December 2022

Advanced Technology Institute Newsletter
Faculty of Engineering and Physical Sciences

News

THE ADVANCED TECHNOLOGY INSTITUTE (ATI) CELEBRATES 20 YEARS OF RESEARCH

The ATI, celebrating its 20th anniversary, has a proud history of exciting innovations over the last two decades that continues to contribute towards Advancements in Science and Technology for the betterment of humanity. By its 10th anniversary, the ATI had already made significant contributions in terms of inventing rapid thermal annealing, together with SIMOX wafers. These continue to drive forward the advancements CMOS integrated technologies.

We introduced the technique of low temperature growth of carbon nanotubes and low-k dielectrics, which will form the basis of future semiconductor technologies. In the last 10 years, we have further pushed these boundaries by developing rapid prototyping (direct writing) techniques and deterministic implantation of elements that will form the basis for next generation quantum technologies.

MESSAGE FROM OUR DIRECTOR, PROFESSOR RAVI SILVA

'Thank you all for your participation and contributions for the ATI 20th Anniversary Celebrations over the past week and over the 2 decades. This concluded a week of presentation of impactful research to society begun with RAISIN, the IBC Workshop and Steering Board, International Thin Film Conference (ITC2022) and the ATI Anniversary celebration. The day exemplified the quality and excellence in the research conducted by the whole team and impact it had on the wider world community. I am so proud to be associated with such quality output and look forward to the continued success of all colleagues and students in their research activities.

With over 250 participants in the activities, with many of our own graduants returning to support our celebration, it was an eventful evening, with celebrations going well past the 8pm closing hour. Let me end with a quote from one of the externals: "We have always seen the value of working closely with academia on cutting edge research. Programmes such as these have helped catalyse research programmes of national importance. We are only interested in working with the very best scientists around the world, tackling some of the most challenging issues in research and society today".'

