Shankar Dutt

Doctoral Student

60 Mills Road, Research School of Physics, Australian National University, Canberra, Australia 2601

(+61) 0421720748 | shankar.dutt@anu.edu.au | www.shankardutt.com | shankardutt | shankardutt | @shankar_phy

Profile

A doctoral student currently with the Research School of Physics of the Australian National University, investigating novel composite nanopore membranes. Using track etch technology and controlled breakdown technique, I work on an industrially compatible technology for the fabrication of extremely small nanopores of controllable shape and size in a variety of materials. Combining this technology with 2D materials such as Graphene or ultra-thin film deposition enables the fabrication of nanopore membranes with desired functionalities that can be used in medical and biological sensors, ultrafiltration, and lab-on-the-chip applications.

Employment

Research Officer 5/6 (0.4 FTE) — *Nov. 2022 - PRESENT*

Australian National University — *Canberra, Australia*

- Spearheaded the commercialisation activities of silicon-based membrane technologies.
- Fabricated and characterised membranes of different materials including silicon dioxide, silicon nitride, and silicon oxynitride.

Education

Doctor of Philosophy — *Sept. 2018 - PRESENT*

Australian National University — *Canberra, Australia*

Development and investigation of functional solid-state nanopore membranes

M.Sc. Physics Honours — *July 2016 - June 2018*

Guru Nanak Dev University — *Amritsar, India*

- University Gold Medallist (Rank - 1)
- GPA - 9.75/10

B.Sc. Physics Honours — *July 2013 - June 2016*

Guru Nanak Dev University — *Amritsar, India*

- University Gold Medallist (Rank - 1)
- GPA - 9.92/10

Research Projects

PhD Research — *Canberra, Australia*

Australian National University

Development and investigation of functional solid-state nanopore membranes — *September 2018 - Present*

- Investigated the fabrication of highly tunable nanopores in different solid state materials and applied for two IP applications(currently in PCT phase) based on this research.
- Investigated chemical and bio-sensing of different molecules using solid-state nanopore membranes.
- Developed first Australian nanopore based bio-sensing platform.
- Co-supervised six Undergraduate students on nanopore fabrication and characterisation.
- As a part of grand challenge project, "Our Health in Our Hands", worked closely with scientists from Immunology and Infectious Disease Lab and Nanotechnology Research Lab at the Australian National University.
- Collaborated with researchers from Australian Synchrotron (Australia), Peking University (China), GSI Helmholtzzentrum für Schwerionenforschung (Germany), Joint Institute for Nuclear Research (Russia), Institute of Nuclear Physics (Kazakhstan), University of California, Riverside (U.S.A.), and Southern Methodist University (U.S.A.).
- Wrote and assisted many research proposals for Synchrotron beamtime, Ion-beam irradiation beamtime at GSI, and DAAD research funding.

Master's Thesis — *Amritsar, India*

Guru Nanak Dev University

Synthesis and Characterization of Copper Tellurite Glasses — *November 2017 - May 2018*

- Studied structural, thermal and electrical characterisation of semiconducting copper tellurite glasses.
- Semiconducting glasses with different compositions were fabricated using melt-quench technique.
- Characterisation was done by neutron diffraction, Raman spectroscopy, thermal analysis and two probe electrical conductivity measurements.

Research Internship — *Paris, France*

École Polytechnique

Study of the acceleration of electrons through laser plasma interaction — *May 2017 - July 2017*

- Assisted with the study on electron wakefield acceleration in the resonant bubble regime with few-millijoule near single-cycle laser pulses at a kilohertz repetition rate.

