of the world, and to help address some of the wider fundamental energy issues we all now collectively face."

Graeme Booth, Doosan Babcock Head of Research and Innovation said: *"Doosan are very happy to be involved in this innovative project that is pushing the boundaries of decentralised, renewable energy system integration. The world is rapidly realising that hydrogen has a pivotal role to play in responding to global energy challenges and, within the ReFLEX Orkney project, this is a fantastic opportunity to demonstrate integrated renewable electricity, heat and transport solutions within a collaborative partnership."*

Orkney Islands Council Leader James Stockan said: *"Orkney Islands Council is delighted to be involved in this project and we are looking forward to working with our key partners to develop the proposals. Through our Enterprising Communities priority set out in our Council Plan, we are committed to supporting strategic projects that enable further development of Orkney as a low carbon energy systems innovation hub and the ReFLEX Orkney project is an excellent example of that."*

Heriot-Watt University, Prof. David Flynn said: *"The only way to deliver an affordable,*

resilient and sustainable energy service to society is through an integrated, whole systems approach. To understand the complexities and to deliver demonstratable solutions, such research must happen in communities, and Orkney is a global leader in energy innovation. This project has the potential to deliver global change in how we achieve our low carbon objectives and also provide UK companies and communities with first mover advantage on unlocking revenue opportunities from our energy infrastructure, providing excellent wealth creation opportunities from the low carbon economy.

"Orkney is not only an energy innovation epicentre but also a flagship for distributed wealth creation."

Energy in Orkney

Orkney has taken many steps over several decades to progress towards a local energy system, including:

- Long standing heritage as a national location for testing modern wind turbine technology since the first deployment in the 1950s (http://www.orkneywind.co.uk/costa.html)
- Some of the first large scale (900 kW) locally, and now wholly community, owned wind turbines, resulting in community-led local regeneration and community development supported through their incomes.
- The deployment of the UK's first large scale Advanced Network Management system to manage distribution network constraints, with live energy data available for the island (Live site: https://www.ssen.co.uk/anm/)
- Annual renewable generation over 100% of annual demand since 2013.
- Creating world leading expertise in novel renewable energy demonstration and generation, e.g. tidal, wave & hydrogen (www.emec.org.uk)
- Production of an Energy Audit for Orkney, showing Orkney's current energy sources and uses, and identifying further ways to move to a local energy system (http://www.oref.co.uk/resources/orkney-energy-audit/)
- Studies into phasing of energy generation outputs and patterns of energy demand, district heating potential, alternative fuels for ferries, strategic planning for generation and distribution infrastructure (http://www.oref.co.uk/resources/orkney-energy-audit/)
- Research and publication of an Electric Vehicle Strategy for Orkney (http://www.oref.co.uk/draft-orkney-electric-vehicle-strategy-2017-2022/)
- Successful demonstration of projects that combine local community-owned and novel renewable electricity generation (wind, marine), energy storage (electricity & hydrogen) and energy demand (electricity, heating and transport) (http://www.communityenergyscotland.org.uk/innovation.asp):
    - Surf n Turf (www.surfnturf.org.uk)
    - SMILE (https://www.h2020smile.eu/)
    - Heat Smart Orkney (http://www.rewdt.org/)
    - BIG HIT (https://www.bighit.eu/)
    - PITCHES (https://gtr.ukri.org/projects?ref=103490).
- Long term and ongoing public outreach and engagement through the Orkney Renewable Energy Forum (www.oref.co.uk)

Statistics from the Department of Business, Energy and Industrial Strategy and the Department of Transport show:

- 10% of homes on Orkney have microgeneration compared to 2.8% in the UK; (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/780097/December_2018_Sub-regional_Feed-in_Tariffs_confirmed_CFR.xls)
- Orkney has 375% more EVs per home than the UK average (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/763822/veh0131.ods)
+

(https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/699014/veh0105.ods)

- Orkney has 2.0 kW of renewable energy capacity per home - 900% higher than the UK average;
- Orkney has 12 times more domestic RHI installations per home than the UK average;
- Annual renewable electricity generation is over 100% of annual electricity use on Orkney.

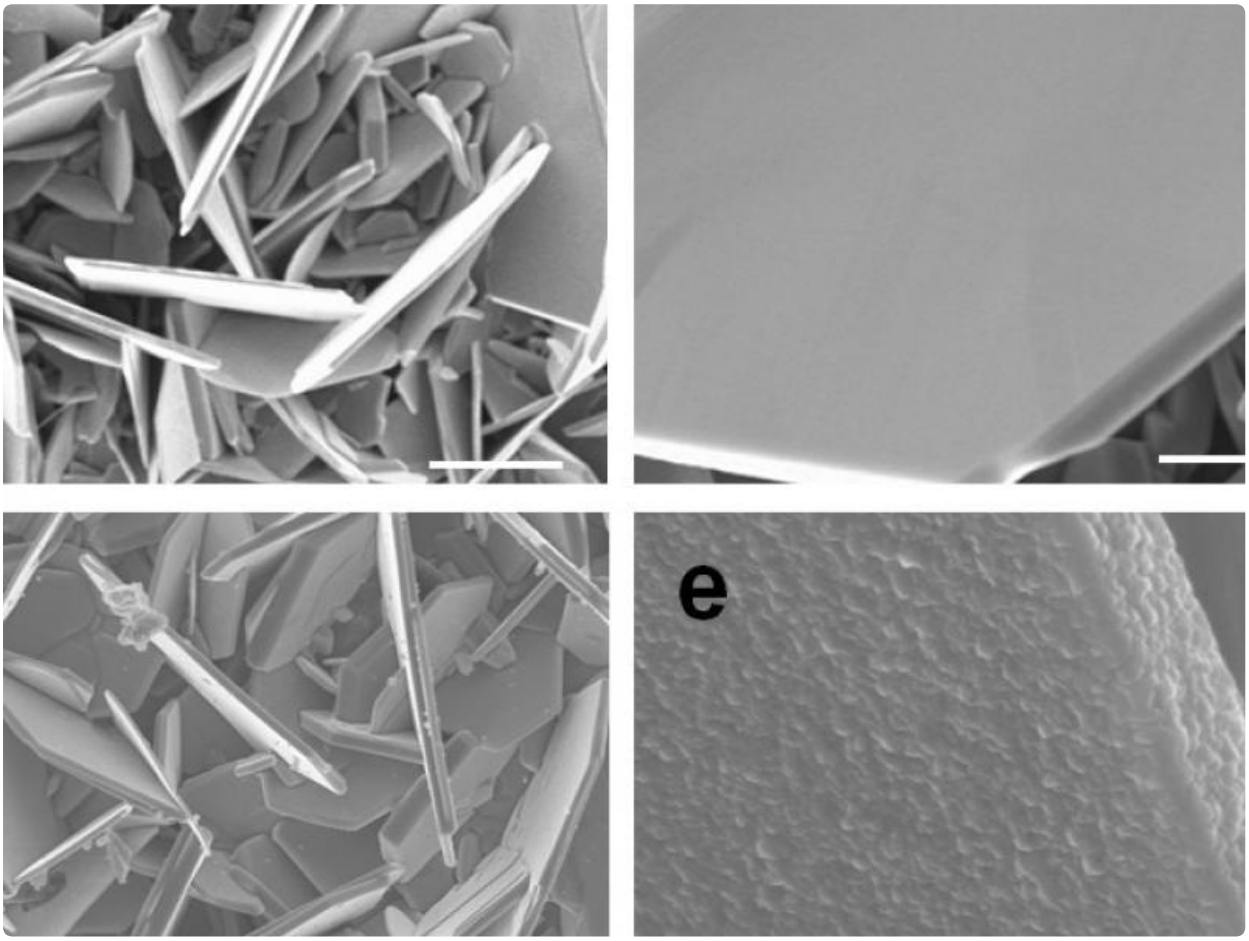
Whilst there is no shortage of renewable generation assets in Orkney, demand-side flexibility assets are only now developing, through pioneering pilot and local community scale activities. Therefore, the ReFLEX Orkney project will deliver an extensive new pool of flexible demand technologies at regional scale.

