9th MRS-S Conference on Advanced Materials

25–27 November 2020

Virtual Conference

Programme and Abstracts

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WELCOME MESSAGE

On behalf of the Materials Research Society of Singapore, we extend a warm welcome to all the participants of the "9th MRS-S Conference on Advanced Materials (MRS-S AMC-9)". This conference is organised biennially by the Materials Research Society of Singapore (MRS-S), ever since the inaugural event in 2004.

These conferences have been providing a platform for scientists working on cutting edge materials research in Singapore to come together to interact, foster research collaboration and inspire the next generation of young talent for 16 years. This year, a total of 22 invited talks and about 100 poster presentations will be made at the conference. To acknowledge and motivate the authors for their hard work, "Best Poster Awards" are awarded to the most outstanding posters.

MRS-S is very grateful to the entire organising committee: in particular Dr Yang Le (Chair) and Assoc. Prof Lydia Helena Wong (Co-Chair) for all their efforts in developing an excellent scientific program. We are also thankful to NTU, NUS, A*STAR and all other premier organisations in Singapore for encouraging their researchers to present their research work at this conference.

We extend our thanks to all invited speakers and poster presenters for their interest and continued participation in all MRS-S activities. We greatly appreciate the poster award judging team for their time and effort in selecting posters for the "Best Poster Award". The support of the entire conference committee including the Executive Committee of MRS-S and administrative staff in looking after all organizational aspects of the conference are greatly appreciated. Most importantly, we are grateful to all participants for their contribution to the conference. Our deep appreciation goes to Ms Lisa Luo for taking care of publicity matters, including website development and minute logistic details.

Please enjoy the conference programme MRS-S has put together and have a good time in our first virtual conference!

Tim White
President, Materials Research Society of Singapore

B.V.R Chowdari
Senior Executive Director & President Emeritus, Materials Research Society of Singapore

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Wednesday, 25 Nov 2020

13:00 - 13:30			Conference Registration
13:30 - 13:50	Opening	Chairs: Yang Le & Chen Jingsheng	Welcome Speech: Prof. Tim White, NTU, MRS-S President Guest-of-Honour: Prof. Subra Suresh, NTU, President
13:50 - 14:35	Session 1	Chairs: Yang Le & Chen Jingsheng	Keynote 1 (Prof. Andrey Rogach, City University of Hong Kong, Hong Kong)
14:35 - 15:00	Session 1		Soft and Biomaterials 1 (Tan Yen Nee, SIT-New Castle)
15:00 - 15:25	Session 1		Energy 1 (Tan Swee Ching, NUS)
15:25 - 15:40			Break (15mins)
15:40 - 16:05	Session 2	Chairs: Dalton Tay & Lydia Wong	Char/Modeling/Theory 1 (Martial Duchamp, NTU)
16:05 - 16:30	Session 2		Electronics & Photonics 1 (Arseniy Kuznetsov, A*STAR IMRE)
16:30 - 16:55	Session 2		New Frontiers 1 (Chen Jingsheng, NUS)
16:55 - 17:20	Session 2		Soft and Biomaterials 2 (Ali Miserez, NTU)

Thursday, 26 Nov 2020

9:30 - 11:00	Poster	Chairs: Zhao Dan & Ho Pin	Flash Oral (Poster Judging)
11:00 - 12:00	Poster		Zoom Session 1 for Odd-numbered Posters (Poster Judging)
12:00 - 13:00	Poster		Zoom Session 2 for Even-numbered Posters (Poster Judging)
13:00 - 13:30			Conference Registration
13:30 - 13:55	Session 3	Chairs: Zhao Dan & Liu Yuxin	Energy 2 (Lum Yan Wei, A*STAR IMRE)
13:55 - 14:20	Session 3		Char/Modeling/Theory 2 (Pieremanuele Canepa, NUS)
14:20 - 14:45	Session 3		Electronics & Photonics 2 (Yang Hui Ying, SUTD)
14:45 - 15:10	Session 3		New Frontiers 2 (Loh Huanqian, NUS)
15:10 - 15:25			Break (15mins)
15:25 - 16:10	Session 4	Chairs: Lum Yanwei & Wan Ru Leow	Keynote 2 (Prof. Albert Polman, AMOLF, Netherlands)
16:10 - 16:35	Session 4		Soft and Biomaterials 3 (Liu Yuxin, A*STAR IMRE)
16:35 - 17:00	Session 4		Energy 3 (Nripan Mathews, NTU)
17:00 - 17:25	Session 4		Char/Modeling/Theory 3 (Wang Xiaonan, NUS)

Friday, 27 Nov 2020

8.30-9.00			Conference Registration
9:00 - 9:45	Session 5	Chairs: Ho Pin & Tan Kwan Wee	Keynote 3 (Prof. Caroline Ross, MIT, US)
9:45 - 10:10	Session 5		Electronics & Photonics 3 (Ranjan Singh, NTU)
10:10 - 10:35	Session 5		New Frontiers 3 (Anjan Soumyanarayanan, A*STAR IMRE)
10:35 - 11:00	Session 5		Soft and Biomaterials 4 (Benjamin Tee, NUS)
11:00 - 11:15			Break (15mins)
11:15 - 11:40	Session 6	Chair: Lydia Wong	Char/Modeling/Theory 4 (Amy Khoo, A*STAR IHPC)
11:40 - 12:05	Session 6		Electronics & Photonics 4 (Tan Zhi Kuang, NUS)
12:05 - 12:30	Session 6		New Frontiers 4 (Lam Yeng Ming, NTU)
12:30 - 13:00	Closing	Chair: Yang Le	Closing Remarks: Prof. Yuanping Feng, NUS, MRS-S Vice President & Poster Awards Presentation

ABSTRACTS:
INVITED PRESENTATIONS

Perovskite Nanocrystals for Light-Emitting Devices and Beyond

Andrey Rogach[1]*
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High emission quantum yield, easily tuned emission colors, and high color purity of chemically synthesized lead halide perovskite nanocrystals make this class of materials particular attractive for applications in light-emitting devices (LEDs) [1]. I will discuss opportunities and challenges of employment of perovskite nanocrystals in LEDs and displays [2]. Shape control of the perovskite nanocrystals is currently getting momentum, offering perovskite nanorods with a polarized emission [3].
I will also provide recent examples of use of the water-resistant composites of perovskite nanocrystals for the temperature imaging in microfluidics [4] and lasing [5].

[1] Y. Li, X. Zhang, et al., Mater. Today 2020, 32, 204-221.
[2] M. Lu, Y. Zhang, et al., Adv. Funct. Mater. 2019, 1902008.
[3] Y. Li, H. Huang, et al., ACS Nano 2019, 13, 8237-8245.
[4] Z. Lu, Y. Li, et al., ACS Appl. Mater. Interfaces 2020, 12, 19805-19812.
[5] S. Li, D. Lei, et al., Nature Comm. 2020, 11, 1192.

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Biography of Keynote Speaker

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Andrey Rogach is a Chair Professor of Photonics Materials at the Department of Materials Science and Engineering, and the Founding Director of the Centre for Functional Photonics at City University of Hong Kong. He received his Ph.D. in chemistry (1995) from the Belarusian State University in Minsk (Belarus), and worked as a staff scientist at the University of Hamburg (Germany) from 1995 to 2002. From 2002–2009 he was a lead staff scientist at the University of Munich (Germany), where he completed his habilitation in experimental physics. His research focuses on synthesis, assembly and optical spectroscopy of colloidal semiconductor and metal nanocrystals and their hybrid structures, and their use for energy-related applications. He authored over 450 scientific publications (Google Scholar h-index: 115) in these fields that have been extensively (over 47,000) cited, which ranked him 51st worldwide among "100 TOP MATERIALS SCIENTISTS OF THE PAST DECADE" by *Thomson Reuters (2011)*, and as Highly Cited Researcher by *Clarivate Analytics (2018 & 2019)*. He holds honourable appointments as an Adjunct Professor at Trinity College Dublin (Ireland) and University of Electronic Science and Technology of China, and as a Honorary Professor at Xi'An Jiaotong University, Jilin University, and Peking University Shenzhen (China). Andrey Rogach is a Fellow of the Electromagnetic Academy (USA) and serves as an Associate Editor of ACS Nano.