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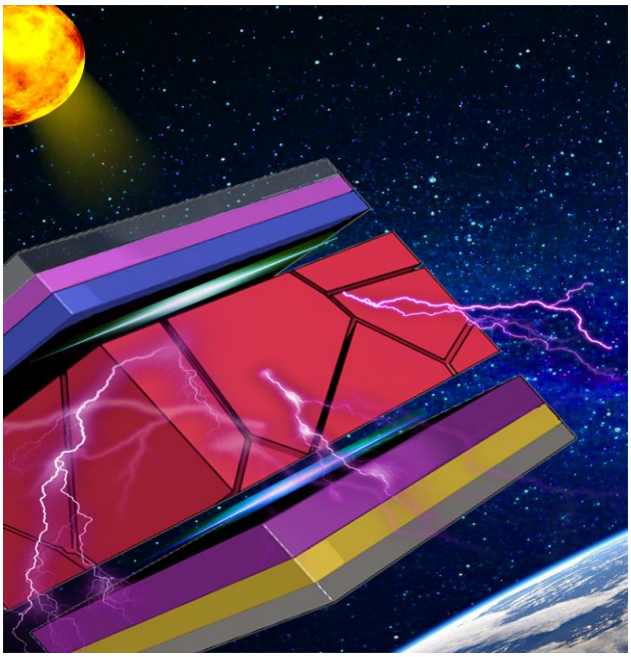
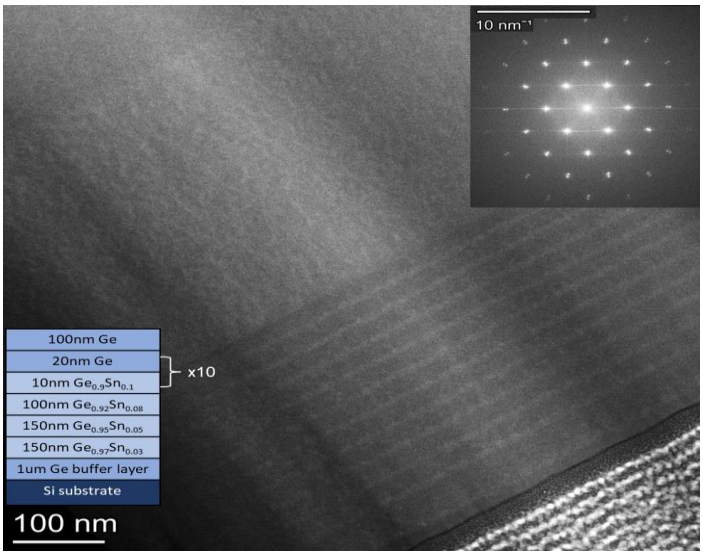
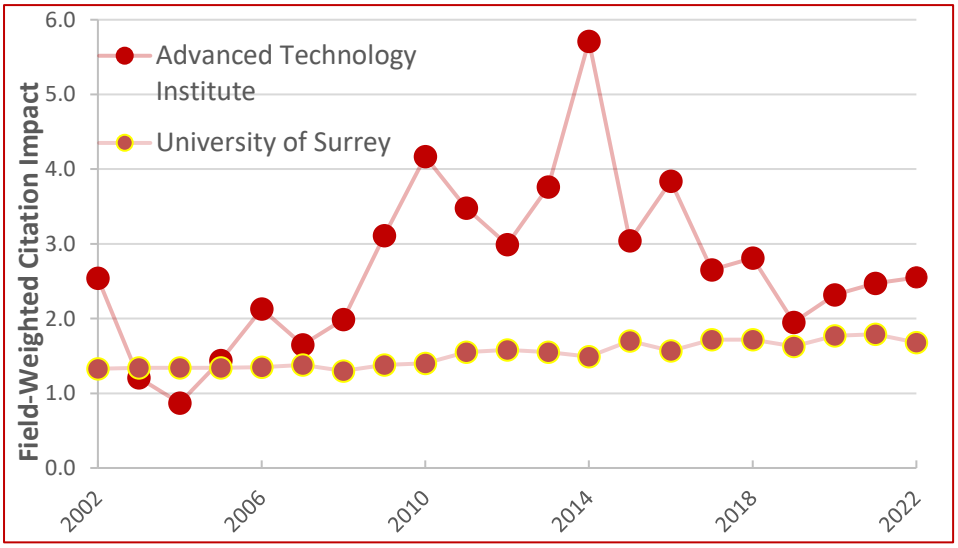
ATI 20TH CELEBRATION TALKS AND DISCUSSIONS



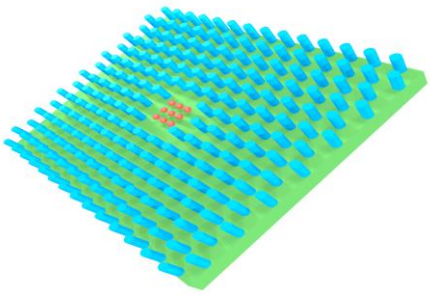
High-performance perovskite solar cells were achieved, yielding an open-circuit voltage of 1.2 V and power at the ATI conversion efficiency of 21.9% (stabilized 21.3%), alongside the enhanced operational and shelf-life stability for unencapsulated devices.
https://doi.org/10.1002/aenm.202202868



Transmission electron microscopy (TEM, Thermo Scientific Talos F200I) image of a multi-quantum-well (MQW) structure grown via molecular beam epitaxy (MBE). The fast-Fourier transform (FFT, in top-right corner) of the Ge buffer layer evidences the epitaxy growth. The lamella was prepared/polished from a wafer using a xenon plasma focused ion beam (Xe-PFIB, Tescan FERA3).
https://doi.org/10.1103/PhysRevMaterials.5.124603



High impact publications over the last two decades in comparison to the world (1.0) and Surrey academic



The quantum dynamics of atomic systems within dissipative environments plays a crucial role in processing information on shorter spatial and temporal scales.
https://doi.org/10.48550/arXiv.2211.08562

Special guest speakers

Prof Helen Treharne
Helen is Professor and Head of School of Computer Science and Electronic Engineering.
Prof Elefterios Lidorikis (University of Ionniana) - *"Optoelectronic modelling of carbon-based materials and devices"* Professor Department of Materials Science and Engineering University of Ioannina.
Prof Fernando Castro (NPL) - *"NPL collaborations with the ATI"*
Fernando Castro is a Principal Scientist and Head of Science for Materials Metrology at NPL.
Dr Taylor Stock (UCL) - *"Device fabrication at the atomic limit: scanning probe lithography for atomically-precise silicon doping"* Lecturer in Electronic Engineering, Dept of Electronic & Electrical Eng at University College London.