Source: http://www.emec.org.uk/

New Discovery Could Lead to Rapid-Charging, Better Performing Lithium-Ion Batteries

Written by AZoM Apr 17 2019

Designing a lithium-ion battery that can charge within minutes yet work at a high capacity is possible, according to a research paper from Rensselaer Polytechnic Institute (RPI) recently published in *Nature Communications*. This development shows the potential to enhance battery performance for solar grid storage, consumer electronics, and electric vehicles.



VS2 flakes with and without TiS2 coating. (Image credit: Rensselaer Polytechnic Institute)

A lithium-ion battery charges and discharges as lithium ions travel between two electrodes, called a cathode and an anode. In a traditional lithium-ion battery, the anode is composed of graphite, while the cathode is made of lithium cobalt oxide.

These materials work well together, which is why lithium-ion batteries have become progressively widespread, but scientists at RPI believe the function can be improved further.

"The way to make batteries better is to improve the materials used for the electrodes," said Nikhil Koratkar, professor of mechanical, aerospace, and nuclear engineering at RPI, and corresponding author of the paper. *"What we are trying to do is make lithium-ion technology even better in performance."*

Koratkar's wide-ranging research into nanotechnology and energy storage has positioned him among the world's most highly cited scientists. In this latest work, Koratkar and his team enhanced performance by switching cobalt oxide with vanadium disulfide (VS_2).

> *"It gives you higher energy density, because it's light. And it gives you faster charging capability, because it's highly conductive. From those points of view, we were attracted to this material.*
>
> *Nikhil Koratkar, Professor of Mechanical, Aerospace, and Nuclear Engineering, Department of Materials Science and Engineering, RPI.*

There has been a lot of excitement regarding the potential of VS_2 in recent years, but so far, Koratkar said, scientists had been defied by its instability—a feature that would result in short battery life. The RPI scientists not only demonstrated why that instability was occurring, but also developed a way to beat it.

The interdisciplinary team, which also included Vincent Meunier, head of the Department of Physics, Applied Physics, and Astronomy, and others, established that lithium insertion caused an irregularity in the spacing between vanadium atoms, referred to as Peierls distortion, which was liable for the disintegration of the VS_2 flakes. They learned that covering the flakes with a nanolayered coating of titanium disulfide (TiS_2)—a material that does not Peierls distort—would steady the VS_2 flakes and enhance their performance within the battery.

> *"This was new. People hadn't realized this was the underlying cause. The TiS_2 coating acts as a buffer layer. It holds the VS_2 material together, providing mechanical support.*

> *Nikhil Koratkar, Professor of Mechanical, Aerospace, and Nuclear Engineering, Department of Materials Science and Engineering, RPI.*

Once that issue was solved, the team discovered that the VS_2-TiS_2 electrodes could work at a high specific capacity, or store plenty of charge per unit mass. Koratkar stated that vanadium and sulfur's small size and weight permit them to supply a high energy density and capacity. Their small size would also benefit the battery's compactness.

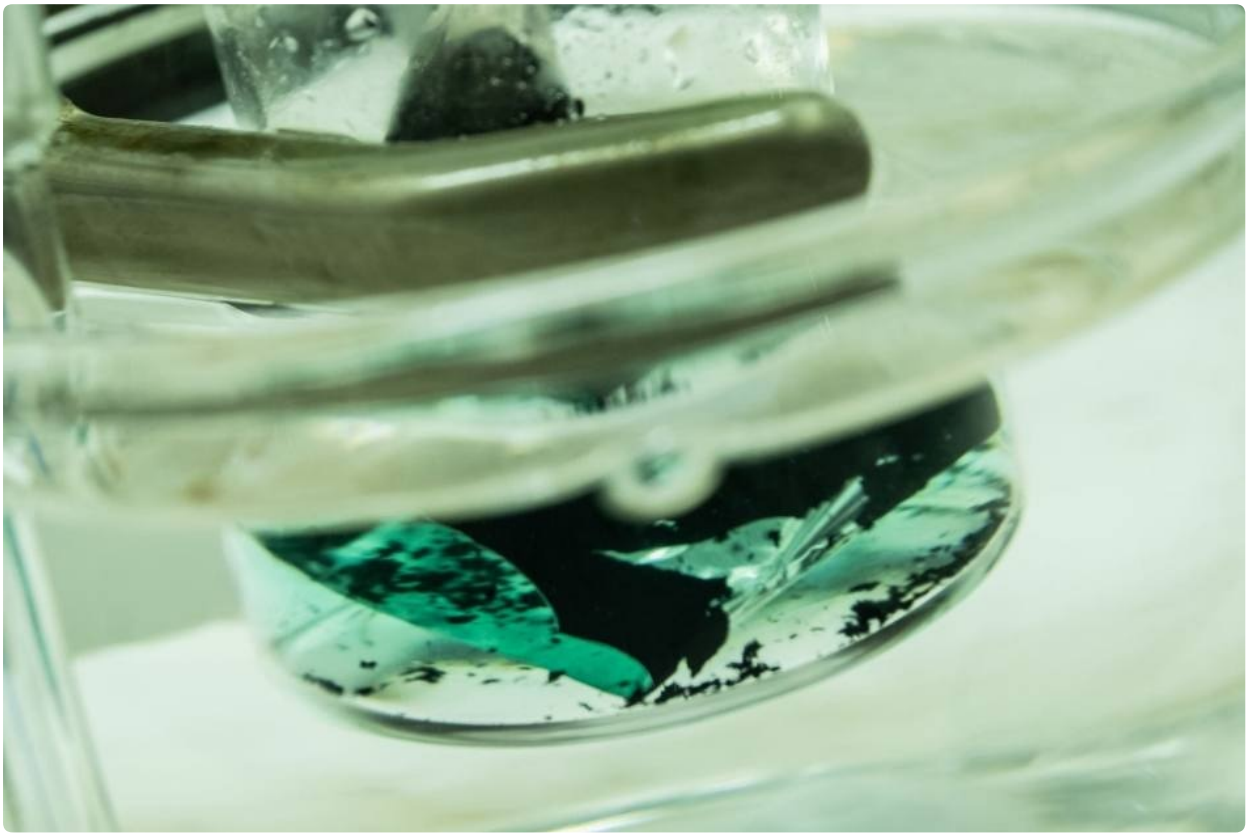
When charging took place more rapidly, Koratkar said, the capacity did not drop as considerably as it frequently does with other electrodes. The electrodes were able to sustain a practical capacity because, in contrast to cobalt oxide, the VS_2-TiS_2 material is electrically conductive.