Holography, quantum correlations and extreme near fields in optical metasurfaces

Albert Polman[1]*
[1] Center for Nanophotonics, AMOLF, Amsterdam, The Netherlands

We use cathodoluminescence imaging spectroscopy (CL) as a powerful tool to characterize optical metasurfaces at deep-subwavelength spatial resolution.[1] In CL, a 5-30 keV electron beam is raster-scanned over the surface while the emitted radiation in the optical and near-infrared spectral range is detected. In the coherent excitation mode the electron beam passing through the metasurface creates a femtosecond electric field oscillation that couples strongly to polarizable electrons in the material, providing a spectrally broadband nanoscale probe of the local optical density of states.
We use CL to image localized modes of resonant plasmonic and dielectric nanostructures and reconstruct their scattering wavefronts using CL holography. We determine the phase and amplitude of wavefronts scattered by single-crystalline Au nanocubes and nanoholes, and derive from that the dominant scattering dipoles.[2] We discuss how the electron wavepacket may collapse as it generates a coherent superposition of surface plasmon polaritons and plasmonic transition dipole radiation that interfere in the far field.
We correlate CL data with photon-induced near-field electron microscopy (PINEM) of plasmonic nanotips in Au nanostars. As shown before,[3] strong plasmonic near fields can dress the high-energy electron energy spectrum into a ladder of coherent harmonics, shaping the electron quantum wavepacket. We will show that this enables probing of the plasmon charge distribution and the corresponding near-field intensity of plasmonic nanotips at the true nanoscale. We introduce how specially tailored optical metasurfaces enable entirely new ways to shape electron wavepackets in space and time.

[1] Polman, A., Kociak, M. & García de Abajo, F.J. Electron-beam spectroscopy for nanophotonics, Nature Mater. 18, 1158 (2019)
[2] Schilder, N., Agrawal, H., Garnett, E.C. & Polman, A. Phase-resolved surface plasmon scattering probed by cathodoluminescence holography, ACS Photon. 7, 1476 (2020)
[3] Feist, A., Echternkamp, K.E., Schauss, J., Yalunin, S.V., Schäfer, S. & Ropers, C. Quantum coherent optical phase modulation in an ultrafast transmission electron microscope, Nature 521, 200 (2015).

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Biography of Keynote Speaker

Name: Albert Polman
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Albert Polman is program leader at the Center for Nanophotonics in the NWO Institute AMOLF in Amsterdam, the Netherlands, and Professor of Photonic Materials for Photovoltaics at the University of Amsterdam. Polman's research group focuses on nanophotovoltaics, the study of light management at the nanoscale to realize solar cells with ultra-high efficiency that can be made at low costs, designs optical metasurfaces for analog optical computing, and develops cathodoluminescence spectroscopy as a super-resolution imaging technique for nanophotonics. Polman has published over 300 papers, has won several awards for his work and is member of the Royal Netherlands Academy of Sciences. He is co-founder of Delmic BV that brings an instrument for cathodoluminescence spectroscopy on the market that was developed in his group.

Iron Garnets: Enabling Materials For Magnonics, Photonics And Spintronics

Caroline A Ross[1]*
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Ferromagnetic insulator thin films have emerged as an important component of magnonic, spintronic and magnetooptical devices. Yttrium iron garnet in particular is an excellent insulator with low magnetic damping, and has been incorporated into heterostructures that exhibit a plethora of spintronic and magnonic phenomena including spin pumping, spin orbit torque, spin Seebeck, proximity effects and spin wave propagation. Rare earth iron garnet films can additionally show a compensation temperature and a magnetoelastic response tunable via the composition. We use pulsed laser deposition to produce single crystal films of rare earth garnets down to a thickness of 2.5 nm, about 2 unit cells. Spin hall magnetoresistance of a Pt overlayer can be used to detect the magnetic state, and spin orbit torque can drive domain wall motion at room temperature at velocities exceeding 4 km/s, switching the magnetic state and providing opportunities for spintronic devices. Iron garnets also exhibit magnetooptical activity and high transparency in the infrared, and we show how garnets grown on silicon can be used in integrated magnetooptical isolators to control the flow of light in photonic circuits.

[1] Nature Commun. 11 1090 (2020).
[2] Nature Nanotech. 14 561 (2019).
[3] Optica 6 473 (2019).
[4] ACS Photonics 5, 5010 (2018).
[5] Phys. Rev. Mater. 2, 094405 (2018).
[6] Nature Materials 16, 309–314 (2017).
[7] Adv. Electron. Mater. 3 1600376 (2017).

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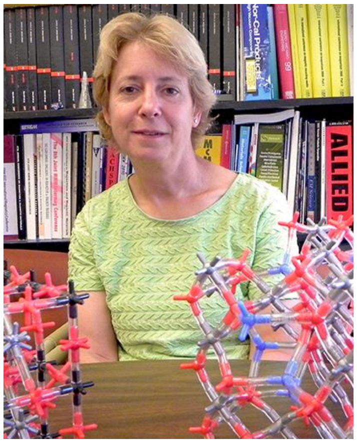

Prof. Caroline Ross has been a professor at the Massachusetts Institute of Technology since 1997, and is the Associate Head of the Department of Materials Science and Engineering. Before joining MIT she spent six years working at Komag, Inc. in San Jose, CA on data storage, and two years as a Postdoctoral Fellow at Harvard University. She has a Ph.D. from Cambridge University, UK and is a Fellow of the APS, the MRS, the UK Institute of Physics and the IEEE. Her interests include thin film magnetic and multiferroic oxides and the self-assembly of block copolymers.

Bioinspired Hybrid Nanomaterials: Biotemplating, Synthesis and Applications for Sensing, Imaging, Delivery and Therapy

Yen Nee Tan[1,2]*
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[2] Newcastle Research & Innovation Institute, 80 Jurong East Street 21, #05-04 Devan Nair Institute for Employment & Employability, Singapore 609607

Inspired by Natural biomineralization processes, our research focuses on the rational design of peptide- and nucleic acid-based biomolecular templates for the synthesis of multifunctional metallic and carbon-based nanomaterials with tunable optical properties and biofunctionalities for sensing, imaging, delivery and therapy. Such bio-hybrid nanomaterials exhibit synergistic combination of biological functions and chemical properties resulting from the nanocore and soft biomolecular shell. For example, we have developed a series of metallic nanobiosensors with target specific bio-shell to detect wide range of analytes in solution from small molecule drugs, protein biomarkers to cancer and bacteria cells [1-3]. Recently, we have exploited the use of designer DNA and peptide templates to synthesize a palette of photoluminescent metal nanoclusters (NCs < 2nm in core size) which could be used as multicolour probes for bioimaging, image-guided photodynamic therapy and multiplexed sensing [4-6]. We also take this biomimetic approach to 'turn' the native protein into bioactive fluorescent nanosensor for rapid drug screening without tedious genetic engineering. To enable greener synthesis with good biocompatibility and sustainability, pure organic resources and biomass wastes were ultilized to synthesize fluorescent carbon dots from biomolecules (biodots) with tailored functionalities for a range of biomedical applications [7-10]. For instance, bioinspired antimicrobial biodots has been successfully developed for ultrasensitive pathogen detection (1 cfu/ml in < 0.5 hour) and combating broad spectrum multi-drug resistant bacteria [10]. With further understanding in biotemplates design, we expect a far more extensive applications of bioinspired hybrid nanomaterials for the advanced biomedical diagnostic and treatment towards personalized nanomedicine in future.

