Curriculum Vitae: Assoc. Prof. Palani Balaya

Dr. Palani Balaya, Ph.D., FACerS
Associate Professor

Date of Birth: 20.06.1963

Office Mailing Address:
Department of Mechanical Engineering
Faculty of Engineering,
9 Engineering Drive 1, EA-02-07
National University of Singapore
Singapore 117575
Email: mpepb@nus.edu.sg
Contact Number: +65-65167644 (O); +65-96751607 (M)
Web link: https://blog.nus.edu.sg/aesl/

EMPLOYMENT HISTORY

- *Associate Professor*, NUS, Singapore, since July 2014
- *Assistant Professor*, NUS, Singapore, Jan. 2007 – June 2014.
- *Guest Scientist*, Max Planck Institute for Solid State Research, Stuttgart, Germany, 2001-2006
- *Visiting Fellow*, Nuclear Physics Department, Madras University, India, 2001
- *Scientist – D*, Inter University Consortium (Mumbai Centre), Bhabha Atomic Research Centre, India, 1996–2001
- *Research Associate*, Indian Institute of Science, India, 1994 – 1996

TEACHING MODULES

- ME5207 Solar Energy Systems
- ME5516 Emerging Energy Conversion and Storage Technologies
- ESP3401 Photovolatic Devices and Systems
- ESP5402 Nanomaterials for Energy Systems

AWARDS/HONORS/PROFESSIONAL EXPERIENCE

- *Fellow*, **American Ceramics Society**, March 2019
- *Commendation List for Teaching*, **Faculty of Engineering, NUS**, March 2019
- *Chair*, ECD Award Committee, **American Ceramics Society**, March 2019
- *Incoming-Secretary Elect Nominee*, Engineering Ceramic Division, **American Ceramic Society**, Jan. 2019
- *Staff Advisor to the Student Organization* **Energy Carta, NUS,** Jan. 2019 – July 2020
- *Chair of the International Committee*, Engineering Ceramic Division, **American Ceramic Society**, Jan. 2018
- *ACerS Global Ambassador*, recognized by **American Ceramic Society**, April 2016
- *Member of John Jeppson Award Committee*, **American Ceramic Society,** 2015-2018
- *Late Shri Har Mahandar Singh Chhatwal Memorial Award*, August 2015 by **Indian Ceramic Society** (Khurja Chapter)
- *Shell Ideas360 Passionate Mentor*, by the **Shell Companies in Singapore**, July 2015
- *Best Poster Award* (group award), at the **ICMAT 2015**, Singapore, June 2015
- *Global Star Award* by the **American Ceramic Society**, Jan. 2015
- *Young Investigator Award* (group award) for the best poster presentation at **IMLB-2012** Jeju, June 2012

- *Best Poster Award* (group award), **ICYRAM 2012**, Singapore, July 2012
- *Innovative Teaching Award* (group award), **Faculty of Engineering, NUS**, AY2007/2008
- *Outreach Project Award,* , **Department of Mechanical Engineering, NUS**, AY2009/10
- *Max Planck Fellowship,* **Max Planck Institute for Solid State Research**, Stuttgart, Germany, Sept. 2001 – Dec. 2006.

- *Coordinating Lead Author* for *Inter-governmental Panel on Climate Change* - Special Report on Renewable Energy Sources and Climate Change Mitigation (**IPCC-SRREN**) Jan. 2009 - May 2011.
- *Lead Author, Technology Primer on Energy Storage,* 2011, Singapore.

- *Topical Editor* (Battery, Fuel Cell, Capacitor) in Journal of Solid State Electrochemistry (Springer) for the period **Jan. 2013 – Oct. 2017**.
- *Guest Editor,* Applied Energy (Elsevier), **07/2010 to 03/2011**.
- *Guest Editor,* Journal of Solid State Electrochemistry (Springer), **06/2009 to 10/2009**