Publications

Patents

S.Dutt, P. Kluth, C. Notthoff. "A method of fabricating nanopores", P117449.AU (Currently in PCT Phase) *2021*

S.Dutt, P. Kluth, C. Notthoff. "A method of fabricating membranes", P116401.AU (Currently in PCT Phase) *2021*

Journal Articles

S. Dutt, L. Lai, Y.M. Bandara, B.I. Karawdeniya, V. Gopalan , P. Kluth. "Time-resolved structural analysis of mutant tRNA associated with defects in neuronal homeostasis through solid-state nanopore sensing", In preparation. *2023*

S. Dutt, H. Shao, B.I. Karawdeniya, Y.M. Bandara, E. Daskalaki, H. Suominen, P. Kluth. "High Accuracy Protein Identification: Fusion of solid-state nanopore sensing and machine learning", *Small Methods* Under review. *2023*

S. Dutt, P.Apel, O. Polezhaeva, N. Kirby, P. Kluth. "Role of antioxidants in swift heavy ion tracks in polypropylene", *Polymer* 282 (2023): 126133. *2022*

S. Dutt, C. Notthoff, X. Wang, C. Trautmann, P. Mota-Santiago, P. Kluth. "Annealing of high energy ion irradiation damage in amorphous silicon dioxide", *Applied Surface Science* 628 (2023): 157370. *2023*

S. Dutt, B.I. Karawdeniya, Y.M. Bandara, N. Afrin, P. Kluth. "Ultra-Thin, High-Lifetime Silicon Nitride Membranes for Nanopore Sensing", *Analytical Chemistry* 95, 13 (2023): 5754-5763. *2023*

A.Kiy, **S.Dutt**, C. Notthoff, M. E. Toimil-Molares, N. Kirby, P. Kluth. "Highly Rectifying Conical Nanopores in Amorphous SiO_2 Membranes for Nanofluidic Osmotic Power Generation and Electroosmotic Pumps", *ACS Applied Nano Materials* 6, 10 (2023): 8564-8573. *2021*

X.Wang, **S. Dutt**, C. Notthoff, A. Kiy, P. Mota-Santiago, S. T. Mudie, M.E. Toimil-Molares, F. Liu,Y. Wang, P. Kluth. "SAXS data modelling for the characterisation of ion tracks in polymers", *Physical Chemistry Chemical Physics* (2022). *2022*

S.Dutt, P. Apel, N. Lizunov, C. Notthoff, Q. Wen, C. Trautmann, P. Mota-Santiago, N. Kirby, P. Kluth. "Shape of nanopores in track-etched polycarbonate membranes", *Journal of Membrane Science* 638 (2021): 119681. *2021*

A. Kiy, C. Notthoff, **S.Dutt**, M. Grigg, A. Hadley, P. Mota-Santiago, N. Kirby, C. Trautmann, M.E. Toimil-Molares, P. Kluth "Ion track etching of polycarbonate membranes monitored by in situ small angle X-ray scattering.", *Physical Chemistry Chemical Physics* 23 (2021): 14231-14241. *2021*

S.Dutt, S. Singh, A. Mahajan, B. Arora, B.K. Sahoo. "van der Waals coefficients of the multi-layered MoS_2 with alkali metals", *Physica Scripta* 95.9 (2020): 095506. *2020*

A. Hadley, C. Notthoff, P. Mota-Santiago, **S. Dutt**, S Mudie, MA Carrillo-Solano, ME Toimil-Molares, C Trautmann, P Kluth. "Analysis of nanometer-sized aligned conical pores using small-angle X-ray scattering", *Physical Review Materials* 4.5 (2020): 056003. *2020*

N. Kaur, A. Khanna, M. Fabian, **S. Dutt**. "Structural and electrical characterization of semiconducting xCuO-(100-x)TeO_2 glasses", *Journal of Non-Crystalline Solids* (2020): 119884. *2020*

D. Gustas, D. Guenot, A. Vernier, **S.Dutt**, F. Bohle, R. Lopez-Martens, A. Lifschitz, J. Faure. "High-Charge relativistic electron bunches from a kHz laser-plasma accelerator", *Physical Review Accelerators and Beams* 21.1 (2018): 013401. *2018*

Other Articles

S.Dutt, C. Notthoff, A. Kiy, Q. Wen, M.E. Toimil-Molares, C. Trautmann, N. Kirby, P. Kluth. "Highly tunable nanopores in silicon dioxide and silicon oxynitride membranes", *AINSE Annual Report* (2022): 37-40. *2023*