[1] X.T. Zheng, W.L. Goh, P. Yeow, D.P. Lane, F.J. Ghadessy & Y.N. Tan*, *Sensors and Actuators B: Chemical* 279, 79-86 (2019)
[2] M.T. Yaraki & Y.N. Tan*, *Chemistry: An Asian Journal,* DOI:10.1002/asia.202000847 (2020)
[3] X. Zheng & Y.N. Tan*, *Sensors International*, 1,100034 (2020)
[4] Y. Yu, B.Y.L Mok, X.J. Loh & Y.N. Tan*, *Advanced Healthcare Materials* 5 (15), 1844-1859 (2016)
[5] J.Y.C. Lim, Y. Yu, G. Jin, K. Li, Y. Lu, J. Xie & Y.N. Tan*, *Nanoscale Advances*, 3921-3932 (2020)
[6] Y. Yu, W.D. Lee & Y.N. Tan*, *Materials Science and Engineering: C* 109, 110525 (2020)
[7] Y. Choi, X. Zheng & Y.N. Tan*, *Molecular Systems Design & Engineering* 5 (1), 67-90 (2020)
[8] H.V. Xu, X.T. Zheng, Y. Zhao & Y.N. Tan*, *ACS Appl. Mater. Interfaces,* 10, 19881-19888 (2018)
[9] X. Zheng & Y.N. Tan*, *Small*, 16 (12), 1903328 (2020)
[10] H.V. Xu, X.T. Zheng, C. Wang, Y. Zhao & Y.N. Tan*, *ACS Appl. Nano Mater*. 1, 2062-2068 (2018)

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Biography of Invited Speaker

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Yen Nee Tan is an Associate Professor of Chemical Engineering at the Newcastle University. She is also the Principal Investigator of Biosensors and Nanomaterials at the Newcastle Research & Innovation Institute (NewRIIS). She obtained her PhD from the Massachusetts Institute of Technology (MIT) and National University of Singapore (NUS) under the Singapore-MIT Alliance Scholarship. Her current research focuses on the development of multifunctional nanomaterials inspired by Nature for the innovations in chemical/biological analysis and nanomedicine. She holds 18 patents on nanobiosensor technologies for medical diagnostic, drug discovery, food safety and environmental applications. She is the recipient of more than 15 international scientific awards, such as Molecular Systems Design and Engineering (MDSE) Emerging Investigator 2020, Nano-Micro Science Innovation Award (Korea, 2018), Young Giants of NanoScience (Hong Kong, 2016), ACCS Chemical Sensors Award (Malaysia, 2015), AsiaNANO Young Researcher Award (Japan, 2010), etc.

MRS-Singapore AMC-9
Invited speaker

Energy Harvesting from Shadows

Swee Ching Tan[1]*
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7 Engineering Drive 1, Singapore 117574

Shadows are ubiquitous and are often considered undesirable in photovoltaic and optoelectronic applications. Not much engineering use has been derived from them. Contrary to this, we have developed a novel method to harness useful energy from this redundant phenomenon. Our device, the shadow-effect energy generator, works on the principle of optical manipulation of the work function in metal thin film-semiconductor structures. Work function contrasts are introduced onto a metal thin film-semiconductor structure by partially blocking the light falling on the device thereby casting a shadow. Exposing the device completely to light does not result in power generation, thereby making this work unprecedented. With a primary focus on harnessing the illumination contrast that arises due to shadows, the developed device has a high resolution for capturing illumination contrasts, even under weak ambient light. This method brings a new perspective to sustainable energy generation and could potentially pave the way for the development of self-powered sensors for common and niche applications.

[1] Zhang Q, Liang Q, Nandakumar DK, Ravi SK, Qu H, Suresh L, Zhang X, Zhang Y, Yang L, Wee ATS, Tan SC. Energy harvesting from shadow-effect. Energy & Environmental Science 2020
[2] Ravi SK, Sun W, Nandakumar DK, Zhang Y, Tan SC. Optical manipulation of work function contrasts on metal thin films. Science Advances 2018, 4(3): eaao6050

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Biography of Invited Speaker

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Dr. Swee Ching Tan received his bachelor's in physics from the National University of Singapore. He gained PhD admission to University of Cambridge, Electrical Engineering Department with Scholarships from Cambridge Commonwealth Trust and Wingate Foundations. His PhD work was to use photosynthetic proteins as light absorbing materials for solar cells under the supervision of Professor Sir Mark Welland. After his PhD, Dr Tan then moved to the Department of Materials Science and Engineering at MIT to become a postdoctoral associate working on high electron mobility devices under Prof Carl V. Thompson and Professor Tomas Palacios. He is currently an Assistant Professor at the Department of Materials Science and Engineering at National University of Singapore. He is also the founder of Ultra Dry Pte. Ltd. a spin-off company from NUS based on the invention of a superhygroscopic material. His research group works on developing novel materials for energy and environmental applications.

MRS-Singapore AMC-9
Invited speaker

In situ TEM studies of the real atomic structure of energy-related materials

Martial Duchamp[1]*, Elizaveta Tyukalova[1], Aaron David Mueller[1]
[1] School of Materials Science and Engineering (MSE), Nanyang Technological University (NTU), 50 Nanyang Avenue, 639798, Singapore.

This presentation will tackle a few scientific questions from material science field addressed by transmission electron microscopy (TEM) techniques, including *in situ* TEM studies under a gaz environment and under a variable temperature range (140˚K to 800˚C) while keeping the atomic resolution.
Copper-zinc-tin-sulphide (CZTSSe)-based solar cells are promising for the production of green electricity. CZTS nanocrystals were annealed in a Se-rich atmosphere in a gas cell inside a TEM. During the heating phase, a complete S−Se exchange reaction occurs while the cation sublattice and morphology of the nanocrystals are preserved. This yields an annealing protocol which is transferred to an industrially similar solar cell fabrication process resulting in a 33% increase in the device open circuit voltage [1].
Transition metal dichalcogenides based nanopores in atomically thin layers have a variety of demonstrated applications including sensing, filtration, energy, and catalysis. The functionality of these devices is governed by the chemistry and geometry of the nanopore edge, but their simultaneous control remains elusive. We demonstrate a method of controlled production of nanopores with desired chemistries and geometries by rapid vacuum annealing. *In situ* annealing studies within high-resolution (HR) scanning (S-)TEM were used to investigate the relationship between annealing temperature, nanopore growth rate, and nanopore edge reconstruction [2].
We address the problem of electron-beam induced damage on materials relevant for energy storage applications, namely $LiNi_{0.5}Mn_{1.5}O_4$ used as a cathode in Li-ion batteries and $ZnCo_{1.8}Ni_{0.2}O_4$ used as catalyst for oxygen evolution reaction application. Both materials were found to transform from the spinel into the rocksalt phase while being imaged by HR-STEM at room temperature. We found HR-STEM characterization at cryogenic temperature delays the critical electron dose for structural modification. From a careful analysis of the experimental data and a detailed understanding of the different degradation processes we reveal the true structure of $LiNi_{0.5}Mn_{1.5}O_4$ and $ZnCo_{1.8}Ni_{0.2}O_4$ materials [3].

[1] Y. Qu, S.W. Chee, M. Duchamp, S. Campbell, G. Zoppi, V. Barrioz, Y. Giret, T.J. Penfold, A. Chaturvedi, U. Mirsaidov, N.S. Beattie, Real-Time Electron Nanoscopy of Photovoltaic Absorber Formation from Kesterite Nanoparticles, ***ACS Applied Energy Materials*** 3 (2020) 122 doi: 10.1021/acsaem.9b01732
[2] K. Bogaert, T. Liu, M. Spina, C.B. Boothroyd, M. Duchamp, S. Gradecak, S. Garaj, Nanopores in Transition Metal Dichalcogenides with Controlled Size and Edge Properties, *under review*
[3] E. Tyukalova & M. Duchamp, Atomic resolution enabled STEM imaging of nanocrystals at cryogenic temperature, ***Journal of Physics: Materials*** *in press* (2020) doi: 10.1088/2515-7639/ab8a95

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Biography of Invited Speaker

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Assistant Professor Martial Duchamp obtained his Phd from EPFL in Switzerland on the study of mechanical and electrical properties 1D materials such as ZnO nanowires and CNTs. He then pursued a post-doctoral fellowship at DTU, Copenhagen in the center of electron nanoscopy. During his first post-doctoral contract, he developed innovative approaches to measure low concentration of dopant in the context of thin-film solar cells using TEM techniques. He then moved to the Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons (ER-C), Jülich, Germany where he pursued his research using unique aberration corrected TEMs (Cs and Cc corrected). As shown by his list of publication, he worked on a broad range of subject, either material science or instrumentation development related topics. He joined MSE as Assistant Professor in 2016.