Koratkar sees numerous applications for this discovery in enhancing car batteries, power for portable electronics, and solar energy storage where high capacity is crucial, but better-charging speed would also be appealing.

Rice University Researchers Find New Way to Deal with the Glut of Used Lithium-Ion Batteries

Written by AZoCleantech Apr 2 2019

Scientists at the Rice University have truly found a way to deal with the excess amount of used lithium-ion batteries left behind—a consequence of the growing demand for cellphones, electric vehicles, and other electronic devices.



A solution turns green as it pulls cobalt from a spent lithium-ion cathode. A Rice University laboratory is developing an environmentally friendly method to recover valuable metals from used batteries. (Image credit: Jeff Fitlow)

Pulickel Ajayan, materials scientist at the Rice lab, extracted important elements from the metal oxides generally used as cathodes in lithium-ion batteries, using an eco-friendly deep eutectic solvent. The scientists stated that the objective is to limit the use of severe processes to recycle batteries and exclude them from landfills.

The solvent, consisting of choline chloride, ethylene glycol, and commodity products, extracted over 90% of cobalt from powdered compounds, and a smaller yet considerable amount from used batteries.

> *Rechargeable battery waste, particularly from lithium-ion batteries, will become an increasingly menacing environmental challenge in the future as the demand for these through their usage in electric vehicles and other gadgets increases dramatically. It's important to recover strategic metals like cobalt that are limited in supply and are critical for the performance of these energy-storage devices. Something to learn from our present situation with plastics is that it is the right time to have a comprehensive strategy for recycling the growing volume of battery waste.*
>
> *Pulickel Ajayan, Materials Scientist, Rice University*

The results have been reported in *Nature Energy*.

> *This has been attempted before with acids. They're effective, but they're corrosive and not eco-friendly. As a whole, recycling lithium-ion batteries is typically expensive and a risk to workers.*
>
> *Kimmai Tran, Study Lead Author and Graduate Student, Rice University*

She stated that other processes also have limitations. Pyrometallurgy entails crushing and blending at extreme temperatures, and the toxic fumes need scrubbing. Hydrometallurgy needs caustic chemicals, while other "green" solvents that recover metal ions usually need additional agents or high-temperature processes to completely acquire them.

"*The nice thing about this deep eutectic solvent is that it can dissolve a wide variety of metal oxides*," stated Tran. "*It's literally made of a chicken feed additive and a common plastic precursor that, when mixed together at room temperature, form a clear, relatively nontoxic solution that has effective solvating properties*."

A deep eutectic solvent is a combination of two or more compounds that freezes at temperatures much lower than each of its precursors. In this manner, one can plainly acquire a liquid from a simple combination of solids, stated Tran.

"*The large depression of freezing and melting points is due to the hydrogen bonds*

formed between the different chemicals," Tran stated. "*By selecting the right precursors, inexpensive 'green' solvents with interesting properties can be fabricated.*"

When Tran joined, the Rice team was already testing a eutectic solution as an electrolyte in next-generation high-temperature supercapacitors.

> *"We tried to use it in metal oxide supercapacitors, and it was dissolving them. The color of the solution would change.*
>
> *Babu Ganguli, Co-Corresponding Author and Research Scientist, Rice University*

The eutectic was attracting ions from the supercapacitor's nickel.

"*Our team was discussing this and we soon realized we could use what was thought to be a disadvantage for electrolyte as an advantage for dissolving and recycling spent lithium batteries*," Ganguli said.

That turned out to be the focus of Tran, as she tested deep eutectic solvents on metal oxides at various time scales and temperatures. The clear solvent, while testing with lithium cobalt oxide powder, produced a broad spectrum of blue-green colors that showed the presence of cobalt dissolved within.

At 356 °F (180 °C), the solvent extracted about 99% of cobalt ions, and almost 90% of lithium ions from the powder when specific conditions were met.

The scientists developed small prototype batteries and cycled them 300 times prior to subjecting the electrodes to the same conditions. The solvent was found to be efficient at dissolving the lithium and cobalt while isolating the metal oxides from the other compounds present in the electrode.

They identified that cobalt could be extracted from the eutectic solution via precipitation or even electroplating to a steel mesh, since this latter technique potentially enabled the deep eutectic solvent itself to be used again.

> *"We focused on cobalt. From a resource standpoint, it's the most critical*

> *part. The battery in your phone will surely have lots of it. Lithium is very valuable too, but cobalt in particular is not only environmentally scarce but also, from a social standpoint, hard to get.*
>
> *Marco Rodrigues, Postdoctoral Researcher, Argonne National Laboratory*

Rodrigues is also an alumnus of Rice University. He remarked that the Department of Energy is taking innovative efforts to improve battery recycling technologies and recently established a center for Li-ion battery recycling.

Further work will need constant efforts.

"*It's likely we won't be able to recycle and replace mining completely*," stated Tran. "*These technologies are relatively new, and there is a lot of optimization that needs to be done, such as exploring other deep eutectic solvents, but we truly believe in the potential for greener ways to do dirty chemistry. Sustainability is in the heart of the work I do and what I want to do for the rest of my career.*"

Keiko Kato, a graduate student, is a co-author of the study. Ajayan is the Benjamin M. and Mary Greenwood Anderson Professor in Engineering and a professor of chemistry.

The work was supported by the National Science Foundation through its Graduate Research Fellowship Program.

Video credit: Rice University

The Developments in Lasers, Optics and Photonics: Laser Tech 2019

By Benedette Cuffari, M.Sc. Mar 12 2019

Between April 15 and 16, 2019, the 2nd International Conference on Laser, Optics, and Photonics, otherwise known as Laser Tech, will take place in Frankfurt Germany. With this year's theme being "*Share the Vision to Shape the Future of Laser, Optics and Photonics*," attendees from a wide range of industries will have the opportunity to discuss new ideas, share practical development experiences and network with some of the leading innovators in technology from around the world.

Valentyn Volkov/Shutterstock

Introduction

The Laser Technology Market currently amounts to 7 billion USD and is expected to continue to rise to as much as 17 billion USD by the year 2020. This success is supported by a plethora of exciting peer-reviewed optics research and advancements that have been made in recent years from scientists around the world.