- *Co-chair,* 13th International Symposium on Ceramic Materials and Components for Energy and Environmental Applications (**CMCEE2020**), Novem. 1-5, (2020) Wuhan, China.
- *Organizer,* SYMP. 6 on *Advanced Materials and Technologies for Energy Storage*" during **44rd International Conference and Exposition on Advanced Ceramics and Composites**, Jan. 26-31 (2020) Daytona Beach, USA.
- *Co-chair,* **2nd Global Forum on Advanced Materials and Technologies for Sustainable Development** (GFMAT-2), July 21-26 (2019) Toronto, Canada
- *Chair,* Conf. on "*Energy Harvesting and Storages: Materials, Devices, and Application-IX*", at the **SPIE Defense + Commercial Sensing,** April 14 – 19 (2019) Baltimore, USA.
- *Organizer,* SYMP. 6: "*Advanced Materials and Technologies for Direct Thermal Energy Conversion and Rechargeable Energy Storage*" during **43rd International Conference and Exposition on Advanced Ceramics and Composites**, Jan. 27- Feb. 1 (2019) Daytona Beach, USA.
- *Chair,* 12th International Symposium on Ceramic Materials and Components for Energy and Environmental Applications (**CMCEE2018**), July 22 – 27 (2018) Singapore.
- *Co-chair,* Conf. on "*Energy Harvesting and Storages: Materials, Devices, and Application-VIII*", at the **SPIE Defense + Commercial Sensing,** April 15 – 19 (2018) Orlando, FL, USA.
- *Organizer,* SYMP. 6: "*Advanced Materials and Technologies for Direct Thermal Energy Conversion and Rechargeable Energy Storage*" during **42nd International Conference and Exposition on Advanced Ceramics and Composites**, Jan. 21-27 (2018), Daytona Beach, USA.
- *Organizer*, Symposium on "*Advanced Materials and Technologies for Electrochemical Energy Storage Systems***"** during **PACRIM 12**, May 21-26 (2017) Waikoloa, Hawaii, USA
- *Organizer,* Symposium on "*Advanced Materials for Energy Storage*" during **MCARE 2017**, February 19-23 (2017) Jeju, Korea.
- *Organizer,* SYMP. 6: "*Advanced Materials and Technologies for Direct Thermal Energy Conversion and Rechargeable Energy Storage*" during **41st International Conference and Exposition on Advanced Ceramics and Composites**, Jan. 22-27 (2017) Daytona Beach, USA.
- *Organizer,* Symposium on "*Batteries and Energy Storage*" during **MCARE 2016**, April 17-21 (2016), Clearwater, FL, USA.
- *Organizer,* Symposium on "*Advanced Materials and Technologies for Direct Thermal Energy Conversion and Rechargeable Energy Storage*" during **40th International Conference and Exposition on Advanced Ceramics and Composites**, Jan. 24-29 (2016) Daytona Beach, USA.
- *Chair,* Symposium – A on "*Advances in Energy Storage Systems: Lithium Batteries, Supercapacitors and Beyond*" during **ICMAT 2015** - the 8th Biennial International Conference on Materials for Advanced Technologies, June 28– July 3 (2015), Singapore.

- *Organizer,* Symposium on "*Advanced Batteries and Supercapacitors for Energy Storage Applications*" during 11th International Symposium on Ceramic Materials and Components for Energy and Environmental Applications (**CMCEE2015**) 14-19, June (2015) Vancouver, Canada.
- *Co-organizer, Symposium* S6 on "*Advanced Materials and Technologies for Energy Generation, Conversion and Rechargeable Energy Storage*" at **39th International Conference and Exposition on Advanced Ceramic and Composites**, 25 Jan. - 30 Jan. (2015) Daytona Beach, USA
- *Organizer, Symposium on "Batteries and Energy Storage"* at Materials Challenges in Alternative & Renewable Energy" (**MCARE 2014**), Feb. 16-20 (2014) Clearwater, FL, USA.
- *Co-chair,* Conf. on "*Energy Harvesting and Storages: Materials, Devices, and Application-V*", at the **SPIE DSS2014,** May 5 – 6 (2014) Baltimore, USA.
- *Co-chair,* Conf. on "*Energy Harvesting and Storages: Materials, Devices, and Application-IV*", at the **SPIE DSS2013**, April 29– May 3 (2013) Baltimore, USA.
- *Co-organizer, Symposium* S3C on "*Advanced Materials and Technologies for Energy-Storage Devices*" at **XXII International Materials Research Congress**: Aug.11 – 13 (2013) Cancun, Mexico.
- *Chair,* **5th Asian Conference on Electrochemical Power Sources** (**ACEPS-5**), Sept.17-20 (2010) Singapore.
- *Chair, Symposium-F* on "*Nanostructured Materials for Electrochemical Energy Systems: Lithium Batteries, Supercapacitors & Fuel Cells*" during **ICMAT2009 -** International Conference on Materials for Advanced Technologies, June 28– July 3 (2009), Singapore.