MRS-Singapore AMC-9
Invited speaker

Active and Tunable Dielectric Nanoantennas and Metasurfaces

Arseniy Kuznetsov[1]*
[1] Institute of Materials Research and Engineering, A*STAR (Agency for Science, Technology and Research), 2 Fusionopolis Way, #08-03 Innovis, 138634, Singapore.

Dielectric nanoantennas represent a new trend in the nanophotonics research [1]. Due to their low losses and strong electric and magnetic resonant behavior at optical frequencies, they can substitute plasmonic nanoparticles for multiple applications providing highly efficient nanophotonic solutions. In addition, the vast choice of industry-friendly materials used for the dielectric nanoantennas fabrication, makes them particularly appealing for industrial use with a short expected development time to reach the market. So far, majority of the developments in this field were related to passive nanoantenna functionalities where they were used to control the external light emission in a fix, non-switchable fashion. In this presentation, I will focus on the new and rapidly developing directions of dielectric nanoantenna research related to their active and tunable functionalities. In particular, I will discuss fluorescence enhancement and lasing in single semiconductor nanoantennas and nanoantenna arrays [2-4]. I will show how the emission directivity and quality factors can be engineered with a proper nanoantenna design. I will also discuss active tunability of the nanoantenna functions by using liquid crystals. In particular, I will demonstrate a tunable dielectric metasurface with individually controlled nanoantenna pixels forming an efficient (>35% efficiency) spatial light modulator with ~1 micron pixel size and >22 degrees projection angle [5].

[1] A. I. Kuznetsov et al., *Science* 354, aag2472 (2016).
[2] S. T. Ha et al., *Nature Nanotech.* 13, 1042 (2018).
[3] V. Mylnikov et al., *ACS Nano* 14, 7338–7346 (2020).
[4] M. Wu et al., *Nano Letters* 20, 6005–6011 (2020).
[5] S.-Q. Li et al., *Science* 364, 1087 (2019).

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Biography of Invited Speaker

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Arseniy Kuznetsov received his double PhD degree from University Paris 13 (France) in 2005 and from Institute of Applied Physics RAS (Russia) in 2006. Since 2007 till 2011 he worked at the Laser Zentrum Hannover (Germany) as Humboldt Research Fellow. Since October 2011 till now he has been working in A*STAR, Singapore. He is currently appointed as a Principle Scientist I and the Head of Advanced Optical Technologies Department. Current activities of his group are devoted to development of novel nanodevices based on dielectric nanoantennas and metasurfaces. He is an author of over 70 journal papers and a co-inventor of 13 filed patent applications. For his pioneering research on dielectric nanoantennas he was awarded 2016 IET A F Harvey Engineering Research Prize (UK) and 2020 IPS World Scientific Physics Research Medal and Prize (Singapore). In 2020, he was also elected as a Fellow of the Optical Society of America (OSA).

Novel materials for spintronics application

Jingsheng Chen[1]*, Jing Zhou, Liang Liu, Qidong Xie
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Electrical manipulation of magnetization is essential for the integration of magnetic functionalities such as magnetic memories and magnetic logic devices into electronic circuits. The current induced spin-orbit torque (SOT) provides an efficient way to switch the magnetization direction, which is considered to have faster switching speed and better endurance comparing to spin transfer torque magnetic random access memory (STT-MRAM). However, there are still some obstacles for its practical application such as field free switching, large charge to spin conversion efficiency for low power consumption. In the present presentation, I will introduce the novel materials/structure that our group developed recently for solving above problems. 1) we found that SOT efficiencies of $L1_0$-IrMn, $L1_2$-$IrMn_3$ and γ-$IrMn_3$ are 0.61, 1.01 and 0.80, respectively, which are substantially larger than that of the polycrystalline IrMn (0.083). Furthermore, we observed a 4-fold rotation symmetry in both the SOT efficiency and the in-plane magnetic anisotropy and an anomalous out-of-plane damping-like torque in both $L1_0$-IrMn and $L1_2$-$IrMn_3$, which are attributed to the effect of surface magnetic asymmetry.[1,2]; 2) we demonstrate the electrical switching of a perpendicular magnetized single ferromagnetic layer, $L1_0$-ordered FePt whose SOT is attributed to the composition gradient in the atomically layered structure along the film normal direction which causes a new type of bulk-like inversion symmetry breaking.[3] We demonstrated current-induced pure current induced magnetization switching in $SrIrO_3$/$SrRuO_3$ bilayer structures [4].3) we demonstrate that PMA and SOT in a heavy metal/transition metal ferromagnet structure-Pt/[Co/Ni]$_2$ can be greatly enhanced by introducing molybdenum disulfide MoS_2 underlayer. [5]

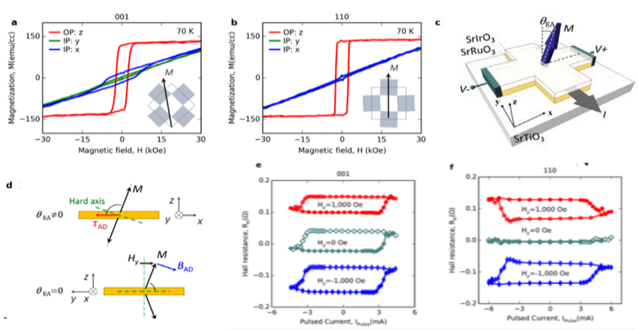

Fig. 1. **a, b,** Out-of-plane (OP) and in-plane (IP) magnetic hysteresis loops of the bilayers on STO (001) and STO (110) substrates, respectively. **c**. Schematic of the set-up for SOT switching of the magnetization (*M*) in the $SrIrO_3$/$SrRuO_3$ bilayer. **d,** Schematic illustrations of two types of SOT switching behaviors. **e, f,** Current-induced magnetization switching in $SrIrO_3$/$SrRuO_3$ bilayers grown on STO (001) and STO (110) substrates, respectively.

[1] J. Zhou et al, Sci. Adv. 5, eaau6696 (2019).
[2] J. Zhou et al, Phys. Rev. B 101, 184403 (2020).
[3] L. Liu et al, Phys. Rev. B 101, 220402 (2020).
[4] L, Liu et al, Nat.Nanotech., 14 (10), 939 (2019).
[5] Q.D. Xie, Adv. Mater., 31, 1900776 (2019).

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Dr Jingsheng Chen is an Associate Professor in Department of Materials Science and Engineering. He obtained his Ph.D degree in 1999 in Lanzhou University, China and joined NUS in December 2007. During 2001-2007 he worked at the Data Storage Institute as a research scientist. He has authored/co-authored more than 260 refereed journal papers including Nature Nanotechnology Nature Communication, Science Advance, Advanced Materials, Advanced Functional Materials, Nano Letters, Physical Review X, Physical Review Letter, NPG Asia Materials, Physical Review B and Applied Physics Letter, etc., 3 book chapters, holds over ten patents and has made more than 50 invited presentation in the international conferences. His research work has obtained more than 6900 citations with H index of 42. His research interest includes magnetic and oxide based non-volatile memories, spintronics, ferroelectric tunnel junction, strongly correlated oxide materials.
MRS-Singapore AMC-9
Invited speaker

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Invited speaker

Liquid-Liquid Phase Separation of Extra-Cellular Biological Materials: Molecular Mechanisms and Translational for Biomedical Applications

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Living organisms constitute a formidable source of inspiration that may help solve critical society and healthcare challenges. Indeed, the Living World produces complex and high-performance materials using aqueous chemistry, at ambient temperature and pressure, and with naturally-occurring chemicals. If we want to harness this sustainable chemistry, we need to fundamentally understand how biology produces natural materials. This includes elucidating the biochemistry of their building blocks, how these blocks self-assemble across multiple hierarchical levels, and establishing structure/property/function relationships from the molecular and genetic level up to the macroscopic scale. I will present our pioneer efforts in this area integrating Life Sciences (RNA-sequencing, high-throughput proteomics, protein biochemistry) with Physical Sciences (multi-scale materials characterization, polymer chemistry), which have led to discoveries of new molecular designs and to a deeper understanding of how biological materials are fabricated by living organisms[1].