Within the specialized field of topological photonics, for example, the development of topological microlasers in 2018 allowed spectacular breakthroughs to be made in the analysis of two dimensional (2D) geometries. Furthermore, the incorporation of a topological-insulator laser into topological systems was found to provide an increased level of protection, nonlinearity, and gain, thereby serving as the foundation for the development of potential photonic lasers, sensors, and antennas.

Over the past several years, a drastic change within the photonics industry has occurred as a result of the tremendous amount of research that has gone into the development of the technology and devices that comprise this area of science. Advancements within the field of fiber optics have primarily supported the development of photonic sensors that are currently used in a wide variety of different industries. To this end, the Global Photonics Sensor Market is expected to experience a rise in its success that values to as much as $18 billion by the year 2021.

As the research in this area continues to advance, the photonics industry is expected to focus their technological developments on products that are increasingly eco-friendly, energy-conserving, safe and secure for their customers.

With this level of remarkable advancements that continue to arise around the world each year, researchers, principal investigators, experts and various other professionals that will be attending the 2019 conference will have the opportunity to discuss the future directions that these developments will have within their respective industries, as well as their potential implications to the environment. In particular, various health professionals including neurologists, dentists, ophthalmologists, and surgeons are expected to discuss the innovative solutions and applications that lasers, optics, and photonics can offer to address countless public health challenges.

Conference Features

With a clear emphasis on sharing evidence-based practice, educational innovation, and practical applications, as well as providing unique global network and collaboration opportunities, Laser Tech 2019 has set ambitious goals for this year’s conference. To further inspire the innovative minds that will be attending this year’s Lasers, Optics and Photonics conference, attendees will be able to directly interact with some of the leading academic and industrial visionaries from around the world.

This unique opportunity will not only expand the knowledge of attendees on the numerous applications and details of these technologies but is also expected to offer

potential solutions to any problems these professionals may be facing in their work. Laser Tech 2019 will, therefore, act as a platform to support knowledge, benchmarking and global networking, all of which will take place in a single and central location to bring all attendees together.

Lecture Series

In addition to providing a secure place to share ideas and knowledge, Laser Tech 2019 will also host various speakers that will be discussing a wide range of topics. These lecture series topics will include:

- Laser Medical Technologies
- Laser Systems
- Semiconductor Lasers
- Advanced Laser Processing and Manufacturing
- Lightwave Communications and Optical Networks
- Optical Metrology
- Active Optical Sensing
- Ultrafast Optics
- Nanophotonics and Micro/Nano Optics
- Fiber Photonics
- Biophotonics

Attendees of all backgrounds and research interests will be able to find informative lectures to attend throughout this conference.

Future Directions

There is no doubt that a significant amount of progress has been made in the development of laser, optics and photonics devices. As the researchers and industry professionals attending Laser Tech will be discussing past successes, they will surely examine how these industries will continue to evolve in the future.

For example, the increased interest in combining quantum dots, which are tiny and atom-like structures, with laser technology has a promising future for integrated photonic circuits. One of the main advantages of quantum dots is their increased stability within photonic circuits as a result of their localized and atom-like energy states. Furthermore, quantum dots also require much less energy due to the eliminated electric current.

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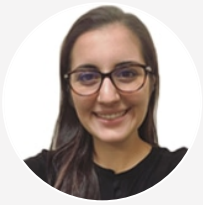


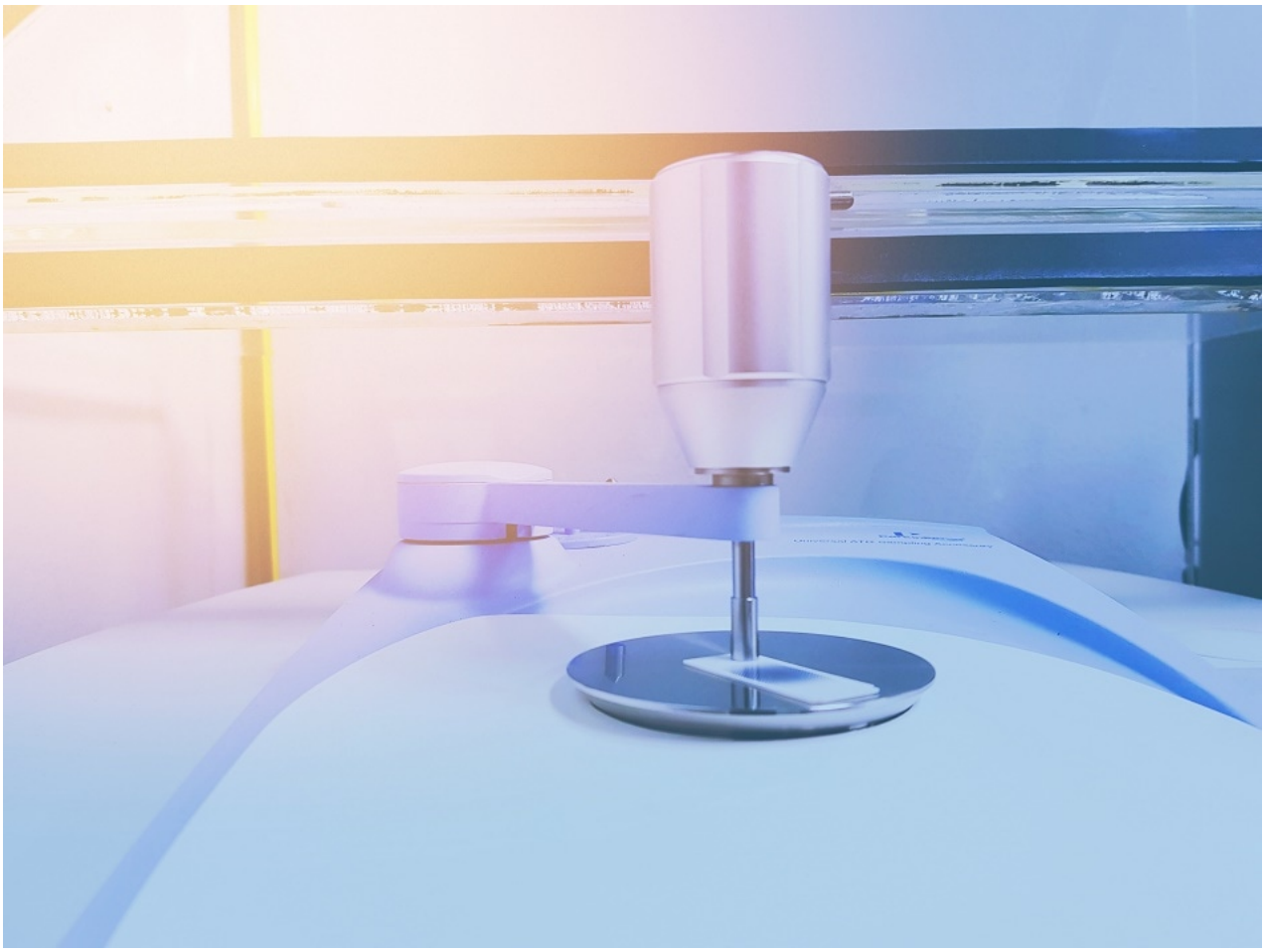
Written by

Benedette Cuffari

After completing her Bachelor of Science in Toxicology with two minors in Spanish and Chemistry in 2016, Benedette continued her studies to complete her Master of Science in Toxicology in May of 2018. During graduate school, Benedette investigated the dermatotoxicity of mechlorethamine and bendamustine, which are two nitrogen mustard alkylating agents that are currently used in anticancer therapy.

