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Laser spectroscopic instrumentation for biomedical and environmental applications

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Additional Information

1. **Name and full correspondence address:**

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3. **Institution:** Manipal Academy of Higher Education

4. **Work experience (in chronological order):**

S.No.	Positions held	Name of the Institute	From	To
1	Research Associate	IIT, Madras	2005	2006
2	Junior Scientist	Manipal Academy of Higher Education	2006	2008
3	Lecturer	Manipal Academy of	2008	2010

		Higher Education		
4	Senior Grade Lecturer	Manipal Academy of Higher Education	2010	2011
5	Assistant Professor (Senior Scale)	Manipal Academy of Higher Education	2011	2014
6	Associate Professor	Manipal Academy of Higher Education	2014	Till date

5. **Professional Recognition/ Award/ Prize/ Certificate, Fellowship received by the applicant:**

S. No	Name of Award	Awarding Agency	Year
1	1st rank (Gold Medal)	M.Phil Physics, Pondicherry University	2005
2	Life member	Indian Laser Association	2008

3	Life member	Laser Spectroscopy Society of India	2012
4	Invited speaker	DAE-BRNS National Laser Symposium (NLS-22)	2014
3	Life member	Indian Science Congress	2016
5	National Scholarship of Slovak republic for a research stay in Comenius University, Bratislava	National Scholarship Programme of the Slovak Republic for a research/teaching/artistic stay in Slovakia.	2019-21
6	Best poster	DAE-BRNS National Laser Symposium (NLS)	2019-21

6. **Publications** ***(List of papers published in SCI Journals, in year wise descending order):***

S. No.	**Author(s)**	**Title**	**Name of Journal**	**Volume**	**Page**	**Year**
1	Adarsh U. K., Bhoje Gowd E, Aseefhali B, V. B. Kartha, Santhosh Chidangil and **Unnikrishnan V. K**	Development of an inter-confirmatory plastic characterization system using	Waste Management	150	339-351	2022

		spectroscopic techniques for waste management				
2	K M Muhammed Shameem, V S Dhanada, Sajan D George, V B Kartha, C Santhosh, **V K Unnikrishnan**	Assessing the feasibility of a low-throughput gated echelle spectrograph for Laser-induced Breakdown spectroscopy (LIBS)-Raman measurements at standoff distances	Optics and Laser Technology	153	108264	2022
3	Nidheesh VR, Aswini Kumar Mohapatra, **Unnikrishnan V K**, Rajesh Nayak, Vasudevan Baskaran Kartha, Santhosh Chidangil	UV Laser-based Photoacoustic Breath Analysis for the Diagnosis of Respiratory Diseases: Detection of Asthma	Sensors and Actuators B: Chemical	370	132367	2022
4	Adarsh U. K., V. B. Kartha, Santhosh Chidangil and **Unnikrishnan V. K**	Spectroscopy: A Promising Tool	Trends in Analytical Chemistry	149	116534	2022

		for Plastic Waste Management				
5	Alina Peethan, M Aravind, **V K Unnikrishnan**, Santhosh Chidangil, Sajan D George	Facile fabrication of plasmonic wettability contrast paper surface for droplet array-based SERS sensing	Applied Surface Science	571	151188	2022
6	Nidheesh VR, Aswini Kumar Mohapatra, **Unnikrishnan V K**, Jijo Lukose, Vasudevan Baskaran Kartha, Santhosh Chidangil	Post-COVID syndrome screening through breath analysis using electronic nose technology	Analytical and Bioanalytical Chemistry	414	3617-3624	2022
7	Keerthi K, Sajan D George, Rajesh Nayak, Santhosh Chidangil and **Unnikrishnan V K**	Role of geometric configurations in effective LIBS signal enhancement	Optik	251	168387	2022
8	Keerthi K, Sajan D George, Santhosh Chidangil and **Unnikrishnan V K**	Elemental analysis of liquid samples by laser induced breakdown spectroscopy	Optics and Laser Technology	147	107622	2022