I will highlight a case study of a hard “biotool”, namely the beak of squids that are entirely made biomacromolecular components, *i.e.* chitin and structural proteins. I will describe the main proteins we have discovered and sequenced in the beak, which we have shown to exhibit liquid-liquid phase separation (LLPS), a mechanism that appears to be critical for the natural fabrication of the beak and many other biological hard tissues[2]. I will also present our translational efforts in exploiting LLPS of beak proteins and peptides for the efficient encapsulation and stimuli-responsive release of various therapeutics[3,4], in particular emphasizing that micro-droplets formed by LLPS offer new opportunities for direct cytosolic delivery of therapeutics.

[1] Guerette, P. A. *et al.* Accelerating the Design of Biomimetic Materials by Integrating RNA-Seq. with Proteomics and Materials Science. *Nature Biotechnology* **31**, 908–915, (2013).
[2] Tan, Y. P. *et al.* Infiltration of a Chitin Scaffold by Protein Coacervates Defines the Squid Beak Mechanical Gradient. *Nature Chemical Biology* **11**, 488–495, (2015).
[3] Lim, Z. W., Varma, V., Ramanujan, R. V. & Miserez, A. Magnetically Responsive Peptide Coacervates for Dual Hyperthermia and Chemotherapy Treatments of Liver Cancer. *Acta Biomaterialia* **110**, 221-230, (2020).
[4] Lim, Z. W., Ping, Y. & Miserez, A. Glucose-Responsive Peptide Coacervates with High Encapsulation Efficiency for Controlled Release of Insulin. *Bioconjugate Chemistry* **29**, 2176-2180, (2018).

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Dr. Ali Miserez is a Faculty member in the Schools of Materials Science and Engineering and Biological Sciences at NTU. He obtained his PhD (2003) from EPFL (Switzerland) in Materials Science and Engineering in the field of composite materials and mechanics of materials. In 2004, he moved to UC Santa Barbara as a post-doctoral fellow supported by a Swiss National Science Foundation fellowship, where he expanded his research interest towards biomimetic engineering and biochemistry of extra-cellular tissues. He joined NTU in 2009, and in 2011 he was awarded the Singapore National Research Foundation Fellowship.
Dr. Miserez's research is centered on revealing the molecular, physico-chemical, and structural principles from unique biological materials, and on translating these designs into novel biomimetic materials. His work has appeared in both general (*Science, Nature Materials, Nature Biotechnology, Nature Chemical Biology*) and specialized journals (*Biomacromolecules, Advanced Materials, JBC, Polymer Chemistry, etc*,). He has delivered numerous invited talks, including at Gordon Research Conferences in the field of bioinspired materials and biomineralization.

MRS-Singapore AMC-9
Invited speaker

Transforming renewable electricity into everyday chemicals

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The chemicals industry consumes ~20% of the world's energy to produce the chemicals that we use in our everyday lives. Commodity chemicals such as glycols, ammonia and organic acids are used, for example, in the manufacture of polymers, fertilizer, coatings and adhesives. Today, the energy needed for these processes is met through the consumption of fossil fuels, which both deplete a finite resource and also contribute to CO_2 emissions into the environment. One strategy to tackle these problems is to develop electrochemical processes to manufacture these commodity chemicals by the direct utilization of increasingly available renewable electricity, preferably under conditions of ambient temperature and pressure. In this talk, I will describe our recent approaches to developing electrochemical processes for the production of ethylene glycol and ethylene oxide. In the former, a theory-guided approach was used to design a Au-doped Pd catalyst to facilitate the transformation of ethylene to ethylene glycol with high faradaic efficiency[1]. In the latter, a chloride mediator was employed to facilitate the production of ethylene oxide from ethylene at industrially relevant production rates[2].

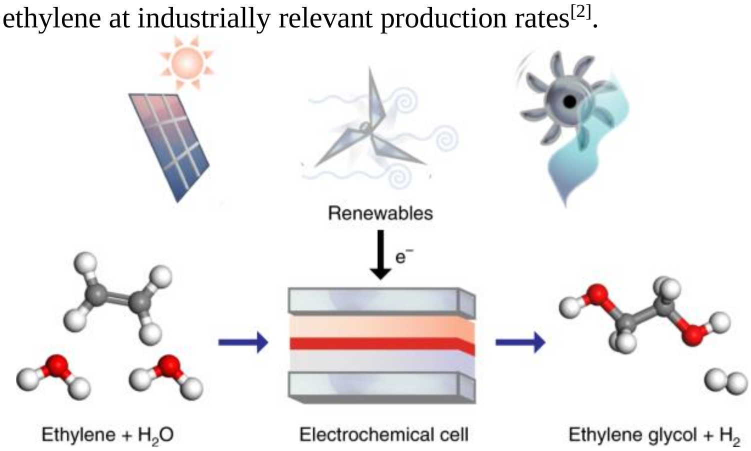

Figure 1. *Renewable energy powered production of ethylene glycol and hydrogen.*

[1] Y. Lum#, J.E. Huang#, Z. Wang and E.H. Sargent et al. *Nature Catalysis*, 2020, **3(1)**, 14-22.
[2] W.R. Leow#, Y. Lum#, A. Ozden and E.H. Sargent et al. *Science*, 2020, **368**, 1228–1233.

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Dr. Lum Yanwei received his PhD in Materials Science & Engineering at the University of California, Berkeley in 2018. His studies were funded by an A*STAR National Science Scholarship and focused on electrocatalytic CO_2 conversion. Following this, he performed postdoctoral work at the University of Toronto, engaged in electrochemical hydrocarbon valorization using an integrated theoretical and experimental approach. Presently, he is a research scientist at the Institute of Materials Research & Engineering (IMRE). His awards include a KAUST Industry Collaboration Program's Young Speaker Award (2018) and an A*STAR Career Development Award (2020).

MRS-Singapore AMC-9
Invited speaker

Screening Interfaces Using First-principles Calculations

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In 2000, during his noble prize lecture Prof. Herbert Kroemer stated ``*The interface is the device''* [1]; Kroemer was referring to the phenomenal success in the design and the application of semiconductor heterojunction devices in microelectronics. Arguably, Kroemer's statement has an ever-increasing relevance across a range of technologies far beyond transistors, where heterojunctions found their initial success. Researchers are increasingly finding that interfaces between materials represent a rich space for the exploration of exotic properties that are not present in bulk materials, such as two-dimensional electron gases (or liquids) and quantum topological states. The importance of the interface can only grow with the evolution of modern technological applications.
Simultaneously, progress in computational materials science in describing complex interfaces is critical for improving the understanding and performance of energy materials, including rechargeable batteries and catalysts [2].
In this talk, I will elucidate how first-principles calculations, based on density functional theory and materials informatics are applied to large pools of material data to rationalize their behaviors when forming functional interfaces [3–7]. Focus will be given to topical materials in energy applications, such as rechargeable batteries, where controlling interfaces is paramount to curb degradation phenomena [3–7].

[1] H Kroemer, *Rev. Mod. Phys*. 73, 783–793 (2001).
[2] K. T. Butler, G. Sai Gautam and P. Canepa, npj Computational Materials (2019).
[3] P. Canepa, G. Sai Gautam, D. C. Hannah, R. Malik, M. Liu, K. G Gallagher, K. A Persson and G. Ceder, *Chem. Rev*., 117, 4287–4341(2017)
[4] P. Canepa *et al.*, *Chem. Mater.*, *30* (9) 3019–3027 (2018).
[5] T. Chen, G. Ceder, G. Sai Gautam and P. Canepa, *Front. Chem.* (2019) 10.3389/fchem.2019.00024
[6] T. Chen, G. Sai Gautam and P. Canepa, *Chem. Mater*. 31, 19, 8087–8099 (2019).
[7] J. Forero-Saboya, C. Davoisne, R. Dedryvere, I. Yousef, P. Canepa and A. Ponrouch, , *Energy Environ. Sci.* (2020) 10.1039/D0EE02347G

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I am an Assistant Professor at the Department of Materials Science and Engineering in the Faculty of Engineering at the National University of Singapore. The nature of my research work is multidisciplinary covering the fields of materials science, chemistry, computational materials science, and incorporate foundations of thermodynamics, electrochemistry, theoretical chemistry and spectroscopy. I received my bachelor's and master's degrees from the University of Torino (Italy) and my PhD from the University of Kent (United Kingdom). I was an independent Ramsay Memorial fellow at the University of Bath (United Kingdom), and a Postdoctoral fellow at the Lawrence Berkeley National Laboratory and the Massachusetts Institute of Technology under the guidance of Prof. Gerbrand Ceder.

