

RESUME

1. Name in full: **Dr. K. MURALEEDHARAN**
2. Date of Birth: **15-October-1960**
3. Designation & Address: **Director
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4. Educational Qualifications:

S. No.	Degree/ Certificate	Year of Passing	University/ Institution	Subject
1	B Tech	1983	Banaras Hindu University- Institute of Technology	Metallurgical Engineering
2	Ph D	1994		

5. Academic/Research/Experience/Employment:

S. No	Period of service		Name of Organization	Position held
	From	To		
1.	July 1983	Oct 1984	Mishra Dhatu Nigam Hyderabad	Graduate Engineer Trainee
2.	Oct 1984	July 1995	DMRL Hyderabad	Group Head (Scientist B, C, and D)
3.	July 1995	Oct 1997	Carnegie Mellon University, Pittsburgh, USA	Post-Doctoral Fellow
4.	Nov 1997	Apr 2003	DMRL Hyderabad	Group Head & Project Leader (Scientist D, E and F)
5.	May 2003	Apr 2005	G-FAST, Delhi DRDO Think Tank)	Team Member Scientist F
6.	Apr 2005	Dec 2010	DMRL Hyderabad	Group Head Project Leader & Head, MM (Scientist F and G)
7.	Jan 2011	Aug 2015	DRDO Hq	Director (Technical), Materials Scientist G
8.	Jul 2010	Dec 2011	University of Hyderabad	Visiting Professor
9.	Apr 2012	Aug 2015	DIAT (DU) Pune	Adjunct Faculty
10.	Aug 2015	To date	CSIR-CGCRI	DIRECTOR

6. Area of Specialization:

- Electron Microscopy
- Atom Probe Field Ion Microscopy
- Materials Characterization
- Physical Metallurgy of Ti alloys
- Microstructural Characterization in Ti alloys and Intermetallics
- Specialty Steels for Defence (Naval)
- Nickel-base Superalloys
- Magnetic Materials (SmCo₅ and Sm₂Co₁₇ based)
- Ceramic Matrix Composites
- Electronic Materials and Device Structures
- Tungsten-base Alloys for FSAPDS
- Nanostructured Materials
- Glass and Ceramics

7. Awards / Honors received:

	Award / Honor	Year	Details
National	Min of Steel and Mines, Govt of India and IIM, Kolkata	1992	Young Metallurgist Award
	Institution of Engineers [Metall. & Materials Science Division]	2011	Eminent Engineering Personality
	Banaras Hindu University	2013	Distinguished Alumni Award
Professional bodies	MRSI	1999	Best Technical Paper in Bulletin of Materials Science
	EMSI	1999	Best Technical presentation award
	IIM and EMSI	9 metallographic contest awards during 1997 to 2010	
	Indian Ceramics Society	2015	MG Bhagat Memorial Lecture Award
Fellow	EMSI	2011	Fellow of EMSI
DRDO	Agni Awards	2005	Development of Naval Steels
		2007	Ore to Product Cycle for Titanium
	National Science Day Oration	2007	Advanced TEM and 3DAP FIM Techniques
Any other (DMRL)	Annual Day and Technology Day Awards	Five Best Technical Paper Awards and Two Best Technology Awards at DMRL Annual Day Celebrations during 1997 -2010	

8. Professional Affiliations:

Life Member

- Indian Institute of Metals, **IIM** (since 1980)
- Magnetic Society of India, **MSI** (since 1998)
- Electron Microscopy Society of India, **EMSI**(since 1997)
- Indian Vacuum Society (since 1999)
- Life Member, Indian Ceramic Society (since 2015)

Founding Life Member

- Materials Research Society of India, **MRSI**(since 1989)

Founding Member and Vice President

- Microscopy Society of India (2010)

Executive Committee Member, Vice President and President

- EMSI (Executive Committee: 2003-2005, 2010-to date)
- Vice President (2011-2013)
- PRESIDENT EMSI (2013-2015)
- Chairman, East Zone, EMSI
- National Council Member, Indian Institute of Metals (2015-17)
- National Council Member, Indian Ceramic Society (2015-17)
- Presently, President, Indian Ceramic Society