		(LIBS): Challenges and potential experimental strategies				
9	Nidheesh VR, Aswini Kumar Mohapatra, **Unnikrishnan V K**, Rajeev Kumar Sinha, Rajesh Nayak, Vasudevan Baskaran Kartha, Santhosh Chidangil	Breath analysis for the screening and diagnosis of diseases	Applied Spectroscopy Reviews	56(8-10)	702-732	2021
10	Jijo Lukose, Ajaya Kumar Barik, **V K Unnikrishnan**, Sajan D George, VB Kartha, Santhosh Chidangil	Development of a spectroscopic technique that enables the saliva based detection of COVID-19 at safe distances	Results in Chemistry	3	100210	2021
11	Jijo Lukose, Ajaya Kumar Barik, Keerthilatha M Pai, **V K Unnikrishnan**, Sajan D George, VB Kartha, Santhosh Chidangil	Photonics of human saliva: potential optical methods for the screening of abnormal health	Biophysical Reviews	13	359-385	2021

		conditions and infections				
12	Dhanada V S, Sajan D George, V B Kartha, Santhosh Chidangil and **Unnikrishnan V K**	Hybrid LIBS-Raman-LIF systems for multi-modal spectroscopic applications: a topical review	Applied Spectroscopy Reviews	56(6)	463-491	2021
13	Dhanada V S, K S Choudhar, Sajan D George, V B Kartha, SanthoshChidangil and **Unnikrishnan V K**	Development and performance evaluation of a multi-modal optical spectroscopic sensor	Journal of Analytical Atomic Spectrometry	36(11)	2391-2401	2021
14	Praveen Devangad, **Unnikrishnan V K**, Suresh D Kulkarni, Santhosh Chidangil	Plasma spectroscopy+ chemometrics: An ideal approach for the spectrochemical analysis of iron phosphate glass samples	Journal of Chemometrics	34	11	2020

15	U Nayek, **V K Unnikrishnan**, A A Abdul Salam, S Chidangil, D Mathur	Thermal Energy Electrons and OH-Radicals Induce Strand Breaks in DNA in an Aqueous Environment: Some Salts Offer Protection Against Strand Breaks	The Journal of Physical Chemistry A	124(8)	1508-1514	2020
16	K M Muhammed Shameem, V S Dhanada, Surya Harikrishnan, Sajan D George, V B Kartha, C Santhosh, **V K Unnikrishnan**	Echelle LIBS-Raman system: A versatile tool for mineralogical and archaeological applications	Talanta	208	120482	2020
17	A Peethan, **V K Unnikrishnan**, S Chidangil, S D George	Laser-Assisted Tailoring of Surface Wettability-Fundamentals and Applications: A Critical Review	Reviews of Adhesion and Adhesives	7 (4)	331-366	2019

18	Upendra Nayek, **V. K. Unnikrishnan**, Abdul Ajees Abdul Salam, Parinda Vasa, Santhosh Chidangil and Deepak Mathur	Strong Strand Breaks in DNA Induced by Thermal Energy Particles and Their Electrostatic Inhibition by Na + Nanostructures	Journal of Physical Chemistry A	123	3241-3247	2019
19	K.S.Choudhari, Suresh D. Kulkarni,**Unnikrishnan V.K**., Rajeev K.Sinha, Santhosh C. and Sajan D.George	Optical characterizations of nanoporous anodic alumina for thickness measurements using interference oscillations	Nano-Structures and Nano-Objects	19	100354	2019
20	K. M. Muhammed Shameem, V. S. Dhanada, **V. K. Unnikrishnan**, Sajan D. George, V. B. Kartha and C. Santhosh	A hyphenated echelle LIBS-Raman system for multi-purpose applications	Review of Scientific Instruments	89	073108-1	2018
21	Jijo Easo George, **V.K. Unnikrishnan**, Deepak Mathur, Santhosh Chidangil, Sajan D.George	Flexible superhydrophobic SERS substrates fabricated by in situ reduction of Ag on	Sensors and Actuators B: Chemical	272	485-493	2018

		femtosecond laser-written hierarchical surfaces				
22	K.M. Muhammed Shameem, Arun Chawla, Madhukar Mallya, Bijay Kumar Barik, **V. K. Unnikrishnan**, V. B. Kartha and C. Santhosh	LIBS-Raman: an effective complimentary approach to analyse renal-calculi	Journal of Biophotonics	201700271	1-10	2018
23	Praven Devangad, M.M. Tamboli, K.M. Muhammed Shameem, Rajesh Nayak, Ajeetkumar Patil, **V.K. Unnikrishnan**, C. Santhosh and G. A. Kumar	Spectroscopic identification of rare earth elements in phosphate glass	Laser Physics	28	015703	2018
24	Adarsh Ananthachar, Surya Harikrishnan, **Unnikrishnan V K** and Santhosh C	Elemental analysis of meteorites using Laser-Induced Breakdown Spectroscopy (LIBS)	Proc. of SPIE	10401	104011O1-104011O8	2018
25	Muhammed Shameem K. M., M. M. Tamboli, Praveen Devangad,	Conventional and standoff pulsed laser–Raman–	Journal of Raman Spectroscopy	48	785-788	2017