MRS-Singapore AMC-9
Invited speaker

Low-dimensional Nanoarchitectured Materials: Synthesis, Application and Future Perspectives

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Advanced two-dimensional (2D) materials have attracted significant interest due to their extraordinary physical and chemical properties over the past decade. Understanding and controlling the growth of novel 2D crystal materials is central for the performance of various applications, spanning from electronics to energy storage. Chemical vapor deposition (CVD) method is a key technology we used to develop exceptional nanomaterials and explore their applications in effective energy storage devices as well as scalable water purification. One of the greatest challenges besetting the development of battery technologies is fast charging, especially within flexible or compact designs. We discuss how the design of low dimensional nanostructure can correlate with the ion transportation efficiency, the activity of electrochemical reaction and energy storage based on chemical transformation. We have also studied the prospects of fast prototyping and scalability for 2D materials-based devices.

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Dr. Yang Hui Ying is currently an associate professor at the Pillar of Engineering Product Development, Singapore University of Technology and Design, Singapore. She studies low dimensional nanomaterials for electrochemical energy storage and water treatment devices, which are centered on exploring the influence of function engineering and chemical doping on the materials synthesis and device performance. She has received a number of prestigious awards including the Outstanding Young Manufacturing Engineer Award, IUMRS Young Researcher Award, IPS Nanotechnology Medal IES Prestigious Engineering Achievement Awards, Tan Kah Kee Young Inventor Award, L'Oreal Singapore for Women in Science National Fellowship, Lee Kuan Yew Fellowship, and Singapore Millennium Foundation Fellowship. She is elected to be the Fellow of Royal Chemistry Society in 2020. Her team is applying fundamental knowledge and new manufacturing methods in developing exceptional nanoscale materials and structures for efficient lithium storage and scalable water purification. Dr. Yang has published more than 260 manuscripts in top international journals with more than 11000 citations and a H-index at 60

The Big Deal about Small Quantum Building Blocks

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A large fraction of supercomputing time today is spent on solving problems in materials physics and chemistry. Quantum simulators, made of small building blocks like atoms and molecules, hold promise to dramatically outperform classical supercomputers, thereby enabling the detailed study of materials on the microscopic scale. In this talk, I will present an overview of quantum simulation with an eye towards materials research and focus on a couple of simulator platforms, namely tweezer arrays and ultracold molecules. While ultracold molecules have traditionally been desired as quantum simulators due to their strong dipolar interactions, tweezer arrays as a platform can be highly scalable while maintaining control over individual quantum particles. I will report on our progress with controlling single atoms in reconfigurable optical tweezer arrays, as well as recent results on inducing strong dipolar interactions between ultracold molecules via microwave dressing [1].

[1] Z. Z. Yan *et al.*, Phys. Rev. Lett. 125, 063401 (2020).

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Loh Huanqian leads a research group that aims to study advanced materials like flexible solar cells and superconductors at the microscopic level. Her lab will use optical tweezer arrays of atoms and molecules like reconfigurable quantum building blocks to mimic advanced materials. With tools to precisely control the motion, internal quantum states, and spatial arrangement of these building blocks, the team will perform quantum simulations in their laboratory to guide the design of new materials. Huanqian earned her PhD in atomic and molecular physics at the University of Colorado Boulder. She holds a National Research Foundation Fellowship (Class of 2018), received a L'Oréal-UNESCO For Women in Science International Rising Talent award in 2020, and is a member of the World Economic Forum Global Future Council on Quantum Applications.

MRS-Singapore AMC-9
Invited speaker

Morphing Bioelectronics for Growing Tissue

Yuxin Liu[1]*, Jinxing Li[2,3], Shang Song[3], Paul George[3], Zhenan Bao[3]
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The human body is a dynamic system that undergoes complex morphological changes over a broad time scale. Biological tissues, such as cardiac and nerve tissues, are in constant movement and their size grows dramatically from infancy to adolescence. Current implantable bioelectronics fail to accommodate rapid tissue growth and therefore are not suitable for pediatric patients. In this talk, I will discuss a new type of electronics, namely, morphing electronics [1] that self-adapt with growing organs *in vivo* without asserting restraining forces. To meet the electronic and mechanical requirement of morphing electronics, we rationally designed and introduced a new class of electronic materials termed "viscoplastic electronic materials" that exhibit necessary strain-rate dependency so that they can permanently deform (i.e. morphing) at a slow strain rate (comparable to the rate of tissue growth), while remain intimately contact with tissue at high strain rate to accommodate body/organ movement. We demonstrate in a rat model that the morphing electronics provide chronic *in vivo* neurological stimulation and recording for the entire adolescent developmental period with excellent biocompatibility and stable device performance. Besides, morphing electronics is capable of self-healing during the surgical procedure. Morphing electronics creates a new avenue for adaptive pediatric electronics medicine and enables seamless interrogation of neural development from the beginning of life to adulthood.

Caption: Morphing electronics plastically deform to accommodate tissue growth without mechanical constrain on developing tissue

[1] Y. Liu et al. *Nature Biotechnology* 38,1031–1036(2020)

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Dr. Yuxin Liu is a research scientist in IMRE, A*STAR. He obtained his Ph.D. degree in Bioengineering from Stanford University in 2019. During his Ph.D and short postdoctoral training in Professor Zhenan Bao’s group, He developed soft electronics and implantable neural interface. His research interest includes tissue-mimicking brain-machine interface and translation research on precision electronic medicine.

Reducing the footprint of solar photovoltaics: materials, fabrication and the circular economy

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With the adoption of solar photovoltaics (PV) accelerating, it is fast becoming the cheapest electricity source in many parts of the world. To meet the aims of the Paris agreement would require about 8500 GW of solar power to be deployed by 2050. Such massive levels of required deployment opens up multiple research challenges for materials scientists and engineers. These include (1) Reducing the costs and carbon foot print in the manufacturing of the solar cells; and (2) Dealing with the massive amounts of solar electronic waste that is expected to be generated.
This talk would cover efforts in the development of perovskite solar cells (PSCs) that have been of great research interest since they have achieved power conversion efficiencies exceeding 25%. These material systems are attractive due to their good bandgap, low defect densities and the ability to be manufactured utilizing solution processed methodologies. The solution processability allows the possibility of a simple and low-cost printing-based fabrication process for the complete device. Efforts in improving the scale, stability of these solar cells would be covered.
The talk would also consider the strategies for recycling Silicon solar cells. Disadvantages of the present established processes, and our efforts to address these limitations would be covered. Hydrometallurgical and solution based approaches to recover silicon through delamination and leaching processes would be covered.

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Dr. Nripan Mathews is an Associate Professor at the School of Materials Science and Engineering and the Energy Research Institute@ NTU (ERIAN). His research focus is primarily on the electronic and optical properties of novel materials and how they can be adapted for practical applications. His primary research interests are photovoltaics, field effect transistors and novel electronic materials. He was selected as a World Economic Forum young scientist and for the A*STAR-SNAS young scientist award previously. He has also been identified as a Highly Cited Researcher by Clarivate Analytics.