ITC 2022 - THE 17TH INTERNATIONAL THIN-FILM TRANSISTOR CONFERENCE

The 17th International Thin-Film Transistor conference was successfully organised and delivered at Surrey University.

The conference's hybrid format was attended by over 85 participants, hosting 66 oral presentations and 14 posters from 14 different countries, and was supported by 11 sponsors.

Highlights of the conference included plenaries by:

4 keynotes

- Dr Zhe Liu (Hangzhou LinkZill Technology)
- Dr Feras Alkhalil, (PragmatIC Semiconductor)
- Prof Shizuo Tokito (Yamagata University)
- Prof Yue Kuo (Texas A&M University)

2 tutorials

- Prof Arokia Nathan (Darwin College, Cambridge, UK)
- Prof Jin Jang (Kyung Hee University, South Korea)

Society for Information Display special session

Facilities tours of the EEE research labs

From the selected unsolicited feedback below, it is clear that visitors have felt taken care of, informed and entertained:
The only aspect of ITC2022 more rewarding than the conference content was the professional camaraderie all week.

I was fascinated by the tour of the Surrey University facilities, thank you!

Thanks to your efforts, I was able to fully enjoy the conference having enjoyable interactions with the great researchers

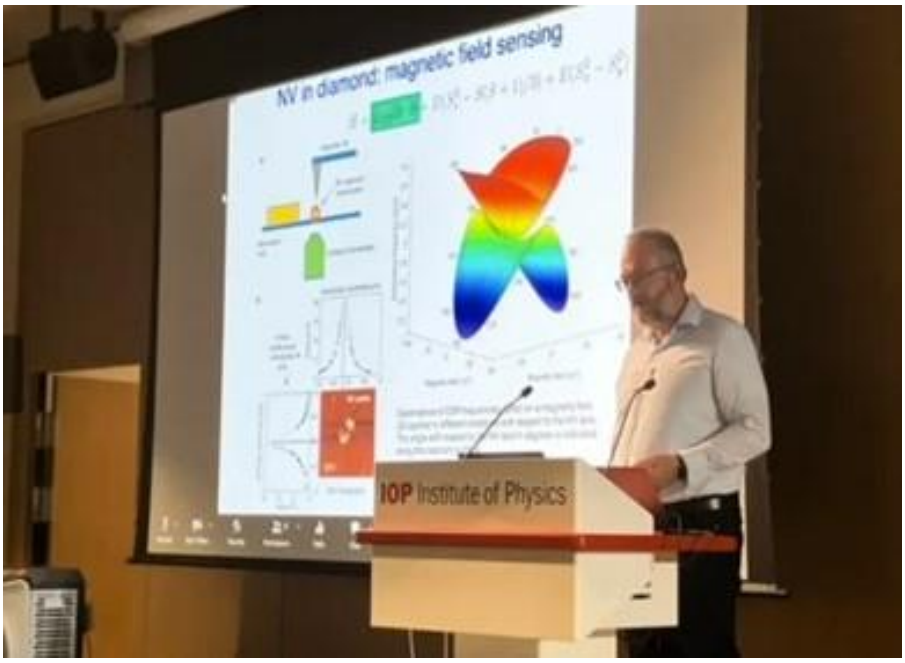
I was very happy to be able to attend this year ITC in person and could see its great success.

Very successful conference! You have done great job!

Four awards were made and supported by the UK & Ireland Chapter of the Society for Information Display. One undergraduate student from the EEE department registered and attended, confirming the commitment of our students and our tightly knit learning community.