- *Member,* Advisory Board, **Energy Carta:** a non-profit organization run by NUS students, since 2013.
- *Member, International Advisory Board:* **CIMTEC 2014**, 6th Forum on New Materials, Symposium FC "Electrochemical Energy Storage Systems: the Next Evolution", Montecatini Terme, Italy; 15-19, June 2014; "4th Asian Conference on Electrochemical Power Sources (**ACEPS-4**)", 8 – 12, Nov. 2009, Taipei, Taiwan; **ACEPS – 5,** Singapore. 17-20, Sept. 2010; **ACEPS-6**, India, 5–8, Jan. 2012; **ACEPS-7**, Japan, 24–27, Nov. 2013; **ACEPS-8**, China, 21-25, August, 2015; **ACEPS-10**, Taiwan, Novem. 24-27, 2019; "**International Conf. on Electroceramics**" 13 – 17, Dec. 2009, Delhi, India

- *Member, Technical Program Committee* for the Conf. on "Energy Harvesting and Storages: Materials, Devices, and Application", at the SPIE Defense, Security and Sensing 2010 (**SPIE DSS 2010**), Orlando, FL, USA, 5 - 9 April 2010; **SPIE DSS 2011**,Orlando, FL, USA 25-29, April 2011; **SPIE DSS 2012**, Baltimore, USA 23-27 April 2012;

MY BATTERY RESEARCH PROGRAMME

My research programme on battery spans from fundamentals to outcome based achievements. At one hand, we focus on **fundamental research** developing novel concepts and electrode materials for lithium-ion battery and sodium-ion battery, and the other hand we focus extensively on **translational research** developing proto-types of various battery cells close to industry standards without compromising impactful publications. At FoE, I took lead to set-up a state-of-the-art pilot line with funding from NUS for fabrication of commercial type large format (18650 and pouch) battery cells, with an aim to develop local capabilities for prototyping high performance lithium-ion batteries and sodium-ion batteries. We also analyse various mechanisms for heat generation in battery cells causing thermal runaway and tailor the fabrication engineering approaches using pilot line to overcome those losses.

PUBLICATIONS (as on 22 March 2019; **Google Scholar)**

- Published 97 articles; **h-index**: 40; Sum of times cited: 7296.

SELECTED PUBLICATIONS ON ENERGY STORAGE

- "Charge and discharge processes and sodium storage in disodium pyridine-2,5-dicarboxylate anode – insights from experiments and theory", H. Padhy, Y. Chen, J. Lüder, S.R. Gajella, S. Manzhos and P. Balaya, **Advanced Energy Materials**, 2018, **8**, Article No. 1701572
- "Towards understanding heat generation characteristics of Li-ion batteries by calorimetry, impedance and potentiometry studies", B. Manikandan, C. Yap, and P. Balaya, **J. Electrochem. Soc.**, 2017, **164**, 12, A2794-A2800.
- "NaVPO4F with High Cycling Stability as a Promising Cathode for Sodium-ion Battery", M. Law and P. Balaya, **Energy Storage Materials**, 2017, **10**, pp102-113.
- "Investigation of physico-chemical processes in lithium-ion batteries by deconvolution of electrochemical impedance spectra", B. Manikandan, V. Ramar, C. Yap, and P. Balaya, **Journal of Power Sources**, 2017, **361**, pp300-309
- "Na2MnSiO4 as an Attractive High Capacity Cathode Material for Sodium-ion Battery", M. Law, V. Ramar, P. Balaya, **Journal of Power Sources**, 2017, **359**, pp277-284.
- "Monoclinic Sodium Iron Hexacyanoferrate Cathode and Non-flammable Glyme-based Electrolyte for Inexpensive Sodium-ion Batteries", A. Rudola, K. Du, P. Balaya, **J. Electrochem. Soc.,** 2017, **164**, 6, A1098-A1109.
- "Heat loss distribution: Impedance and thermal loss analyses in LiFePO4/graphite 18650 electrochemical cell", B. Manikandan, V. Ramar, C. Yap, L. Lu, A.A.O. Tay and **P.Balaya**, **Journal of Power Sources** 2016, **328**, p.413
- "The Effect of Polymorphism on the Lithium Storage Performance of Li_2MnSiO_4", V. Ramar and **P. Balaya**, **Journal of Power Sources**, 2015, **306**, p.552
- "Introducing a 0.2 V Sodium-ion Battery Anode: The $Na_2Ti_3O_7$ to $Na_{3-x}Ti_3O_7$ Pathway", A. Rudola, N. Sharma and **P. Balaya**, **Electrochemistry Communications**, 2015, **61**, p.10.
- "A new phenomenon in sodium batteries – voltage step due to solvent interaction", A. Rudola, D. Aurbach and **P. Balaya**, **Electrochemistry Communications**, 2014, **46**, p.56.
- "The first report on excellent cycling stability and superior rate capability of $Na_3V_2(PO_4)_3$ for Sodium-ion batteries", K. Saravanan, C. W. Mason, A. Rudola, K. H. Wong, **P. Balaya**, **Advanced Energy Materials**, 2013, **3**, 4, p444.
- "Mesoporous TiO_2 with High Packing Density for Superior Lithium Storage", K. Saravanan, K. Ananthanarayanan, and **P. Balaya**, **Energy Environ. Sci.,** 2010, **3,** p939 (**Cover Article**)
- "Size Effects and Nanomaterials for Energy Applications", **P. Balaya**, **Energy and Environ. Sci.,** 2008, **1,** p645 **(Perspective Review)**.