Why is Fourier Transform Infrared (FTIR) Spectroscopy Used?

By Louise Saul, M.Sc. Mar 19 2019



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Fourier Transform Infrared Spectroscopy (FTIR) is a type of infrared spectroscopy that simultaneously collects high-spectral-resolution data over a wide range and is the preferred method of IR spectroscopy for laboratories. The definition of FTIR comes from the fact that a mathematical process known as Fourier Transform is used to convert raw data into a readable spectrum.

What is FTIR Spectroscopy?

FTIR deals with the infrared region of the electromagnetic spectrum, and it works by measuring how much light is absorbed by the bonds of vibrating molecules to provide a molecular fingerprint. The infrared spectrum can be split into near IR, mid-IR and far IR.

Near IR has the greatest energy and can penetrate a sample much deeper than mid or far IR, but it is less sensitive than mid or far IR.

The principles of IR show that molecules vibrate and bonds stretch and bend when they absorb infrared radiation. It works by passing a beam of IR light through a sample, and for an IR detectable transition, the molecules of the sample must undergo dipole moment change during vibration. When the frequency of the IR is the same as the vibrational frequency of the bonds, absorption occurs and a spectrum can be recorded.

With IR, different functional groups absorb heat at different frequencies. It is dependent upon their structure and a vibrational spectrum can be used to determine the functional groups present in a sample. When interpreting the data obtained by an IR spectrometer, results are compared to a frequency table to find out which functional groups are present.

Combination with Other Techniques

FTIR can be combined with other analytical techniques to gain more information about a sample. These include:

- FTIR microscopy
- Diffuse Reflectance Infrared Fourier Transform Spectroscopy (DRIFTS)
- Infrared-spectroscopy coupled to Thermogravimetric Analysis (FTIR/TGA)
- Gas chromatography infra-red (GC-IR) analysis
- Combination with Raman spectroscopy

FTIR Uses

FTIR is widely used in many industries and is used for the analysis of both organic and inorganic compounds. It can confirm the composition of both solids, liquids, and gases.

FTIR is mainly used for:

- The identification of unknown compounds
- Quantitative information, such as additives or contaminants
- Kinetic information through the growth or decay of infrared absorptions
- To give complex information when coupled with other devices such as TGA, GC or Rheometry

The industries that utilize FTIR include organic synthesis, polymer science, petrochemical engineering, biological research, the pharmaceutical industry and analysis

of food. Portable FTIR spectrometers have also been researched and used for field analysis.

In biological research, FTIR can be used to investigate proteins in hydrophobic membrane environments. Time-resolved (tr)-FTIR spectroscopy can monitor reactions of the amino acids, ligands and specific water molecules in the active center of a protein. Then time can range from nanoseconds to seconds and provide a detailed understanding of the molecular reaction mechanism.

In the environmental industry, FTIR also has many different applications. It can be used to analyze soil samples and to monitor air and water quality. It can address environmental and health concerns that have been caused by the increasing pollution levels.

The food industry uses FTIR to make sure that they are complying to the required government standards. It can monitor the physical, chemical and rheological properties of food. An example is looking at the trans-fat content of manufactured food products by infrared attenuated total reflectance (ATR). Another case of utilizing FTIR in the food industry is to compare the differences in grains of wheat varieties. Foodborne pathogens can also be identified by FTIR.

In the forensics industry, FTIR is used to quickly identify illegal drugs, crime scene evidence, banned materials, and counterfeit goods. These techniques can provide fast, easy and consistent analysis for chemical evaluation, seized drugs, paint and materials from hit and runs, and textile identification.

In pharmaceutical research, FTIR has multiple applications. It is mainly used to identify the structure of unknown compounds, but can also be used for:

- Quality verification of materials
- Deformulation of polymers, rubbers, and other materials through thermogravimetric infra-red (TGA-IR) and gas chromatography infra-red (GC-IR) analysis
- To identify contaminants
- To analyze thin films and coatings
- To monitor automotive and smokestack emissions
- For failure analysis

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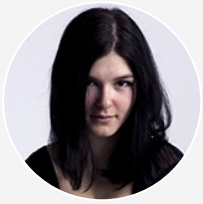

Written by

Louise Saul

Louise pursued her passion for science by studying for a BSc (Hons) Biochemistry degree at Sheffield Hallam University, where she gained a first class degree. She has since gained a M.Sc. by research and has worked in a number of scientific organizations.

The Role of Laser Scanning Confocal Microscopy (LSCM) in Food Analysis

By Benedette Cuffari, M.Sc. Mar 11 2019

Image Credits: Alex_Traksel/shutterstock.com

Microscopic techniques, such as light microscopy, have been used extensively to study the microstructure of food systems since the 1980s. Studying these microstructures in relation to their physical properties and processing behavior provide valuable information for the food industry. Due to the limitations of the visible light on which light microscopy depends, the microstructures of food can be visualized only by cutting thin sections of the food sample. The preparation of the food sample for light microscopy and section cutting can also be very time-consuming. In addition to that, there is a risk of introduction of artifacts into the prepared samples during sample processing which involves various chemicals for fixation and dehydration. Newer microscopic techniques, such as Laser Scanning Confocal Microscopy (LSCM), allow researchers to examine the microstructures of food without the need for tedious sample preparation and cutting thin sections of the food specimen.

Laser Scanning Confocal Microscopy (LSCM)

Unlike the light microscopes that use visible light to illuminate the sample, LSCM instead utilizes a focused scanning laser to illuminate a subsurface of a three-dimensional (3D) specimen. The visual information from that focal plane is then passed back through the specimen and is projected onto the confocal aperture, which is otherwise referred to the pinhole, which is located in front of the detector. In addition to that, samples can be probed with different kinds of fluorochromes, such as rhodamine, fluorescein isothiocyanate (FITC) and Nile red to stain proteins or fat. Labeling the sample with multiple fluorochromes that stain specific components would provide incredible details of the food sample.