The next ITC will take place in 2024 at KAIST in Daejeon, South Korea.

RAISIN WORKSHOP



The Photonics and Quantum Science group at the **ATI**, Surrey leading an EPSRC International Quantum Technologies network, RAISIN, for the development of a roadmap for applications of implanted single impurities to advance quantum technologies. The first major event organized by the network took place this September at the Institute of Physics headquarters in London, with the final day held at the University of Surrey.

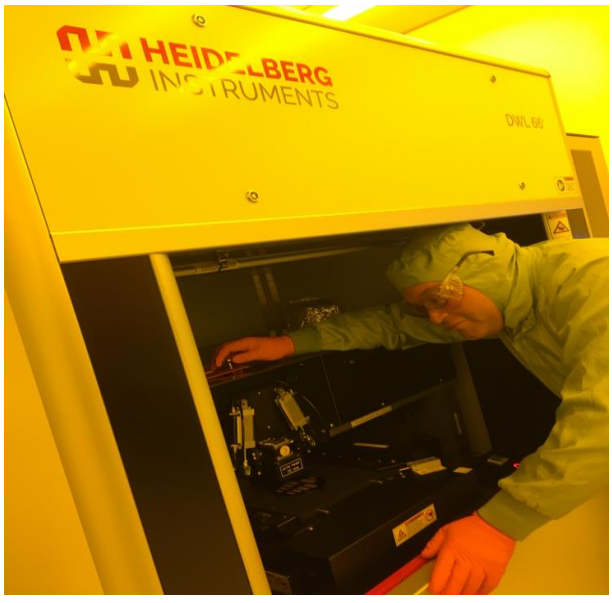
This international workshop brought together the leaders in the field of single ion implantation with the quantum technology applications community. In addition to the annual meeting, the network also runs a monthly international webinar series and provides funding opportunities for collaborative exchanges. More about RAISIN available at: https://raisin-qt.net/

NEW HORIZONS FUNDING SUCCESS

Our research to advance scalable manufacturing of quantum technologies and integrate it with established systems has received a boost from the EPSRC's highly competitive New Horizons initiative.

Steve Clowes, Roger Webb, David Cox, and Vlad Stolojan successfully secured funding for their work into single impurities in silicon, which have the potential to act as quantum bits (qubits) in future quantum computers. Their research makes the most of the state-of-the-art single ion implantation facilities in our Ion Beam Centre and electron microscopy capabilities in the Advanced Technology Institute.

NEW FABRICATION CAPABILITIES FOR THE ATI-CLEANROOM



New laser-writer photolithography (LWP) and atomic-layer-deposition (ALD) capabilities have been installed at the ATI-Cleanroom.

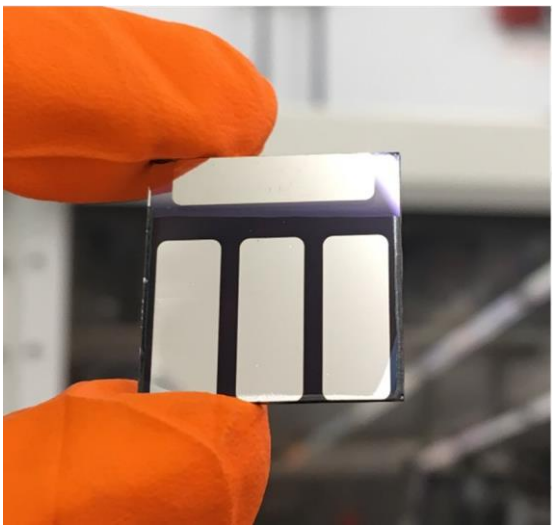
These systems open new capabilities for next-generation device and circuit fabrication at the cleanroom, including new semiconductor device architectures, bio-compatible medical devices, seamlessly integrated energy storage devices, novel designs for photovoltaic devices, ultrafast photonic devices, and novel quantum devices.

Fabrication projects include designs from our industrial partners as well as from NPL.