9. (a) Number of Research Publications:

National journals	International Journals
Seven (07)	Total: Fifty (50) 48 published, 1 in press, 1 communicated
[details in Annexure I]	[details in Annexure II]

Research papers presented in conferences

Conference	Year
A total of 26 presentations (2 in National and 24 in International Conferences) that led to publications in Peer-reviewed proceedings in a Journal / Book [Annexure III]	1997-2013

Technical Reports	19	Mostly DMRL, SSPL and DRDO technical Reports, see detailed list attached in Annexure IV
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In addition, I have delivered more than 80 invited talks, key note addresses in Seminars/ Workshops/ international and National Conferences and Continuing Education Programmes/Workshops.

(b) List of best 5 publications in last 10 years:

10. Number of books authored/edited:

	No.	Title & Year
Book Chapter(s)	1	On Specimen Preparation for Electron Microscopy

11. Number of patents granted/applied for:

Details	Year of Filing
Development of Steel with YS 780MPa for Naval Applications, Indian Patent (K Muraleedharan, R Balamuralikrishnan, S Nagarjuna, K Ankalu, Nirmalya Rahri, B Gopalakrishna, Ashish Nandy, DMRL, Hyderabad)	2011

12. Dissertations supervised:

(a) Ph D: Three

COMPLETED

- DV Sridhara Rao at IIT, Delhi (2005)
(Dr R Muralidharan and Professor VD Vankar co-supervisors)
- Sai Saravanan at University of Hyderabad (2007)
(Professor AP Pathak co-supervisor)

ON-GOING

- Sabyasachi Saha at IISc, Bangalore
(Professor D Banerjee co-supervisor)

(b) Guidance Seven (7) B Tech projects while at DMRL

(c) **Teaching at Post graduate Level:**

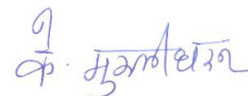
Materials Characterization, Physical Metallurgy, Materials Selection and High Temperature Materials, Nano-technology

- University of Hyderabad (2009-2011) @ M Tech level
- DIAT (DU) (2012-to date) @ M Tech & Ph D level

(d) Post Graduate

Date: February 25, 2019

Place: Kolkata



(Signature)

Specific Contributions of Dr Muraleedharan

Dr K Muraleedharan is one of the highly recognized experts in this country in the area of electron microscopy and physical metallurgy. He has made significant contributions in the understanding of physical metallurgy of a number of materials useful to DRDO. He has employed efficiently and effectively the transmission electron microscopy (TEM) technique, the primary tool of his research, in the process-structure-property relationship in a number of materials systems. Some of the major projects and activities that has benefited by his incisive analyses are: Development of high temperature Ti-alloys; Indigenous productionization of DMR-249A and DMR-249B steels for Indian Navy; High energy permanent magnets based on Sm_2Co_5 and $\text{Sm}_2\text{Co}_{17}$ for the strategic sectors; Ni-base superalloys for elevated temperature applications and W-base alloys for ordnance applications, Ceramic matrix composites based on SiC-SiC and SiO_2 - SiO_2 for high temperature applications; and Electron microscopy of Electronic materials and Device Structures.

Successes of two of the above activities (Indigenous Productionization Naval Steels and Development of complete Ore-to-Product cycle in Ti metal) have led to recognition by DRDO Agni Awards for the project teams in 2005 and 2007 respectively. Dr Muraleedharan played a key role in providing the microstructural characterization for these activities.

He has also contributed significantly towards building a World-class structural characterization infrastructure at DMRL. He has amply demonstrated his ability and efficiency in building of infrastructure and laboratories and providing effective scientific leadership. He led a visionary project DMR-254 entitled, 'Science and Design of Materials at Atomic Scale' under which facilities for characterization and modeling facilities have been set up at DMRL. This includes the only 3-dimensional atom probe in the country with a single atom resolution. His contributions in the field of TEM and 3DAAP FIM studies have recently been recognized by the Electron Microscopy Society of India and they bestowed on him the Coveted EMSI Fellowship for the year 2011, during the Golden Jubilee Celebrations of EMSI at Hyderabad. The Institution of Engineers, too recognized his contributions by awarding him the 'Eminent Engineering Personality' Award at its function held at BHU very recently.