S.Dutt, C. Notthoff, A. Hadley, N. Lizunov, M.E. Toimil-Molares, C. Trautmann, P. Mota-Santiago, P. Apel, N. Kirby, P. Kluth. "Investigating track-etched nanopore membranes", *AINSE Annual Report* (2021): 51-54. *2022*

Experimental Expertise

Synchrotron based small-angle X-ray scattering

Australian Synchrotron

- Performed numerous experiments at the SAXS/WAXS beamline.
- Developed new form factor models for the analysis of 1D-SAXS data and different data analysis softwares.

Ion beam irradiation

14UD Accelerator and High Energy Implanter

- Hands on experience on using and doing irradiation at the biggest swift heavy ion accelerator in the Southern Hemisphere.
- Irradiated different materials with number of ions/atoms from energy ranging from 1MeV to 185MeV and fluence ranging from 1×10^{7} ions cm^{-2} to 1×10^{15} ions cm^{-2}.

Thin-film depositions

Australian National Fabrication Facility

- Performed and developed protocols for thin film depositions using plasma-enhanced chemical vapor deposition, low pressure chemical vapor deposition, atomic layer deposition, sputter deposition and e-beam deposition.
- Deposited a range of materials including dielectrics (silicon dioxide, silicon nitride, silicon oxynitride, titanium dioxide, hafnium oxide, tin oxide, aluminium oxide), metals(gold, platinum, aluminium, silver), a-silicon and many more.

Microscopy Techniques

Australian National Fabrication Facility and Research School of Physics, ANU

- Practical experience on using scanning electron microscope and atomic force microscope.

Spectroscopy Techniques

Research School of Physics, ANU

- Hands on experience on UV-VIS-NIR spectroscopy and FTIR spectroscopy.

Microelectromechanical systems

Australian National Fabrication Facility and Research School of Physics, ANU

- Formulated protocols and experiments for fabrication of versatile membranes using lithography and MEMS techniques.
- Fabricated silicon nitride, silicon dioxide, silicon oxynitride membranes as thin as 4nm.
- Developed protocols for chemical etching and dry etching (using inductively coupled plasma etching technique) for different materials.

Grants

Research Translation and Engagement Primer — *AUD $24,200*

Australian National University

Co-Investigator : Grant for providing researchers with opportunities to develop research translation and engagement activities (e.g. with industry and government) — *2022*

Discovery Translation Fund — *AUD $75,000*

ANU Connect Ventures

Co-Investigator : Grant for prototyping, equipment, testing and external verification to enable crucial 'proof of concept' development of new technologies or the establishment of new ventures. — *2022*

SAXS Beamtime Grants — *AUD 500,000*

ANSTO-Australian Synchrotron

Co-proposer of eight successful SAXS/WAXS beamtime proposals — *Sept 2018 - Sept 2023*

GPU Grant — *AUD $16,000*

Nvidia

LEAD : Two Nvidia A6000 GPUs were awarded for the development of machine learning-based biomarker identification in solid-state nanopore platform. — *2022*

Cloud Computation Time — *AUD $2,000*

Google

LEAD : Google Cloud Research Credits were given to advance the nanopore sensing research. — *2022*

AINSE Travel Grant — *AUD $1,000*

Australian Institute of Nuclear Science and Engineering

LEAD : Travel Grant was awarded for attending SHIM 2022 conference in Finland. — *2022*

Vice-Chancellor's HDR Travel Grant — *AUD $1,500*

Australian National University

LEAD : Travel Grant was awarded for attending SHIM 2022 conference in Finland. — *2022*

Short Term Research Grant *€7,000*

Deutscher Akademischer Austauschdienst (DAAD)

LEAD : Short term research grant to visit and do research in Germany for three months *2021*