For further information please contact Dr Jose Anguita, the clean room manager: j.anguita@surrey.ac.uk

SIMPLE SEMICONDUCTOR SOLUTIONS COULD BOOST SOLAR ENERGY GENERATION AND ENABLE BETTER SPACE PROBES

A 'simple' tweak to perovskite solar cells during the fabrication stage could help to unlock the untold potential of the renewable energy source, claims research from the University of Surrey.



Surrey's **Advanced Technology Institute (ATI)** has demonstrated that by precisely controlling the fabrication process, it is possible to regulate and reduce unwanted energy loss in perovskite solar panels. **Dr Bowei Li**, a lead researcher of the programme at the Advanced Technology Institute, University of Surrey, said: "The future of perovskite solar panels is incredibly exciting, with the promise of not only improving the performance of solar farms and roof panels but many opportunities in powering spacecraft and interstellar probes. We hope the relatively straightforward approach demonstrated in our study, which tackles recombination losses, can improve the reproducibility, efficiency and stability of perovskite solar cells."

(https://doi.org/10.1002/aenm.202202868)

Perovskite solar cells are widely considered the natural successor to silicon-based solar devices because of their high energy conversion efficiency, low development cost, and lightweight nature. Named after a naturally occurring mineral with a structurally similar chemical formula, perovskites are synthetic composites with three-dimensional lattice crystal structures. The University of Surrey's Advanced Technology Institute is a global leader in research into perovskite solar cells and their contribution to boosting global clean energy generation.

The research has been published by Advanced Energy Materials. It is a collaboration between the University of Oxford, University of Cambridge, Swansea University, University of Sheffield, University of Toronto, Institute of Physics, Chinese Academy of Sciences, and University of Electronic Science and Technology of China.

SURREY'S PROTOTYPE BATTERY ONLY NEEDS SECONDS OF SUNLIGHT TO KEEP SMART WEARABLES CHARGED

Thirty seconds of sunlight could boost the battery life of future smartwatches and other wearables by tens of minutes, thanks to a renewable and rechargeable battery prototype developed by the University of Surrey. Surrey's **Advanced Technology Institute (ATI)** has demonstrated how its new photo-rechargeable system, which merges zinc-ion batteries with perovskite solar cells, could allow wearables to spring back to life without the need to plug in. (https://doi.org/10.1016/j.ensm.2022.06.043)

Jinxin Bi, a PhD candidate at ATI and the first author of the paper, said:
"This technology provides a promising strategy for efficient use of clean energy and enables wearable electronics to be operated continuously without plugin charging. Our prototype could represent a step forw ard to how we interact with wearables and other internet-of-things devices, such as remote real-time health monitors." Surrey's environmentally friendly, photo-rechargeable system is unique because of its elegant and well-matched structural design between the integrated battery and solar cell, allowing it to demonstrate high energy and volume density comparable to state-of-the-art micro-batteries and supercapacitors.

Dr Wei Zhang, project co-lead and expert in perovskite solar cells from the ATI, said: "This project is an example of how the University of Surrey is dedicated to producing research and innovation that equips humanity with the knowledge, tools and technologies to help us live better and more sustainable lives". The research was published in Energy Storage Materials.

ATI FACILITATED ACTIVITIES

Progress to net zero at the University of Surrey

The University was only 1 of 2 within the UK to pledge Net Zero by 2030 back in 2018. Funding via the Equal Opportunities Foundation provided the University with the stability it needed to pursue its sustainability plans. From our clean energy research to Net Zero Plan to CHeSS (Clean, Healthy and Sustainable Surrey) to Surrey Energy Partnerships.

We continue to reduce our emissions to meet our carbon budget in order to do our part in limiting warming to 1.5°C. We are working on include Energy Reduction, Solar, EV Charging, and Heat Decarbonisation: https://www.surrey.ac.uk/sites/default/files/2022-09/net-zero-carbon-plan-2022.pdf

"*Solar and wind are at present cheapest for large-scale energy generation. With current issues in energy security, should not the world and COP27 endorse them and speed up their deployment with a moon-shot challenge?*" - **Professor Ravi Silva**, COP27

SSE energy solutions

In February 2022, The University of Surrey formed a strategic partnership with energy company SSE Energy Solutions that will dramatically increase the amount of energy it generates and uses from renewable sources.