	Unnikrishnan V. K., Sajan D. George, V. B. Kartha and Santhosh C.	echelle–time-gated (PRET) system				
26	K. M. Muhammed Shameem, Khoobaram S. Choudhari, Aseefhali Bankapur, Suresh D. Kulkarni, **V. K. Unnikrishnan**, Sajan D. George, V. B. Kartha and C. Santhosh	A hybrid LIBS–Raman system combined with chemometrics: an efficient tool for plastic identification and sorting	Analytical and Bioanalytical Chemistry	13	3299-3308	2017
27	M.M. Tamboli**, V.K. Unnikrishnan**, R. Nayak, P. Devangad, K.M. Muhammed Shameem , V. B. Kartha and C. Santhosh	Development of a Stand-off Laser Induced Breakdown Spectroscopy (ST-LIBS) system for the analysis of complex matrices	Journal of Instrumentation	11	P08021	2016
28	Praveen Devangad, **V.K. Unnikrishnan**, M.M. Tamboli, K.M. Muhammed Shameem, Rajesh Nayak, K. S. Choudhari and C. Santhosh	Quantification of Mn in glass matrices using laser induced breakdown spectroscopy (LIBS) combined	RSC Analytical Methods	8	7177	2016

		with chemometric approaches				
29	Tanvi Karpate, Muhammed Shameem K. M., Rajesh Nayak, **Unnikrishnan V. K**. and Santhosh C	LIBS: a potential tool for industrial/agricultural waste water analysis	Proc. of SPIE	9893	989317-1	2016
30	Praveen Devangad, **V.K. Unnikrishnan**, Rajesh Nayak, M.M. Tamboli, K.M. Muhammed Shameem , C. Santhosh , G.A. Kumar and D.K. Sardar	Performance evaluation of Laser Induced Breakdown Spectroscopy (LIBS) for quantitative analysis of rare earth elements in phosphate glasses	Optical Materials	52	32	2016
31	Muhammed Shameem K. M., Arun Chawla, Aseefhali Bankapur, **Unnikrishnan V. K.** and Santhosh	Application of spectroscopic techniques for the analysis of kidney stones: A pilot study	Proc. of SPIE	9715	97151E-1	2016
32	Debraj Gangopadhyay, Sachin Kumar Singh, Poornima Sharma,	Spectroscopic and structural study of the newly	Spectrochimica Acta Part A: Molecular	154	200	2016

	Hirdyesh Mishra, **V K Unnikrishnan**, Bachcha Singh and Ranjan K. Singh	synthesized heteroligand complex of copper with creatinine and urea	and Biomolecular Spectroscopy			
33	Ajeetkumar Patil, **Unnikrishnan V.K.**, Ravikiran Ongole, Keerthilatha M. Pai, V.B. Kartha and Santhosh Chidangil	Early Diagnosis of Tongue Malignancy Using Laser Induced Fluorescence Spectroscopy Technique	Proc. of SPIE-OSA	9537	95370J-1	2015
34	**VK Unnikrishnan**, Rajesh Nayak, Sujatha Bhat, Stanley Mathew, VB Kartha and C Santhosh	Biomedical applications of laser-induced breakdown spectroscopy (LIBS)	Proc. of SPIE	9332	933211-1	2015
35	**V K Unnikrishnan,** Rajesh Nayak, V B Kartha, C Santhosh, M S Sonavane, R G Yeotikar, M L Shah, G P Gupta and B M Suri	Homogeneity testing and quantitative analysis of manganese (Mn) in vitrified Mn-doped glasses by laser-induced	AIP Advances	4	97104	2014

		breakdown spectroscopy (LIBS)				
36	**V K Unnikrishnan,** K S Choudhari, Suresh D Kulkarni, Rajesh Nayak, V B Kartha, C Santhosh and B M Suri	Biomedical and Environmental applications of Laser Induced Breakdown Spectroscopy (LIBS)	Pramana Journal of Physics	82	307	2014
37	**Unnikrishnan V K,** K S Choudhari, Suresh D Kulkarni, Rajesh Nayak, V B Kartha and C Santhosh	Analytical predictive capabilities of Laser Induced Breakdown Spectroscopy (LIBS) with Principal Component Analysis (PCA) for plastic classification	RSC Advances	3	25872	2013
38	Ajeetkumar Patil, K S Choudhari, **V K Unnikrishnan,** Nandita Shenoy, Ravikiran Ongole,	Salivary Protein Markers- A Non-Invasive Protein Profile based Method for the	Journal of Biomedical Optics	18(10)	101317	2013