Accelerated Materials Development with Machine Learning

Xiaonan Wang[1]*
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The rapid development of deep learning enabled artificial intelligence (AI) has brought new opportunities to accelerate conventional experimental design in materials science. The discovery of high-dimensional synthesis recipes that yield desired material properties used to be costly and time-consuming, while advances in machine learning (ML) driven high-throughput experiments are able to rapidly achieve optimal conditions to produce the target materials. In this talk, I will first provide an overview on ML tools for material discovery and sophisticated applications of different ML strategies, which shows how AI strategies are applied through material discovery stages (including characterization, property prediction, synthesis, and theory paradigm discovery) [1]. Our recently developed online active learning approaches will then be discussed, which can effectively guide experiments and achieve full-map understanding of the design space. Several case studies will be demonstrated including: 1) a two-step active learning framework that combines Bayesian Optimization (BO) and Deep Neural Network (DNN) in a loop with a high-throughput microfluidic platform, to optimize the synthesis of silver nanoparticles with the desired absorbance spectrum, 2) a hierarchical AI framework, tested for strain sensor material synthesis, and 3) an automated molecular surgery platform based on Atomic force microscopy (AFM). The combination of machine learning, automation, and high-performance computing is enabling researchers to discover, optimize, and understand new materials much faster.
Moreover, we have developed a series of interpretation and visualization approaches to understand "black-box" ML models and make them more favored by domain experts to extract knowledge of complex systems that embed a huge amount of hidden information. Although promising opportunities are identified, many challenges exist this highly interdisciplinary field, such as construction of valuable and open datasets, in-depth understandings of descriptors, lack of standard algorithms workflow and fully autonomous experimental platforms. We are aiming to enable a better integration of AI methods with the material discovery process, with the keys to successful applications of AI in material discovery and challenges fully addressed.

[1] J Li et al., *Matter*, 3, (2020) 393-432.

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Dr Xiaonan Wang is an assistant professor in the Department of Chemical and Biomolecular Engineering at the National University of Singapore (NUS). She received her BEng from Tsinghua University in 2011 and PhD from University of California, Davis in 2015. After working as a postdoctoral research associate at Imperial College London, she joined NUS as an assistant professor since 2017. Her research focuses on the development of intelligent computational methods including multi-scale modelling, optimization, data analytics and machine learning for applications in advanced materials, energy, environmental and manufacturing systems to support smart and sustainable development. She is leading a Smart Systems Engineering research group at NUS of more than 20 team members as PI and also the deputy director of the Accelerated Materials Development programme in Singapore (S$25M funding). She has published more than 50 peer-reviewed papers, organized and chaired several international conferences, and delivered more than 40 presentations and invited talks at conferences and universities on five continents. She was recognized as an IChemE Global Awards Young Researcher finalist and selected for Royal Society International Exchanges Award, as well several best paper awards at IEEE and Applied Energy Conferences.

MRS-Singapore AMC-9
Invited speaker

Towards 6G communications with terahertz on-chip topological photonics

Yihao Yang[1,2], Yuichiro Yamagami[3], Xiongbin Yu[3],
Prakash Pitchappa[1,2] Julian Webber[3], Baile Zhang[1,2], Guillaume Ducournau[4]
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THz wireless communication have been proposed as potential solution for achieving sixth generation (6G) mobile communications. The terahertz band has extremely large bandwidth and can support terabit/s data rates over a kilometer of distance. Inter-chip communication requires support for high bandwidths with low-loss and low-dispersion despite the routing with several sharp bends. However, conventional THz waveguides suffer from significant losses with sharp bends. In this work, based on the recently discovered topological phase of light, we demonstrate robust THz topological valley transport on low-loss, all-silicon photonic crystals. We show that the valley polarized topological kink states exhibit unity transmission over a bulk band gap after propagation through several sharp bends. Such states are excellent information carriers due to their robustness, single-mode propagation, and linear dispersion-key properties for next generation THz communications. By leveraging the unique properties of kink states, we demonstrate error-free communication through a highly twisted domain wall at high data rate of 50 Gb/s.

[1] Y. Yang, Y. Yamagami, X. Yu, P. Pitchappa, B. Zhang, M. Fujita, T. Nagatsuma, R. Singh, "Terahertz topological photonics for on-chip communication," Nature Photonics 14, 446-451(2020). https://doi.org/10.1038/s41566-020-0618-9

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Prof. Singh is an elected Fellow of the Optical Society (OSA) for pioneering contributions to the field of terahertz science and technology. His current research interest lies in 6G Wireless communication and superconductivity. He has published more than 150 peer reviewed journal papers including Nature, Nature Photonics, and Applied Physics Letters. He has been listed as top 1% highly cited researcher in the field of physics and his works has been highlighted by several scientific magazines and public media. He received his Ph. D. in Photonics from Oklahoma State University in 2009 and then postdoc'd at Los Alamos National Laboratory from 2009 to 2013 before moving to NTU.

MRS-Singapore AMC-9
Invited speaker

Creating and Manipulating Magnetic Skyrmions

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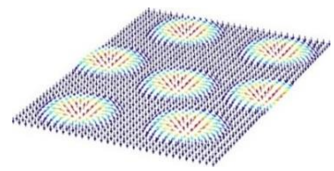
Magnetic skyrmions are topological spin structures emerging from the interplay of atomic-scale magnetic interactions. Their room temperature stability and tunability in multilayer films has spawned a fascinating research field witnessing rapid progress in fundamental science and device applications [1-2]. Practical technologies require skyrmions stable in the absence of external fields [3], together with the ability to electrically write, move, and read them within device configurations.



Schematic array of skyrmions

Here we describe our efforts to investigate skyrmion creation and manipulation in multilayer films and devices. First, we present our finding of a distinct macroscopic marker associated with zero field (ZF) skyrmion stability in conventional multilayers [4]. Using this technique, we show that, counterintuitively, skyrmion stability is enhanced at higher temperatures. Next, we examine synthetic antiferromagnetic films – which present a facile means to stabilize compact ZF skyrmions. We conclude with efforts to electrically write, delete, and move skyrmions in nanowire devices [5-6].

References

[1] A. Soumyanarayanan *et al.*, Nature (2016) 539, 509.
[2] A. Soumyanarayanan *et al.*, Nature Materials (2017) 16, 898.
[3] P. Ho *et al.*, Physical Review Applied (2019) 11, 024064.
[4] A.K.C. Tan *et al.*, Physical Review Materials (2020) In Press.
[5] A.K.C. Tan*, P. Ho* *et al.*, Submitted (2020).
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Anjan Soumyanarayanan is an Assistant Professor of Physics at NUS and a Senior Scientist at IMRE, A*STAR – where he leads the Spin Technology for Electronic Devices (SpEED) programme.

Anjan's research interests are in topological and quantum phenomena at the surfaces and interfaces of thin film materials. His team develops thin films and devices and investigates their properties using microscopic, spectroscopic, and transport techniques. His recent work has focused on spin-orbitronics – including magnetic skyrmions and topological materials.

Anjan obtained his B.A. in Natural Sciences in 2005 from Cambridge University, UK, and PhD in Physics in 2013 from MIT, USA. In 2018 he received the IEEE Magnetics Society Early Career Award and the Singapore Young Scientist Award for his work on skyrmions.

Soft Self-healable Electronic Materials

Benjamin C.K. Tee[1,2]*
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Self-healing materials can play an intriguing and increasingly important role in intelligent sustainable materials[1]. Such materials are able to repair themselves autonomously or semi-autonomously, leading to recovery of its intrinsic material properties. Electronic functionality such as dielectrics and conductivity can enable various devices such as sensors and light emitting devices to be made with self-healing capability. In this talk, I will discuss our recent advances in autonomously unique self-healing materials that can function as skin-like sensors[2] and generate light as a means to communicate in human-machine interactions and soft robotics[3]. We utilize ionic-dipole and dipole-dipole interactions that can enhance the mechanical properties as well as impart electronic functionalities for various soft materials applications.