On-site renewable energy generation will increase from 0.1% to 20% of total annual demand. A leading landmark figure for a UK university.

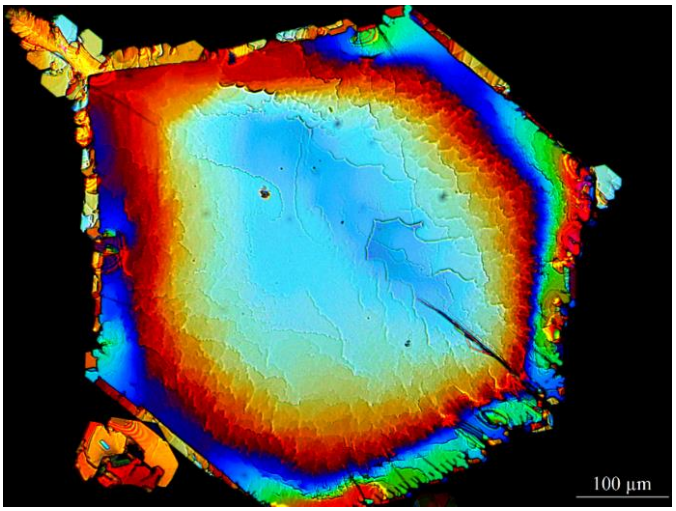
"This partnership is a landmark moment for the University of Surrey as it underpins our ambition to achieve our net zero carbon target by 2030 and affirms our commitment to being one of the most sustainable universities in the sector. This exciting partnership with SSE Energy Solutions, together with our other initiatives in sustainability, enables us to make ever greater contributions to our already strong performance against the UN's Sustainable Development Goals. - **Professor Max Lu**, President and Vice-Chancellor of the University of Surrey.

GRANT UPDATES

- The **Ion Beam Centre (IBC)** has been awarded its own Core Equipment Grant of £482,157 to directly support upgrades of the facilities housed at the Ion Beam Centre to enhance the facilities available to its users.

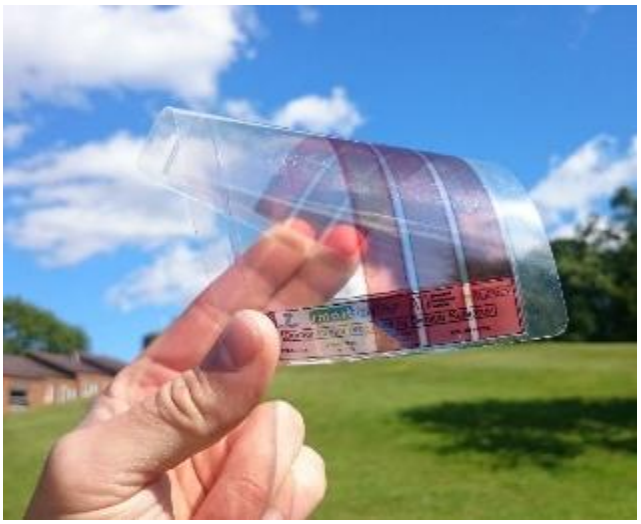
- **Dr Yunlong Zhao** and **Dr Kai Yang** awarded the Faraday Institute - 2022 Battery Study and Seed Research Project in June 2022, entitled "Rational design and manufacture of stacked Li–CO2 pouch cells". This work to improve batteries is part of Surrey's wider research to tackle the challenge of sustainable energy generation and move us ever closer to reaching net-zero emissions.