He had pioneered and has been leading an activity with SSPL, GAETEC and IISc as collaborators in the characterization of device structures based on GaAs and GaN. Under this activity seminal research contributions have been made by the group led by him. These efforts have led to the recognition and acceptance of DMRL as the primary centre for characterization and modeling of nanostructured materials in DRDO.

Dr Muraleedharan has also been a member of DRDO think tank, G-FAST where he made significant contributions in forecasting and creating DRDO road maps in a few materials related areas (Materials for Armour, Materials for Hypersonic Vehicles, Materials for Electronic and Functional Applications, Stealth being some of the examples).

He has been an active member of organizing committees of a number of events and VVIP visits at DMRL. He played a stellar role in the organization of the visit of the President of India to DMRL in 2005. He organized with a high degree of efficiency, the visit of the Standing Committee on Defence to DMRL in 2007. He was the driving force behind the organizing of an International Symposium on Science, Technology and Policy that marked the 70th birthday of Dr VS Arunachalam, the former SA to RM. He also was the Convener of the Golden Jubilee Celebrations of DRDO at DMRL and organized many events, culminating in the first ever Materials Cluster Symposium in 2008. Dr Muraleedharan was also involved in the organization of many other events at Hyderabad and also the nano2006 international at Bangalore. In 2010, he organized with University of Hyderabad, a Workshop on Materials Modeling and Simulation that brought together researchers and students working in this important area for discussion on scope and roadmap for the area in materials R&D. He possesses the essential skills in organizing events and will be in a position to provide active leadership in many such activities in future.

He has also organized and lectured at many continuing education programmes (CEP) at DMRL and other DRDO laboratories. During 2011, he has delivered 12 invited lectures at various S&T Organisations and Events covering his contributions in the areas of Materials Characterisation and DRDO's nanotechnology programme.

While Dr Muraleedharan has made these significant contributions as a scientist, team leader, project leader and an able organizer, he has contributed towards

the general management of the laboratory activities. He possesses the necessary leadership and soft skills in addition to the technical acumen that he has demonstrated so effectively. He has contributed to the laboratory as HRD coordinator (2005-2006). He also served as the Division Head of Materials Management activities at DMRL in addition to leading the electron microscopy group as well as the project activities of development of specialty steels for Indian Navy. He was the Director of the Materials Directorate at DRDO headquarters and is also coordinating NBC Defence as well as nano Science and Technology activities of DRDO. He played a key role in shaping the XII Plan activities for Materials Cluster and also has also consolidated the efforts to have a major DRDO programme for the Production and Certification of Specialty steels for ship and submarine construction in India.

Dr Muraleedharan has been a member of the DMRL family in various capacities involving R&D, product development, planning and executing projects, human resources, materials management and buildup activities. He was selected in 2011 to lead the Directorate of Materials at DRDO, as he possesses the necessary domain knowledge and technical expertise, experience in various laboratory functions, the required motivation.

Currently he is the Director of Central Glass and Ceramics Research Institute, Kolkata under the Council of Scientific and Industrial Research. He is guiding the Institute into new horizons where the leadership has to be provided to make the institute more and more self-sufficient. Many technologies and products from the institute are becoming crucial for the National Missions of the Government of India. He is also evolving new HR policies for the transformation of the institute into a more effective and efficient unit of CSIR.