Application of LSCM in Food Analysis

LSCM facilitates the examination of microstructures and several 3D food specimens like cheese at various focal planes with minimum to little sample preparation. By adjusting the stage of the microscope, information from several consecutive optical sections of the specimen can be obtained with exceptional lateral resolution. Some of the common applications of LSCM in food analysis include:

Description of Fats in Bulk

Optical sections of high-fat food are difficult to prepare using light microscopy techniques since the sample preparation would result in migration of fat globules. For example, milk fat, which is one of the most common ingredients in many food products has about 400 different fatty acids. The fatty acids present in milk fat have broad crystallization and melting ranges. Researchers have utilized LSCM to study the distribution of microstructures and the rheological properties of various fractions of milk fat. By using LSCM that is equipped with special stages that hold the food samples, the behavior of the fats at various conditions such as temperature changes and agitation can be studied.

Studying Biopolymer Mixtures

Proteins and carbohydrates, like polysaccharides, co-exist in most food samples. Processing technologies such as high-pressure processing are used to pack such biopolymer food materials in a way to extend their shelf life without depleting their nutritional properties. LSCM can, therefore, be used to visualize the behavior of

commonly used biopolymer mixtures, such as a skim milk-gelatin mixture, by examining the changes in the microstructures present within the food sample when subjected to various rheological conditions, such as changes in viscosity in relation to changes in pressure and shear rate.

Analysis of Emulsion Systems

Emulsions are biphasic systems where the dispersed phase is distributed in the dispersion medium. For example, in an oil in water (o/w) emulsion, small oil droplets, which would be the dispersed phase, are usually coated with an emulsifier and is dispersed in water, which is considered to be the dispersion medium. The composition of such biphasic systems and the microstructures can be visualized and characterized by using specific fluorophores for proteins and lipids using LSCM.

Conclusion

LSCM, alone or in combination with other microscopic techniques such as light microscopy and polarized light microscopy can serve as a valuable tool in food analysis. The ability of LSCM to examine the internal structure of various 3D specimens at various depths of fields and multiple fluorochrome labeling without extensive sample preparation makes the food analysis less time consuming and more efficient.

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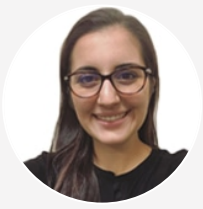

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New Laser-Driven Photoacoustic Microfluidic Pump can Drive Fluids in Any Direction

Written by AZoOptics Mar 12 2019

Even the tiniest mechanical pumps have drawbacks caused by the intricate microfabrication techniques needed to manufacture them and the reality that there are restrictions on how small they can be.

Researchers have announced the discovery of a laser-driven photoacoustic microfluidic pump, capable of moving fluids in any direction without moving parts or electrical contacts. (Image credit: University of Houston)

Scientists have revealed a promising solution, a laser-driven photoacoustic microfluidic pump, with the ability to move fluids in any direction without moving parts or electrical contacts.

The research is reported in the *Proceedings of the National Academy of Sciences*.

With the help of a plasmonic quartz plate implanted with gold atoms, the scientists showed the ability to move liquids by using a laser to produce an ultrasonic wave.

> *We can use the laser to make liquids move in any direction.*
>
> *Jiming Bao, Study Lead Author and Associate Professor, Department of Electrical and Computer Engineering, University of Houston.*

The research is based on a new optofluidics principle found out by Bao's lab and published in 2017. That study described the use of a laser to stimulate a stream of liquid, coupling photoacoustics with acoustic streaming.

In the latest study, a quartz substrate implanted with 10^{16} gold atoms, or ten thousand trillion atoms, per square centimeter was developed. Also, the study tested whether a laser pulse could produce an ultrasonic wave that can generate a liquid stream. The quartz plate—approximately the size of a fingernail—was implanted with gold nanoparticles; when a pulsed laser strikes the plate, the gold nanoparticles produce an ultrasonic wave, which then directs the fluid through acoustic streaming.

"*This new micropump is based on a newly discovered principle of photoacoustic laser streaming and is simply made of an Au [gold] implanted plasmonic quartz plate*," the researchers wrote. "*Under a pulsed laser excitation, any point on the plate can generate a directional long-lasting ultrasound wave which drives the fluid via acoustic streaming*."

The research could have practical implications ranging from drug delivery and biomedical devices to optofluidic and microfluidic research. Wei-Kan Chu, a physicist and project leader at the Texas Center for Superconductivity at UH, said the exact value is not yet identified.

> *We would like to better understand the mechanisms of this, and that could open up something beyond our imagination.*
>
> *Wei-Kan Chu, Physicist and Project Leader, Texas Center for Superconductivity, University of Houston.*

The device was developed in Chu's lab, who is a co-author, along with Nzumbe Epie,

Xiaonan Shan, and Dong Liu, all of UH; Shuai Yue, Feng Lin, and Zhiming Wang of the University of Electronic Science and Technology of China; Qiuhui Zhang of Henan University of Engineering; and Suchuan Dong of Purdue University.

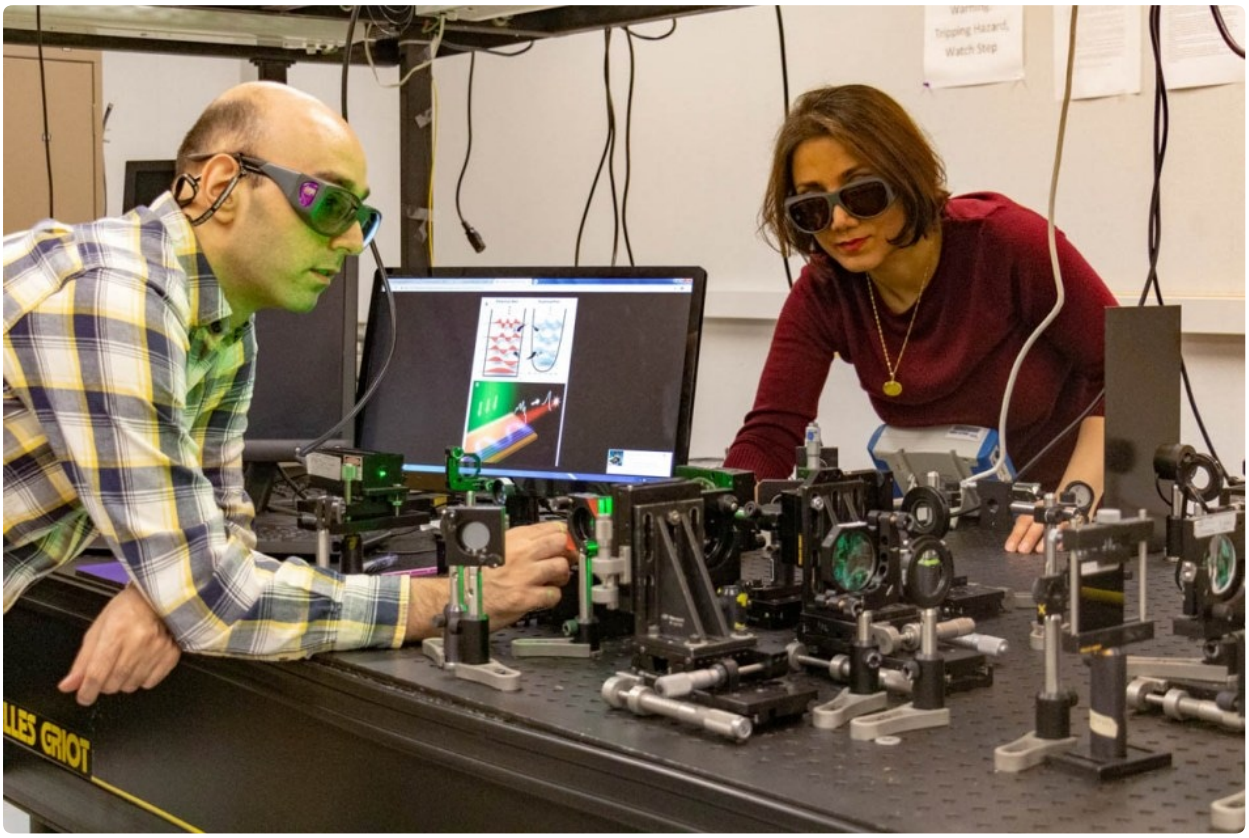
According to Bao, the nanoparticles provide nearly an unlimited number of targets for the laser, which can be aimed far more accurately when compared to a mechanical micropump.