MSc NANOTECHNOLOGY AND RENEWABLE ENERGY



One Year Full time MSc and Two-Year full-time MSc Electronic Eng

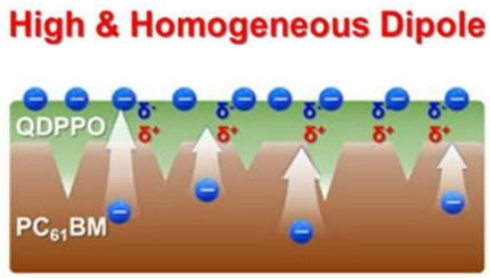
- Nanoscience and Nanotechnology
- Nanofabrication and Characterisation
- Renewable Energy Technologies
- Battery and Electrical Systems
- Nanoelectronics and Devices
- Semiconductor Devices and Optoelectronics
- Optional modules from a range of courses
- Advanced Research Project

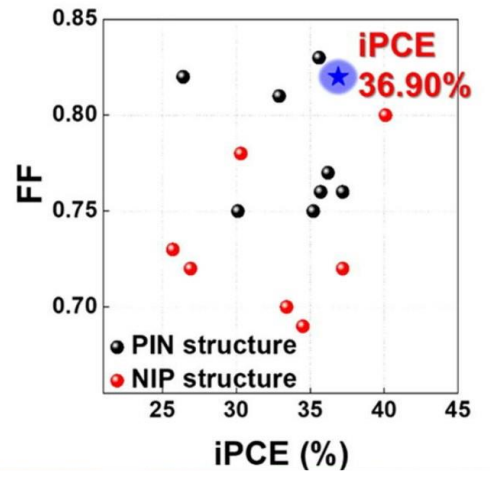


In addition to the 1 year MSc, we also offer a two-year full-time MSc Electronic Eng with a Professional Postgraduate Year, which as a two year programme enables students to undertake an extended project in the second year as well as develop professional skills while there is also an opportunity to undertake a 3-6 month placement within the programme.

For direct enquires please contact Programme Director, Dr Maxim Shkunov m.shkunov@surrey.ac.uk

INTERFACIAL DIPOLE CONTROL ENABLES 36.90% EFFICIENT INDOOR EFFICIENCY OF PEROVSKITE SOLAR CELLS





In the paper published in Chemical Engineering Journal, **Dr Jae Sung Yun**, a Lecturer of the **Advanced Technology Institute (ATI)** at the University of Surrey, investigated the effect of interfacial dipoles on the performance of perovskite solar cells in low-intensity indoor light environments.

(https://doi.org/10.1016/j.cej.2022.140284)

The work is performed with international collaboration with Professor Kim from Ajou University, Korea. Dr. Yun and Prof. Kim said “Interfacial dipoles were controlled by inserting different polar layers with different molecular dipole moments (BCP, QPPO and QDPPO) on top of electron transport layers (ETLs). Significantly improved uniformity of interfacial dipoles, in the QDPPO layer, effectively reduced charge recombination and enabled persistent fill factors (FF’s) under low-intensity light environments.”

These beneficial effects of QDPPO enabled high iPCE (indoor power conversion efficiency) of perovskite solar cells of up to 27.49 % under 800 lux LED light condition, which was further enhanced to 36.90 %, while maintaining high FF of 0.82 by additional insertion of PEAI passivation layer under 800 lux LED, which is among the highest levels reported for indoor perovskite solar cells. The work can be found here.

ATI CELEBRATION FINAL THOUGHTS

Professor Alf Adams

"It was very satisfying to witness the successes of research in the ATI. The concept arose through discussions I had with Prof Mike Kelly, who was the head of the Electrical Engineering Department, about how the research on semiconductors in the Physics could be combined with that in Electronic Engineering. I think that the ATI is an outstanding example of the benefits of interdepartmental collaboration"

Professor Elefterios Lidorikis (University of Ionniana)

"It was a great pleasure and honor for me to be part of the celebrations for such an important milestone, the 20th anniversary of ATI! An inspiration to hear about the history of ATI, listen to the achievements of its former students/researchers now exceling in academia and industry, and see the ground-breaking research activities of its current members. In this stimulating environment, it was quite an honour for me to talk about the novel work being done in collaboration with ATI over the course of several European projects.