List of publicationsNational Journals

1. 'Creep of a □ Heat Treated Titanium Alloy', D Mukherjee, D Banerjee and **K Muraleedharan**, **Trans IIM**, Vol 42 (supplement) (1989) S155-164.
2. 'Transmission Electron Microscopy and X-ray Diffraction Studies of Characterisation of Quantum Wells', DV Sridhara Rao, **K Muraleedharan**, GK Dey, G Bhagavannarayan, P Banerji, D Pal and DN Bose, **Bull. Mater. Sci.**, Vol 22 (1999) 947-951.
[WON AWARD FOR BEST PAPER]
3. 'Studies on Sm(Co_{0.9-x}Fe_xCu_{0.1})_{4.8} Nanocomposite Magnetic Powder', K Suresh, R Gopalan, AK Singh, **K Muraleedharan**, DV Sridhara Rao and V Chandrasekharan, **Indian Journal of Physics**, Vol 78A (2004) 115-119.
4. 'Estimation of the Voltage of Transmission Electron Microscope (TEM) by <012> CBED-HOLZ Analysis using GaAs Crystal', DV Sridhara Rao, R Balamuralikrishnan and **K Muraleedharan**, **Bull Mater Sci**, Vol 27 (2004) 471-482.
5. 'Transmission Electron Microscopy Characterization Of Electronic Materials And Device Structures', DV Suidhara Rao, G Sai Saravanan, **K Muraleedharan**, R Balamuralikrishnan, R Muralidharan and HP Vyas, **Metals Materials and Processes**, Vol 19 (2007) 171-180.
6. 'Continuous Casting and Controlled Rolling of a Microalloyed HSLA Steel DMR-249A', N Venkateswara Rao, BS Bansal, K Ankalu, Abhijit Dutta, M Srinivas, **K Muraleedharan**, R Balamuralikrishnan, and G Malakondaiah, **Metals Materials and Processes**, Vol 19 (2007) 261-272.
7. 'Electron Microscopy of MW-CNTs for Display Devices Application', P Ghosal, R Sarkar, **K Muraleedharan**, P Chaturvedi, JSBS Rawat and Harsh, **Defence Science Journal**, Vol 58 (2008) 655.

List of publicationsInternational Journals

1. 'The Quasicrystalline Phase in the Mg-Al-Zn System', T Rajasekharan, D Akhtar, R Gopalan and **K Muraleedharan**, **Nature**, Vol 322 (1986) 528-530.
2. 'Structure of Vapour-Deposited (Fe, Co, Ni)-Ge Alloy Films', D Akhtar, RP Mathur and **K Muraleedharan**, **International Journal of Rapid Solidification**, Vol 2 (1987) 273-281.
3. 'Identification of τ ' phase in ZrO₂-7.5wt% Y₂O₃ Thermal-Barrier Coatings', **K Muraleedharan**, J Subramanyam and SB Bhaduri, **J of American Ceramic Society**, Vol 71 (1988) C226-227.
4. 'Creep of Zircaloy-2 at Low Stresses', N Prasad, G Malakondaiah, **K Muraleedharan** and P Rama Rao, **J of Nuclear Materials** , Vol 158 (1988) 30-41.
5. 'Alloy Partitioning in Ti-24Al-11Nb by Analytical Electron Microscopy', **K Muraleedharan**, D Banerjee, **Metall. Trans. A**, Vol 20A (1989) 1139-1142.
6. 'Orthorhombic Distortions of the α_2 Phase in Ti₃Al-Nb Alloys - Artifacts and Facts', **K Muraleedharan**, SV Nagender Naidu and D Banerjee, **Scripta MetallMater**, Vol 24 (1990) 27-32.
7. 'Transformations in a Ti-24Al-15Nb Alloy: Part I. Phase Equilibria and Microstructure', **K Muraleedharan**, AK Gogia, TK Nandy, D Banerjee and S Lele, **Metall Trans A**, Vol 23 (1992) 401-415.
8. 'Transformations in a Ti-24Al-15Nb Alloy: Part II. A Composition Invariant $\alpha_2 \rightarrow \alpha + \beta$ Transformation', **K Muraleedharan**, TK Nandy, D Banerjee and S Lele, **Metall Trans A**, Vol 23 (1992) 417-431.
9. 'The Effect of Heat Treatment and Nb Content on the Room Temperature Tensile Properties and Microstructure of Ti₃Al-Nb Alloys', AK Gogia, TK Nandy, **K Muraleedharan** and D Banerjee, **Mater Sci Eng A**, Vol A159 (1992) 73-86.
10. 'Phase Transformations Involving the α_2 and β Phases in Ti-Al-Nb Alloys', **K Muraleedharan** and D Banerjee, **Scripta Metall Mater**, Vol 29 (1995) 527-532.
11. 'Hot Deformation Characteristics of Inconel Alloy MA754 and Development of Processing Map', MC Somani, **K Muraleedharan**, NC Birla, V Singh and YVRK Prasad, **Metall. Trans. A**, Vol 25A (1994) 1693-1702.