	Keerthilatha M Pai, V B Kartha, C Santhosh	Early Diagnosis of Oral Pre-malignancy and Malignancy				
39	**V. K. Unnikrishnan,** Rajesh Nayak, Praveen Devangad, M. M. Tamboli, C. Santhosh, G. A. Kumar and D. K. Sardar	Calibration based laser-induced breakdown spectroscopy (LIBS) for quantitative analysis of doped rare earth elements in phosphors	Material Letters	107	322	2013
40	**V K Unnikrishnan,** Rajesh Nayak, Kiran Aithal, V B Kartha, C Santhosh, G P Gupta and B M Suri	Analysis of Trace Elements in Complex Matrices (Soil) by Laser Induced Breakdown Spectroscopy (LIBS)	RSC Analytical Methods	5	1294	2013
41	**V K Unnikrishnan,** K Mridul, R Nayak, K Alti, V B Kartha, C Santhosh, G P Gupta and B M Suri	Calibration-free laser-induced breakdown spectroscopy for quantitative	Pramana Journal of Physics	79	299	2012

		elemental analysis of materials				
42	**V.K. Unnikrishnan** , Rajesh Nayak, Rodney Bernard, K. Jeena Priya, Ajeetkumar Patil, J. Ebenezer, Keerthilatha M. Pai, Sajan D. George, V.B. Kartha and C. Santhosh	Parameter optimization of a Laser-Induced Fluorescence (LIF) system for in-vivo screening of oral cancer	Journal of Laser Applications	23	1	2011
43	G. P. Gupta, B. M. Suri, A. Verma, M. Sundararaman, **V. K. Unnikrishnan**, K. Alti, V. B. Kartha and C. Santhosh	Quantitative elemental analysis of nickel alloys using calibration-based laser-induced breakdown spectroscopy	Journal of Alloys and Compounds	509	3740	2011
44	**V. K. Unnikrishnan**, Kamlesh Alti, Rajesh Nayak, Rodney Bernard, V. B. Kartha, C. Santhosh1, G. P. Gupta and B. M. Suri	Spectroscopy of Laser-Produced Plasmas: Setting up of High Performance Laser-Induced Breakdown Spectroscopy (LIBS) System	Pramana Journal of Physics	75	1145	2010

45	**V K Unnikrishnan**, Kamlesh Alti, V B Kartha, C Santhosh, G P Gupta and B M Suri	Measurements of plasma temperature and electron density in laser-induced copper plasma by time-resolved spectroscopy of neutral atom and ion emissions	Pramana Journal of Physics	74	983	2010
46	Ajeetkumar Patil, Vijendra Prabhu, K.S. Choudhari, **V.K. Unnikrishnan**, Sajan D. George, Ravikiran Ongole, Keerthilatha M. Pai, Jayarama K. Shetty, Sujatha Bhat, Vasudevan Bhaskaran Kartha, Santhosh Chidangil	Evaluation of high-performance liquid chromatography laser-induced fluorescence for serum protein profiling for early diagnosis of oral cancer	Journal of Biomedical Optics	15(6)	67007	2010
47	**V. K. Unnikrishnan**, Kamlesh Alti, Rajesh Nayak, Rodney Bernard, Niyati Khetarpal, V. B. Kartha, C. Santhosh, G. P. Gupta and B. M. Suri	Optimized LIBS setup with echelle spectrograph for multi elemental analysis	Journal of Instrumentation	5	p4005	2010

7. **Detail of patents:** Two (applied)

Title: System and method for providing classification of plastic materials
Application No: 202141055146
Date of Filing: 29/11/2021
Applicant: Manipal Academy of Higher Education
Inventors: Unnikrishnan V K, Adarsh U K, V B Kartha & Santhosh Chidangil