NOTABLE ACHIEVEMENT

- Stabilized high temperature cubic phase of Li_2SO_4 at ambient temperature by melt quenching with strong evidence of orientational disorder of SO_4 ions at room temperature through EPR measurement (University of Hyderabad)
- First to provide indirect experimental evidence for the space charge effect showing mesoscopic phenomenon in $SrTiO_3$ nanoceramic using impedance spectroscopy (Max Planck Institute for Solid State Research)
- First to demonstrate 100% reversible lithium storage using conversion reaction in RuO_2 (Max Planck Institute for Solid State Research)
- Introduced mesoporous TiO_2 for lithium storage operating up to 30C, also without conductive carbon additive up to 20C (National University of Singapore)
- Introduced a new voltage step phenomenon in sodium batteries due to solvent interaction (National University of Singapore)
- First to introduce non-carbon based anode material (sodium titanate) with lowest redox potential (0.2V vs Na) for sodium storage (National University of Singapore)

- First to demonstrate superior storage performance (40C and 30,000 cycle life) of $Na_3V_2(PO_4)_3$ cathode material for Na-ion battery (National University of Singapore)
- First to fabricate and demonstrate successful performance of 18650 cells (0.6Ah) and large format pouch cells (6Ah) of non-flammable sodium-ion battery (National University of Singapore)
- Introduced water based eco-binder from natural resources for cathode and anode of lithium-ion battery with superior performance compared to PVDF/NMP and CMC-SBR/water (National University of Singapore)
- First to introduce high energy density in-situ sodium plated battery with current collector foil as anode (National University of Singapore)

PREVIOUS AND CURRENT RESEARCH GRANTS IN RELATED AREAS (LAST 5 YEARS)

Received successfully US DARPA funding twice (2009 and 2012). These are very prestigious and competitive fundings.

1) PI, Development of Sodium-ion Battery Pack for Stationary Storage Systems, (EMA-EIRP, 06/2016 – 08/2019)
2) Co-PI, Aqueous Li-air battery , (NRF-CRP; 01/2014 – 12/2018)
3) Co-PI, Redox-Flow Lithium Batteries as a New Concept and Implementable Solution for Large Scale Energy Storage, (NRF-CRP; 09/2012 – 08/2017)
4) PI, Development of Hybrid Electrolyte Lithium air Rechargeable Battery, (SERC; 07/2012 – 06/2017)
5) PI, "High Rate Performing Li-ion Battery", (DARPA-AOARD; 10/2012 – 09/2014)
6) PI, "Development of Integrated Li-ion Battery for Portable Electronic Devices", (NRF-PoC; 07/ 2012 – 06/2013)
7) Lead PI, "Developing Local Capabilities for Prototyping High Performance Li-ion Batteries and Na-ion Batteries" (FoE/ILO/Department; July 2014 – June 2016)

PATENTS: 32 patents filed/granted (Singapore, USA, Korea, Japan, China, European).

INVITED/KEYNOTE TALKS: Delivered 82 Invited/Keynote/Plenary talks at scholarly conferences/symposia/workshops/meetings during the period 2007 – 2019.

LIST OF ADVISEES

- PhD students: 9 awarded; 5 ongoing*;*
- Post-doctoral Fellows: 15; ME students: 1; Research Engineer: 3; BE final year projects: 60

OTHER OUTSTANDING RECOGNITIONS

- *Plenary Talk* at International Conference on Ceramic & Advanced Materials for Energy and Environment (CAMEE 2015), Bangalore, India, 14-17, Decem. 2015.
- *Keynote talk* at International Battery Association 2019, 3 – 8, March 2019, San Diego, USA
- *Inaugural keynote talk* at International Conference on Nano Science & Engineering Applications, Jawaharlal Nehru Technological University, Hyderabad, India, 26-28, Jan. 2014.
- Ph.D. student's thesis won the "*World Future Foundation PhD Prize*" in Environmental and Sustainability Research in 2012 with a cash prize of US$ 10,000.00.
- PhD student's thesis received "*Gold Medal*" in 2011 for his Best Thesis entitled, "Synthesis of Nano-Structured Materials and their Application in Lithium Ion Batteries".
- Invited talk at the European Material Research Society (E-MRS) Conf. at Nice, France in 2011 was highlighted by MRS Bulletin as a society news entitled "*MRS Collaborates with E-MRS on Energy Symposia within the 2011 E-MRS Spring Meeting/ IUMRS-ICAM Meeting*", MRS Bulletin, 36 (2011) 930.

- Interviewed by the prestigious Royal Society of Chemistry, UK during visit to UK in March 2010 for an article "*A Sunny Outlook*" published in "Highlights of Chemical Sciences", Nov. 2010.