12. 'Carbide Precipitation in 2.25 Cr-1 Mo Steel and its Weldments During Creep Testing', S Ahila, PBSNV Prasad, S Ramakrishna Iyer, VM Radhakrishnan and **K Muraleedharan**, **Materials Letters**, Vol 20 (1994) 107-111.
13. 'Phase Stability and Ordering Behaviour of the O Phase in Ti-Al-Nb Alloys', **K Muraleedharan**, TK Nandy, D Banerjee and S Lele, **Intermetallics**, Vol 5 (1995) 187-199.
14. 'Effect of Silicon on Elevated Temperature Properties of a Ti₃Al Based Alloy', PK Sagar, TK Nandy, AK Gogia, **K Muraleedharan**, D Banerjee, **Mater. Sci. Eng. A**, Vol A192/193 (1995) 799-804.
15. 'The α_2 to O Transformation in Ti-Al-Nb Alloys', **K Muraleedharan**, D Banerjee, S Banerjee and S Lele, **Philosophical Magazine A**, Vol 71 (1995) 1011-1036.
16. 'High-temperature Mechanical Behaviour of Cold-worked Stress-relieved Zr-2.5Nb', K Kapoor, **K Muraleedharan** and K.M. Sreedharan, **J of Materials Engineering and Performance**, Vol 4 (1995) 610-16.
17. 'Effect of Titanium Substitution on the Structure and Properties of Fe₃Al Based Intermetallic Alloys', U Prakash, **K Muraleedharan**, RA Buckley, H Jones, PA Shenton, **J Mater Sci**, Vol 31 (1996) 1569-1573.
18. 'In-situ Observations of Crack Initiation and Growth at Notches in Cast Ti-48Al-2Cr-2Nb', TM Pollock, DR Mumm, **K Muraleedharan** and PL Martin, **Scripta Materialia**, Vol 35 (1996) 1311-1316.
19. 'High Temperature Deformation Processing of Ti-24Al-20Nb', PK Sagar, D Banerjee, K Muraleedharan and YVRK Prasad, **Metall Mater Trans A**, Vol 27A (1996) 2593-2604.
20. 'Substructure in Titanium Alloy Martensite', D Banerjee, **K Muraleedharan** and JL Strudel, **Philosophical Magazine A**, Vol 77 (1998) 299-323.
21. 'Mechanical Processing and Microstructural Control in Hot Working of Hot Isostatically Pressed P/M IN-100 Superalloy', MC Somani, **K Muraleedharan**, YVRK Prasad and V Singh, **Mater Sci Eng A**, Vol A245 (1998) 88-99.
22. 'Microstructure Evolution and Tensile Properties of Zr-2.5wt%Nb Pressure Tubes Processed from Billets with Different Microstructures', K Kapoor and **K Muraleedharan**, and N Saratchandran, **J of Materials Engineering and Performance**, Vol 8 (1999) 61-67.

