



Ravi Kumar Biroju

**STU Centre for
Nanodiagnostics of
Materials**

**Project number
2363/03/01**

**Project duration
12/2022 - 9/2025**

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"With the support and prestige offered by a SASPRO 2 fellowship, Dr. Ravi K. Biroju will be excellently placed to reach a position of professional maturity such as leading his own research group. He has been working as an active academic researcher for the last 10 years with 24 international peer-reviewed research articles (citations: 783; h-index: 14) to his record. The outcomes of the A2CAT project will open the best career options for Dr. Ravi K. Biroju in academic and R&D departments in the specialized field of visible light photo(electro)catalysts developed from TMD vdW alloys."

Dr. Ravi K. Biroju is born and brought up in Telangana State, Hyderabad, India. He did his PhD thesis at the Centre for Nanotechnology, Indian Institute of Technology Guwahati, India, studying the topic 'Chemical Vapour Deposited (CVD) growth of two dimensional (2D) nanomaterials, 2D van der Waal solids for photoconductive and photocatalysis applications' under the supervision of Prof. Pravat K. Giri. He was placed as a post-doctoral research fellow at Tata Institute of Fundamental Research Hyderabad with Dr T N Narayanan's research group, immediately after his PhD. He was awarded several prestigious research grants such as the Marie-Sklodowska-Curie IF grant (WHIPCAT), University of Birmingham, UK in 2017, SERB- NPDF and Royal Society of Chemistry (RSC) Research fund (2022-23). He was also a recipient of the PBC grant 2017, in Israel. He has served as an Assistant Professor at Vellore Institute of Technology (VIT), VIT University, and KL University Hyderabad, India. His research is focused on the fabrication of two-dimensional van der Waals (vdW) solids for energy and environmental applications. Particularly, optoelectronic devices, photocatalysis and photo(electro)catalysis of this kind of vdW solids. He is currently working as a SASPRO 2 Marie-Sklodowska-Curie Research Fellow at the Centre for Nanodiagnostics of Materials, Slovakia University of Science and Technology with Dr. Viliam Vretenar and Dr. Maria Caplovicova.

PROJECT SUMMARY

2D Atomic Layered Quaternary and Ternary Alloys for Innovative Photocatalysts

2D Transition Metal Dichalcogenides (TMD) are receiving much attention from the scientific community as novel candidates for energy and environmental applications due to the possibilities of tuning their optical, mechanical, optoelectronic, and electrochemical properties by combinatorial stacking/vertical-lateral heterostructures composed of quaternary and ternary alloys via controlled alloying of different atomic layers. Visible light absorption, indirect to direct bandgap transition, layer-dependent tunable photoluminescence (PL) etc. are some of the main properties of layered TMDs, making them unique for photocatalysis applications. The A2CAT proposal aims at preparing novel TMD alloys with combinations of different transition metals (M: Mo, W) and chalcogenides (X: S, Se and Te) by physical vapour deposition (PVD) (e.g. quaternary $(\text{Mo}_{1-y}\text{W}_y\text{S}_2(1-x)\text{Se}_{2x})$ and ternary $(\text{MoS}_2(1-x)\text{Se}_{2x}$ or $\text{Mo}_{1-y}\text{W}_y\text{S}_2(1-x)$) to develop efficient photo- and electro-catalysts (PCs and ECs). Actually, 2D TMDs with different compositions and structural phases provide a playground where, engineering their band structure, new avenues to construct novel PCs and ECs can be paved. A simple atmospheric pressure PVD deposition technique will be used to deposit pristine and combinatorial- quaternary & ternary alloyed atomic layers of TMD onto various substrates and Mg, Cr and Pt doped metallic phases will be also studied. Their photophysical and photocatalytic properties will be measured by visible light absorption and Raman/PL spectroscopies. Their structure-property at an atomic level will be investigated by high-angle annular dark field (HAADF) - scanning transmission electron microscopy (STEM) and Auger electron spectroscopy (AES) techniques to probe chemical and compositional surface environments in quaternary/ternary TMD alloys. Their activity towards electrochemical energy conversion (EEC), for example, hydrogen evolution reaction or CO₂ reduction, will be evaluated by linear sweep voltammetry and cyclic voltammetry in acidic electrolytes in dark and light conditions. Recrystallization and reconstruction of surface defects formed at low binding energies at site-by-site atomic levels will be extensively investigated in pre and post-processed TMD alloys using HAADF-STEM and AES. In addition, Density Functional Theory (DFT) calculations will be carried out to assist in interpreting the experimental results.



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PUBLICATIONS

Ravi K. Biroju*, Bhanu Chandra Marepally, Pariksha Malik, Soumen Dhara, Gengan Saravanan, Dipak Maity, Tharangattu N. Narayanan and P. K. Giri "Surface-Enhanced Raman Scattering from Defect Engineered CVD Graphene Physically Functionalized with Plasmonic Au, Ag and Cu Nanoparticles" (*ACS Omega* 2023, 8, 4344-4356, [10.1021/acsomega.2c07706](https://doi.org/10.1021/acsomega.2c07706)), IF: 4.132

Ravi K. Biroju*, Patrick Harrison, Wolfgang Theis, Neil Vaughan Rees, Rahul Sharma, Tharangattu N. Narayanan and Myung Gwan Hahn "Pt147 Size Selected Platinum Nanoclusters Soft Landed on WS-2 Nanosheets" (*ACS Appl. Nano Mater.* 2021, <https://doi.org/10.1021/acsanm.1c02683>; A cover art associated to this work has been selected as a Front Cover for a future issue of *ACS Applied Nano Materials*), IF: 5.096

Balakrishna Ananthoju, Ravi K. Biroju, Wolfgang Theis and Robert A. W. Dryfe "Controlled Electrodeposition of Gold: Maximization Defect-Enhanced Raman Scattering Response" (*Small* 2019, 1901555). IF: 11.459

Ravi K. Biroju, Deya Das, Rahul Sharma, Shubhadeep Pal, Larionette P. L. Mawlong, Kapil Bhorkar, Abhishek K. Singh, P. K. Giri, Tharangattu N. Narayanan "Hydrogen Evolution Reaction Activity of Graphene-MoS₂ van der Waals Heterostructures" (*ACS Energy Lett.* 2017, 2, 1355-1361). 'Among the most read articles in the past month'. IF: 19.003

Ravi K. Biroju; Shubhadeep Pal.; Rahul Sharma.; P. K. Giri.; Tharangattu N. Narayanan "Stacking Sequence Dependent Photo-Electrocatalytic Performance of CVD Grown MoS₂/Graphene Van Der Waals Solids" (*Nanotechnology* 2017, 28, 085101). Appeared IOP LAB TALKS 'Atomic Layer Sequence Influences Catalysis'. IF: 3.540

Rahul Sharma, Krishna Rani Sahoo, Pankaj Kumar Rastogi, Ravi K. Biroju+, Wolfgang Theis, Tharangattu N. Narayanan "On the Synthesis of Morphology Controlled Transition Metal Dichalcogenides via CVD for Electrochemical Hydrogen Generation" (*Physica Status Solidi (RRL) Rapid Research Letters*, DOI: [10.1002/pssr.201900257](https://doi.org/10.1002/pssr.201900257)). IF: 2.291

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