"*The mechanisms of how and why these works are not yet very clear*," Chu said. "*We need to understand the science better in order to develop the potential of its unforeseeable applications*."

UCF Team Builds First Supersymmetric Laser Array

Written by AZoOptics Mar 1 2019

Researchers from the University of Central Florida (UCF) have overcome an age-old problem in laser science, and the results could have applications in drilling, surgery, and 3D laser mapping.



Associate Professor Mercedeh Khajavikhan and her team have developed the first supersymmetric laser array. (Image credit: University of Central Florida)

Using the supersymmetry principle, they have designed the first supersymmetric laser array. Details of their findings can be found in the journal *Science*.

Supersymmetry is an estimation in physics that states every particle of matter, such as an electron, has one or more superpartners that is the same apart from a precise variance in their momentum.

"This is the first demonstration of a supersymmetric laser array that is promising to meet the needs for high power integrated laser array with a high-quality beam emission," says

study co-author Mercedeh Khajavikhan, an associate professor of optics and photonics in UCF's College of Optics and Photonics.

Khajavikhan led the team that designed the laser array, which is made up rows of lasers and can yield large output power and greater beam quality. This is a first array that reliably produces high radiance, as earlier designs have delivered degraded beam quality.

Khajavikhan says that previous work by Demetrios Christodoulides, a Pegasus professor of optics and photonics, Cobb Family Endowed Chair in the college and study co-author, recommended the use of supersymmetry in optics and her team has investigated it further in its studies.

"However, it is only recently that my group managed to bring these ideas in actual laser settings, where such notions can be fruitfully used to address real problems in photonics," she says.

The key to her team's laser arrays is spacing lasers next to each other using calculations that take into consideration supersymmetry. She says this development is very crucial in a number of areas that a high-power integrated laser is required.

> *"We foresee many applications of supersymmetric laser arrays in medicine, military, industry, and communications, wherever there is a need for high power integrated laser arrays having a high beam quality.*
>
> *Mercedeh Khajavikhan, Associate Professor of Optics and Photonics, College of Optics and Photonics, UCF.*

One stimulating application could be in the use of LIDAR, which employs lasers to survey and map 3D terrain and is used in areas such as self-driving cars, atmospheric physics, archaeology, forestry, and more.

> *"LIDAR requires a high-power and high-beam quality laser. Currently, because of the lack of this type of lasers in integrated form, they use other kinds of lasers. The supersymmetric laser provides an integrated high-power laser solution that also shows high beam quality.*

> *Mercedeh Khajavikhan, Associate Professor of Optics and Photonics, College of Optics and Photonics, UCF.*

The study's co-authors include Mohammad P. Hokmabadi, the study's lead author and a postdoctoral associate in the College of Optics and Photonics; Nicholas S. Nye, a graduate research assistant in the college; and Ramy El-Ganainy, an associate professor at Michigan Technological University and UCF alumni.

Khajavikhan holds more than a few degrees including a doctorate in electrical engineering from the University of Minnesota. She went to UCF in 2012.

Using High-Speed Lasers to Reveal Mechanisms Behind the Creation of H3+, the Primeval Molecule

Written by AZoQuantum Mar 14 2019

Researchers consider that the trihydrogen (H3+) molecule made the universe. In the latest issues of *Nature Communications* and the *Journal of Chemical Physics*, researchers from the Michigan State University have described the use of high-speed lasers to reveal the mechanisms that play a vital role in the creation and unusual chemistry of H3+.

Marcos Dantus, University Distinguished Professor in chemistry and physics, has recreated interstellar ions with lasers. (Image credit: MSU)

H3+ is omnipresent in the Milky Way, the universe, the Earth's ionosphere, and gas giants. It is also being prepared and investigated in the lab of Marcos Dantus, University Distinguished Professor in chemistry and physics. A team of researchers has started to gain insights into the chemistry of this iconic molecule using ultrafast lasers, as well as technology invented by Dantus.

> *"Observing how roaming H2 molecules evolve to H3+ is nothing short of astounding. We first documented this process using methanol; now we've been able to expand and duplicate this process in a number of molecules and identified a number of new pathways.*
>
> *Marcos Dantus, University Distinguished Professor in chemistry and*

> *physics, Michigan State University.*

However, astrochemists view the larger picture, observing H3+ and describing it through an interstellar perspective. It is developed so rapidly—in less time compared to the time taken for a bullet to cross an atom—that it is very challenging to find out how three chemical bonds are split and three new ones are formed within such a short period of time.

This is when chemists working with femtosecond lasers come into play. In spite of exploring the stars with the help of a telescope, Dantus and colleagues actually look at the smaller picture. The complete procedure is observed at the molecular level and measured in femtoseconds, or one-millionth of one-billionth of a second. The process observed by the researchers takes about 100–240 fs. Dantus is aware of this since the clock starts when the first laser pulse is fired. Then, the laser pulse “sees” what is happening.

The two-laser method demonstrated the hydrogen transfer, and also the hydrogen-roaming chemistry, which causes the formation of H3+. A neutral molecule (H2) is briefly produced by roaming mechanisms, where the molecule stays in the proximity and derives a third hydrogen molecule to form H3+. And as it has turned out, this can happen in more than just one way. In an experiment involving ethanol, the researchers demonstrated six potential pathways, validating four of them.

Due to the fact that laser pulses are comparable to sound waves, Dantus and colleagues found out a “tune” that optimizes the formation of H3+ and one that inhibits the formation. Conversion of these “shaped” pulses to a slide whistle leads to successful formation when the note begins flats, rises slightly, and ends with a downward, deeper dive. The song turns out to be music to the ears of chemists who can visualize various promising applications for this innovation.