Title: A system facilitating characterization of materials and a method thereof
Application No: 202241047099
Date of Filing: 18/08/2022
Applicant: Manipal Academy of Higher Education
Inventors: Unnikrishnan V K, Dhanada V S, Muhammed Shameem K M, Maktumsen Tamboli, V B Kartha & Santhosh Chidangil

8. **Books/Reports/Chapters/General articles etc.**

Book Chapter: Biomedical Engineering, Biomedical Instrumentation and Devices, Section I, *Biomedical Applications of LIBS – A preliminary study*, V K Unnikrishnan, Rajesh Nayak, Praveen Devangad, M K Dinoop, V B Kartha, B M Suri and C Santhosh, p.30, ISBN 978–81–8487-195-1, Narosa Publishing Pvt Ltd. Delhi, India, 2012.

Book Chapter: Hyphenated LIBS Techniques from the book Laser Induced Breakdown Spectroscopy (LIBS), Chapter21, *Laser Induced Breakdown Spectroscopy (LIBS): Concepts, Instrumentation, Data Analysis and Applications*, Adarsh U K, Dhanada V S, Santhosh Chidangil and Unnikrishnan V K, John Wiley & Sons, 2022

9. **Previous and present grant information**

Title of Study	*From*	*To*	*Funding agency*	*Grant ID*	*Grant amount (Lakhs)*	*Status: completed/ ongoing*	*Project Summary indicating significant scientific contribution in case of completed project OR Background, Objectives, Methodology, Results in case of ongoing projects*	*No. of publications /patents/copy rights from this project if any*
Miniaturized Laser-Induced Breakdown Spectroscopy (LIBS) system for field applications	2014	2018	BRNS	34/14/04/2014-BRNS	27.5	Completed	In recent years LIBS has been shown to be a versatile elemental analysis tool attracting increased attention because of the broad range of applications. LIBS can be conveniently used in the laboratory as well as for in situ/remote analysis of environmental samples (soil, water, air etc), clinical samples (tissue and body fluids), hazardous materials, and planetary surfaces. The said work successfully developed a portable LIBS system combined with advanced instrumentation, on the simultaneous detection and quantification of several elements in environmental samples with special emphasis on hazardous elements in soil.	Publications: 26 Patent: 2 (applied)

Elemental analysis of precious alloys	2016	2018	Titan Company Ltd	Industry consultancy project	3.0	Completed	Ultimate aim of this industry sponsored project was to check the purity of gold quantitatively using LIBS with very high sensitivity and accuracy so that it can replace the existing karatmeters. Proof of the concept has been done and the project is now into its second stage.	Publications: 0 Patent: 1 (under preparation)
Development of a miniaturized and portable Laser-Induced Breakdown Spectroscopy (LIBS) set-up for fast identification and sorting of different plastic classes	2019	2022	DST	DST/TDT/DDP-26/2018	48	On going	Plastics form a wide range of synthetic or semi-synthetic organic polymers of high molecular mass. These polymers are made up of chain of carbon atoms with repeating units. Some of them have only carbon and hydrogen (polyethylene) and some others have oxygen, sulfur and nitrogen in addition to carbon and hydrogen. To assist recycling, Society of the Plastics Industry instituted a voluntary resin identification coding system where all plastics were classified into 7 classes whose recycling attracts economic importance. Another important fact is the possible adverse health effects of these plastics. Among all the plastic classes, Polyethylene Terephthalate (PET) is a suspected carcinogen and Polystyrene (PS) is prone to migrate in to food and store in body fat. Identification methods used at present such as Raman spectroscopy and mass	Publications: 2 Patent: 1 (applied)

							spectroscopy coupled to Gas Chromatography have their own limitations. IR spectroscopy has emerged as an important tool to identify different plastics. Distinction between Polypropylene (PP) and High-Density Polyethylene (PE) is difficult by IR as both these are made up of only aliphatic hydrocarbons. None of these methods are easily adaptable for in situ/remote analysis. It has also been observed that noticeable amounts of organic pollutants get adsorbed on the plastics, which can affect the identification (using NIR or IR method) and thus may demand further analysis. IR methods often require contact with the material, which is not desirable. In view of the above, we propose to design and develop a Laser-Induced Breakdown Spectroscopy (LIBS) system for rapid identification and screening of plastics.	

10. **Infrastructural support available**

Lasers (CW and pulsed)

Detectors (CCD/ICCD)

Remote and conventional LIBS-LIF-Raman spectroscopy system (single unit) for biomedical/environmental applications