[1] Tee, B. C. K. & Ouyang, J. Soft Electronically Functional Polymeric Composite Materials for a Flexible and Stretchable Digital Future. *Adv. Mater.* **0**, 1802560 (2018).
[2] Cao, Y. *et al.* Self-healing electronic skins for aquatic environments. *Nat. Electron.* **2**, 75–82 (2019).
[3] Tan, Y. J. *et al.* A transparent, self-healing and high-κ dielectric for low-field-emission stretchable optoelectronics. *Nat. Mater.* (2019). doi:10.1038/s41563-019-0548-4

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Biography of Invited Speaker

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Dr. Benjamin C.K. Tee is appointed President’s Assistant Professor in Materials Science and Engineering Department at the National University of Singapore and recipient of the National Research Foundation Fellowship. He obtained his PhD at Stanford University, and was a Singapore-Stanford Biodesign Global Innovation Postdoctoral Fellow in 2014. He has developed and patented several award-winning electronic skin sensor technologies. He is an MIT TR35 Innovator (Global) in 2015 and listed as World Economic Forum’s Young Scientist of the year in 2019. He was featured by CNN International as one of their Tomorrow’s Hero series and by Channel News Asia International in the ASEAN’s Next Generation Leaders documentary series. His leads his research group: Sensors.AI to develop technologies at the cutting edge of materials science, mechanics, electronics and biology, with a focus on sensitive electronic skins that has tremendous potential to advance global healthcare technologies in an increasingly Artificial Intelligence (AI) era. He can be found on www.benjamintee.com

First-Principles Study of Dzyaloshinskii-Moriya Interactions in Magnetic Multilayers

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Dzyaloshinskii-Moriya interaction (DMI) is an interaction driven by magnetic exchange and spin-orbit coupling in systems with broken inversion symmetry, and it gives rise to interesting spin textures such as spin spirals, Neel domain walls and skyrmions that show great promise for future spintronics. Using first-principles density functional theory methods, we have studied DMI in magnetic multilayers with the aim of understanding its electronic origins and developing strategies for tuning its sign and magnitude. To this end, we have investigated the IrFe(x)Co(y)Pt multilayer and shown that incorporating Fe layers lowers the exchange stiffness while increasing DMI significantly. This increase results from the addition of large and opposite DMI at PtCo and IrFe interfaces,[1] and our predictions have been experimentally verified both from Brilloiuin light scattering as well as magnetic force imaging that show modulation of skymion sizes and densities consistent with our calculations. Also, recent micromagnetic simulations have shown that interfacial DMI may enable deterministic field-free spin-orbit torque switching of perpendicular ferromagnets.[2] This has motivated us to investigate DMI in X-CoFeB-MgO structures for SOT-MRAM applications, where X are 5d heavy metals (HM) ranging from Ta to Au. Our calculations show that DMI at the HM interface increases with the degree of hybridization between the 3*d* ferromagnet and 5*d* HM bands and the sign of DMI depends on HM orbital mixing close to the Fermi level. We also show that the MgO cap gives appreciable contributions to DMI but to a smaller extent than the HM layer.

[1] A. Soumyanarayanan *et al.*, *Nat. Mater.* 16, 898 (2017).
[2] B. J. Chen, J. Lourembam, S. Goolaup, S. T. Lim, *Appl. Phys. Lett.* 114, 022401 (2019).

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Biography of Invited Speaker

Name: Khoong Hong Khoo
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Khoong Hong Khoo graduated with a B.Sc Honors (1st class) in Physics from the National University of Singapore in 2000 and obtained her Ph.D. in Physics from the University of California at Berkeley in 2006, working with Steven G. Louie. She then joined James R. Chelikowsky at the University of Texas at Austin as a postdoctoral associate before becoming a scientist at the Institute of High Performance Computing in 2010. Her research interests include electronic structure and magnetic properties of emerging materials.

MRS-Singapore AMC-9
Invited speaker

Perovskite Light-Emitting Devices for Wearables and Displays

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Near-infrared optoelectronic devices have found significant applications in facial recognition, eye tracking, motion sensing and health monitoring technologies. In this talk, I will discuss some of our new developments on efficient near-infrared light-emitting devices based on metal halide perovskite semiconductors. I will also highlight some of the design principles and processing methods that we have employed to achieve high-performance devices with improved efficiency, radiance and reliability. Finally, I will showcase some novel implementations of large-area and flexible NIR devices in new wearable devices and technologies.

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Biography of Invited Speaker

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Assistant Professor Zhi Kuang Tan is born and raised in Singapore. He studied Chemistry and Technology Entrepreneurship at the National University of Singapore (NUS), and received his Bachelor of Science with a first class Honours in 2010. He earned his PhD in Physics at the University of Cambridge through the support of the prestigious Singapore National Research Foundation (NRF) scholarship. During his PhD, Prof. Tan investigated the physics of optoelectronic devices, with a focus on the heterojunction energetics of organic light-emitting diodes (OLED) and solar cells. In 2014, he led the first discovery of electroluminescence in perovskite semiconductor light-emitting diodes. His research has been published in reputable scientific journals, including *Nature Nanotechnology*, *Nature Photonics* and *Advanced Materials*, and has received an aggregate of more than 4000 citations. His research inventions have also led to multiple licensed patents and two startup companies in advanced display technologies. In 2017, he won the National University of Singapore Early Career Research Award. Prof. Tan currently leads a research group in the Department of Chemistry at the National University of Singapore. His group aims to investigate and exploit the luminescent properties of perovskite semiconductors and quantum dots for advanced color displays and wearable device applications.

Molecular Design For Hybrid Perovskites – From Passive To Active

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Organic-inorganic hybrid perovskites have the potential to be used as a new class of emitters with tunable emission, high color purity and good ease of fabrication. A lot of studies have so far been focused on three-dimensional (3D) perovskites, such as $CH_3NH_3PbBr_3$ and $CH_3NH_3PbI_3$ for green and infrared emission. Here, we explore a series of hybrid perovskite emitters with a general formula of $(C_4H_9NH_3)_2(CH_3NH_3)_{n-1}Pb_nI_{3n+1}$ (where n = 1, 2, 3), which possesses a multiple quantum well structure. The quantum well thickness of these materials is adjustable through simple molecular engineering which results in a continuously tunable bandgap and emission spectra. Essentially, the van der Waals forces between long chain organic molecules help to drive the organization in these perovskites. Due to quantum confinement effect, the resultant optical band gap of these series of perovskites can be from 2.3 eV down to 1.6 eV approaching the band gap of 3D $MAPbI_3$ (~1.55 eV). Accordingly, their emissions gradually shift from green (520 nm) to infrared range (740 nm). To demonstrate their application in light emitting devices, we fabricated perovskite LEDs with a multi-layered structure of ITO/poly(ethylenedioxythiophene):polystyrene sulfonate/poly(N,N'-bis(4-butylphenyl)-N,N'-bis(phenyl)-benzidine)/perovskite/1,3,5-Tris(1-phenyl-1H-benzimidazol-2-yl)benzene/LiF/Al. We were able to then fabricated red, green and blue LEDs with hybrid perovskites possessing multiple quantum well (MQW) structure. These layered perovskites are beneficial in terms of the flexibility in fine-tuning their light emission properties. Furthermore, it also enables the preparation of uniform and smooth film over large area thus making it suitable for scalable manufacturing. As an extension to this work, I will also share some work that we have done with active cations which of energy levels that can be made use of to encourage singlet fission and this opens up a very interesting optoelectronic behavior.

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Biography of Invited Speaker

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Prof Yeng Ming LAM received her Ph.D. degree in Materials Science and Metallurgy from the University of Cambridge in 2001. She is currently a Professor and the Chair of the School of Materials Science and Engineering, NTU. She is also the Director of the Facility for Analysis, Characterization, Testing and Simulations (FACTs). She is also the Founder for FytoSol Pte Ltd that is dedicated to deliver solutions to horticulture and agriculture needs. She sits on the governing board for International Symposium for Polymer Analysis and Characterization(ISPAC) and the National committee on Measurement and characterisation. She held a concurrent Senior Scientist position in RWTH University in Aachen, Germany, between 2011 and 2014 and a concurrent Senior Scientist position in IMRE, A*Star, from 2010-2011. She was awarded the Nanyang Award for Excellence in Teaching in 2006 and the L'Oréal Unesco For Women in Science National Fellowship and the Nanyang Outstanding Young Alumni Award in 2009.