Academic Awards & Honors

2023	Elsevier NIMB Young Researcher Award at the 21st International Conference on Radiation Effects in Insulators	*Japan*
2022	The Jak Kelly Award by the Royal Society of New South Wales	*Australia*
2022	Award for Postgraduate Excellence in Physics by the Australian Institute of Physics	*Australia*
2022	John Carver Prize by Research School of Physics, Australian National University	*Australia*
2019	AINSE Postgraduate Research Scholarship	*Australia*
2019	Australian Government Research Training Program International Scholarship	*Australia*
2019	Australian Government Research Training Program International Fee-Offset Scholarship	*Australia*
2018	ANU PhD Scholarship(International)	*Australia*
2018	ANU HDR Fee Remission Merit Scholarship	*Australia*
2018	Student of the Year by Department of Physics, Guru Nanak Dev University	*India*
2018	University Gold Medallist(Rank-1) in M.Sc. (Physics Hons.)	*India*
2017	Charpak Master's Scholarship by Embassy of France in India	*France*
2017	International Scholarship by École Polytechnique	*France*
2016	Summer Research Fellow of Indian Academy of Science	*India*
2016	University Gold Medallist(Rank-1) in B.Sc. (Physics Hons.)	*India*
2014	University Merit Scholarship by Guru Nanak Dev University	*India*
2014	SHE INSPIRE Scholarship by Department of Science and Technology, Govt. of India	*India*

Talks and Presentations

Invited Talks

Invited Talk Fukuoka, Japan	**S.Dutt**,C. Notthoff, X. Wang, C.Trautmann, P.Mota-Santiago, P. Kluth. "Annealing of swift heavy ion tracks in amorphous silicon dioxide", ***21st International Conference on Radiation Effects in Insulators***	*2023*
Invited Talk Virtual Presentation (Yaroslavl, Russia)	**S.Dutt**,C. Notthoff, A. Kiy, X. Wang, C.Trautmann, P.Mota-Santiago, N. Kirby, P. Kluth. "Swift heavy ion tracks in amorphous silicon dioxide", ***The XXVI International Conference on Ion-Surface Interactions***	*2023*
Invited Talk Helsinki, Finland	**S.Dutt**,C. Notthoff, A. Kiy , P. Apel, N. Lizunov, P. Mota-Santiago, N. Kirby, M.E. Toimil-Molares, C. Trautmann, I. Korolkov, M. Zdorovets, P. Kluth. "Exploring ion tracks and nanopores using small-angle X-ray scattering", ***29th international conference on atomic collisions in solids & 11th international symposium on swift heavy ions in matter***	*2022*
Invited Talk Darmstadt, Germany	**S.Dutt**, C. Notthoff, X. Wang, A. Kiy , P. Apel, N. Lizunov, P. Mota-Santiago, N. Kirby, M.E. Toimil-Molares, C. Trautmann, I. Korolkov, M. Zdorovets, P. Kluth. "Versatile solid-state nanopore membranes", ***GSI MAT Seminar***	*2022*

Conference Presentations

Oral Presentation San Diego, USA	**S.Dutt**, B.I. Karawdeniya, Y.M. Bandara, N. Afrin, P. Kluth. " Ultra-thin, high-lifetime silicon nitride nanopore membranes for biosensing", ***67th Biophysical Society Annual Meeting***	*2023*
Oral Presentation Taipei, Taiwan	**S.Dutt**, C. Notthoff, Q. Wen, A. Kiy, M.E. Toimil-Molares, I. Korolkov, M. Zdorovets, N. Kirby, P. Kluth. "Fabrication of highly tunable silicon dioxide and silicon oxynitride nanopore membranes", ***16th International Conference on Inorganic Membranes***	*2022*