> *“These chemical reactions are the building blocks of life in the universe. The prevalence of roaming hydrogen molecules in high-energy chemical reactions involving organic molecules and organic ions is relevant not only for materials irradiated with lasers, but also materials and tissues irradiated with x-rays, high energy electrons, positrons and more.*
>
> *Marcos Dantus, University Distinguished Professor in chemistry and*

> *physics, Michigan State University.*

This research unravels chemistry that is relevant with respect to the formation of universe with water and organic molecules. He added that the mysteries it could unravel, from medical to astrochemical, are limitless.

MSU researchers who contributed to the *Nature Communications* paper included Nagitha Ekanayake, Muath Nairat, Nicholas Weingartz, Benjamin Farris, Benjamin Levine, and James Jackson. Researchers from Kansas State University also contributed to this research.

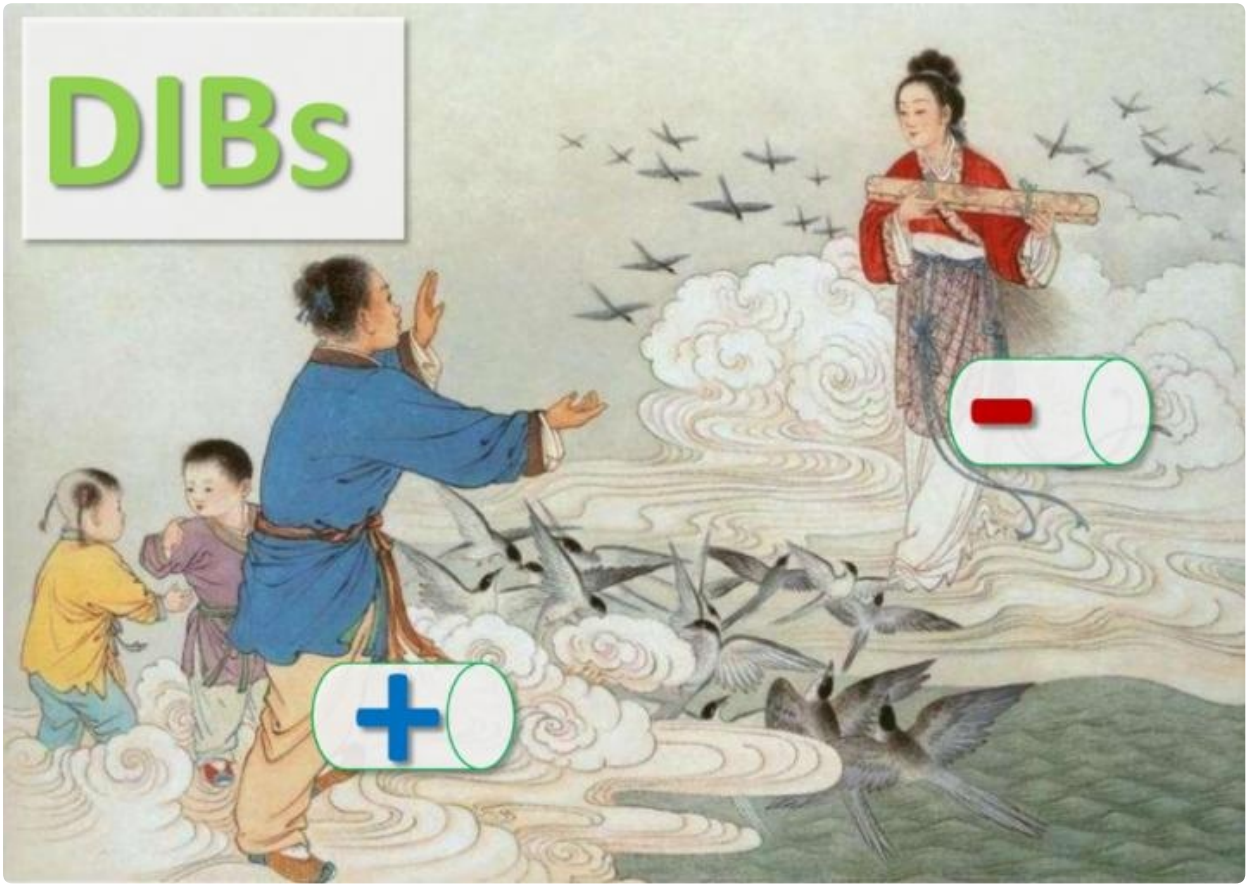
MSU researchers who contributed to the *Journal of Chemical Physics* paper included Ekanayake, Nairat, Matthew Michie, Weingartz, and Levine.

This study was financially supported by the Department of Energy and the National Science Foundation.

Researchers Design Highly Efficient Aluminum–Graphite Dual-Ion Batteries at Low Cost

Written by AZoM Mar 29 2019

Dual-ion batteries (DIBs), in which cations and anions take part in the electrochemical redox reaction, are one of the most potential candidates that fulfill the demands of the cost-effectiveness of commercial applications.



Anions and cations in DIBs act like the Cowherd and the Weaver Girl. (Image credit: Tang Yongbing)

They have many advantages such as excellent safety, high working voltage, and eco-friendliness than the usual lithium-ion batteries (LIBs).

Researchers, under the guidance of Prof. Tang Yongbing and Dr Zhou Xiaolong, at the Shenzhen Institutes of Advanced Technology (SIAT) of the Chinese Academy of Sciences, in collaboration with other researchers published an invited review article titled “Beyond Conventional Batteries: Strategies towards Low-Cost Dual-Ion Batteries with High Performance” in *Angewandte Chemie International Edition*.

DIBs are of great interest across the world due to their ease of recycling, low cost, low environmental impact, high working voltage, and so on. But the conventional double-carbon structure of DIBs possesses a low energy density owing to the limitation of theoretical capacity and compaction density of graphite.

In 2016, Prof. Tang's team developed a new aluminum–graphite DIB that was capable of combining the electrodes. It produced a new, cheap, highly efficient aluminum–graphite DIB system using aluminum foil, which is less expensive and eco-friendly, as not only the cathode active material but also the current collector and graphite as the anode material.

The anion and cathode are similar to the two lovers in a Chinese fairy tale, *Cowherd and the Weaver Girl*, who could meet only once in a year on a magpie bridge in the sky. The two lovers are parted by the vast Milky Way Galaxy (electrolytes); however, using magpie bridge (ion channel), they contact each other (discharge), and later go back to their original places (charge). This sequence goes on repeatedly.

The major differences between LIBs and DIBs are outlined as follows: When charging, intercalation of anions into cathodes occurs, leading to a different electrochemical energy storage mechanism and a high working voltage. The electrolytes are regarded as active materials in DIBs because the anions originate from the electrolytes. Hence, in the charge–discharge process, cations and anions are separated and brought together in the electrolyte.

The researchers have also extended the discovery of integrated design to the alkali-rich (alkaline earth) metal-ion battery system. The effective development of a cheap and eco-friendly sodium-based DIB—the potassium-ion-based DIB—and the high-working-voltage calcium-ion battery at ambient temperature by the researchers laid a firm groundwork for the industrial application of such integrated technology.

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