Oral Presentation Taipei, Taiwan	**S.Dutt**, C. Notthoff, Q. Wen, A. Kiy, M.E. Toimil-Molares, I. Korolkov, M. Zdorovets, N. Kirby, P. Kluth. "Fabrication of highly tunable silicon dioxide and silicon oxynitride nanopore membranes", ***16th International Conference on Inorganic Membranes***	*2022*
Oral Presentation Melbourne, Australia	**S.Dutt**, P. Apel, C. Notthoff, A. Kiy, N. Lizunov, Q. Wen, C. Trautmann, P. Mota-Santiago, N. Kirby, P. Kluth. "Shape of track-etched nanopores characterized by small-angle X-ray scattering", ***ANSTO User Meeting 2021***	*2021*
Oral Presentation Online Symposium	**S.Dutt**, C. Notthoff, A. Kiy , C. Trautmann, P. Mota-Santiago, N. Kirby, P. Kluth. "Fabrication, Characterisation and Application of solid-state nanopore membrane", ***8th MSA Early Career Researcher Online Membrane Symposium***	*2021*
Poster Presentation Oxfordshire, United Kingdom	**S.Dutt**, P. Apel, N. Lizunov, C. Notthoff, Q. Wen, C. Trautmann, P. Mota-Santiago, N. Kirby, P. Kluth. "Shape of nanopores in track-etched polycarbonate membranes", ***S4SAS Conference 2021***	*2021*
Oral Presentation Canberra, Australia	**S.Dutt**, A. Kiy, B.I. Karawdeniya, K. Murugappan, C. Notthoff, N. Kirby, M.E. Toimil-Molares, C. Trautmann, A. Tricoli, P. Kluth. "Versatile nanoporous silicon dioxide membranes: fabrication, characterisation and applicaton ", ***Our health in our hands symposium***	*2020*
Poster Presentation Melbourne, Australia	**S.Dutt**, C. Notthoff,A. Hadley, A. Kiy, N. Kirby, M.E. Toimil-Molares, C. Trautmann, P. Kluth. "Investigation of etched ion-tracks in SiO_2 membranes ", ***Australian Synchrotron User Meeting 2020***	*2020*
Oral Presentation Brisbane, Australia	**S.Dutt**, C. Notthoff,A. Hadley, A. Kiy, N. Kirby, M.E. Toimil-Molares, C. Trautmann, P. Kluth. "Fabrication of solid-state nano-pore graphene composite membranes ", ***International conference on nanoscience and nanotechnology (ICONN-2020)***	*2020*
Poster Presentation Nur-Sultan, Kazakhstan	**S.Dutt**, A. Hadley, C. Notthoff, N. Kirby, M.E. Toimil-Molares, C. Trautmann, P. Kluth. "Fabrication of solid-state nano-pore membranes ", ***20th International conference on radiation effects in insulators***	*2019*
Oral Presentation Amritsar, India	**S.Dutt**, S. Singh, A. Mahajan, B. Arora, B.K. Sahoo. "van der Waals coefficients of the multi-layered MoS_2 with alkali metals", ***Recent research trends in material sciences***	*2017*

Skills

Modeling and Analysis	Mathematica, Matlab, Python, Origin, AutoCad, LaTeX, MS-Office, Corel-Draw, Inventor, C/C++, IgorPro
Software Developments	• IgorPro Macro (graphical user interface) for fitting 1D SAXS data fitting from nanopores and ion tracks • Web applications: (a) Simulation of conical nanopore shape (b) SAXS 1D Data fitting (c) Nanopore size calculator • Python and C based (command line interface) 1D SAXS data fitting software from nanopores and ion tracks • Python and C based (graphical user interface) nanopore biosensing data analysis
Languages	English, Punjabi and Hindi

Additional Activities

2022	**Reviewed papers for Physical Review B, ACS Applied Nano Materials, Biotechnology Progress and the Journal of Applied Crystallography**	
2021	**Technical Organisation Committee,** 7th IUPAP International Conference on Women in Physics	*Australia*
2020	**Organisation Committee,** Fundamental Sciences & Quantum Technologies using Atomic Systems	*India*
2019	**Marker,** 20th Asian Physics Olympiad	*Australia*
2016-2018	**Gender Champion: Leadership role working towards breaking gender barriers and making gender equality a reality,** Government of India	*India*