23. 'Current Status of the Phase Diagrams: Ti-Al and Al-Li', T.B. Massalski and **K. Muraleedharan**, *Advanced Light Alloys and Composites* (NATO Science Series Partnership Sub-Series 3, High Technology, Vol 59)Ed: [R Ciach](#), Kulwer Academic Publishers, Netherlands (1998), pp 1-10.
24. 'Development of W-Co-Ni Heavy Alloy System', TP Bagchi, P Ghosal, **K Muraleedharan** and B Sarma, *P/M Science and Technology Briefs*, Vol 2 (2000) 947-951.
25. 'Studies on Structural Transformation and Magnetic Properties in Sm₂Co₁₇ Type Alloys', R Gopalan, **K Muraleedharan**, TSRK Sastry, AK Singh, VA Joshi, DV Sridhara Rao and V Chandrasekharan, *J Mater Sci*, Vol 36 (2001) 4117-4123.
26. 'Structural Investigations in 2:17 Type SmCo Alloys', R Gopalan, **K Muraleedharan**, TSRK Sastry, S Suwas, VA Joshi and V Chandrasekharan, *Trans. Materials Research Society of Japan*, Vol 26 (2001) 801-804.
27. 'Effect of Thermomechanical Processing on Microstructure of a Ti-13Nb-13Zr Alloy', M Geetha, AK Singh, **K Muraleedharan**, AK Gogia and R Asokamani, *J. Alloys and Compounds*, Vol 329 (2001) 264-271.
28. 'Solidification Structure in a Cast □ Alloy', AK Singh, **K Muraleedharan** and D Banerjee, *Scripta Mater.*, Vol 48 (2003) 767-772.
29. 'Structure and Photoluminescence Characteristics of Molecular Beam Epitaxially Grown Vertically Aligned In_{0.33}Ga_{0.67}As/GaAs Quantum Dots', T Srinivasan, SN Singh, SK Mehta, R Muralidharan, DV Sridhara Rao, R Balamuralikrishnan and **K Muraleedharan**, *J Crystal Growth*, Vol 280 (2005) 378-384.
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31. 'Ion beam analysis of defects and strain in swift heavy ion irradiated InGaAs/GaAs heterostructures", S Dhamodaran, N Sathish, AP Pathak, DK Avasthi, R Muralidharan, B Sundaravel, KGM Nair, DV Sridhara Rao, **K Muraleedharan**, and D Emfietzoglou, *Nucl. Inst. Methods B*, Vol 254 (2007) 283-288.
32. 'Three-Dimensional Atom Probe Investigation of Microstructural Evolution during Tempering of an Ultra-High-Strength High-Toughness Steel', R Veerababu, R Balamuralikrishnan, **K Muraleedharan**, and M Srinivas, *Metall. Mater. Trans. A*, Vol 39A (2008) 1486-1495. DOI: 10.1007/s11661-007-9333-0

33. 'Grain Size and Grain Boundary Character Distribution in Ultra-fine Grained (ECAP) Nickel', K Sitarama Raju, M Ghanashyam Krishna, KA Padmanabhan, **K Muraleedharan**, NP Gurao, G Wilde', **Materials Science and Engineering A**, Vol 491 (2008) 1-7.
34. 'Deposition and Characterization of TiAlN/TiAlON/Si₃N₄ Tandem Absorbers prepared using Reactive Direct Current Magnetron Sputtering", Harish C Barshilia, N Selvakumar, KS Rajam, DV Sridhara Rao and **K Muraleedharan**, **Thin Solid Films**, Vol 516 (2008) 6071–6078.
doi: 10.1016/j.tsf.2007.10.113
35. 'Phase formation, microstructure and magnetic properties investigation in Cu and Fe substituted SmCo₅ melt-spun ribbons', K Suresh, R Gopalan, G Bhikshamaiah, AK Singh, DV Sridhara Rao, **K Muraleedharan**, and V Chandrasekaran, **Journal of Alloys and Compounds**, Vol 463 (2008) 73-77
36. 'Ohmic contacts to pseudomorphic HEMTs with low contact resistance due to enhanced Ge penetration through AlGaAs layers', G Sai Saravanan, K Mahadeva Bhat, **K Muraleedharan**, HP Vyas, R Muralidharan and AP Pathak, **Semiconductor Science and Technology**, Vol 23 (2008) 501-506. [(2008) 025019 doi: 10.1088/0268-1242/23/2/025019]
37. 'Characterization and Sintering Studies of Mechanically Milled nano Tungsten Powder', R Sarkar, P Ghosal, M Premkumar, AK Singh, K Muraleedharan, A Chakraborti, TP Bagchi and B Sarma, **Powder Metallurgy**, Vol 51 (2008) 166-170.
38. 'Influence of activation of Si²⁹⁺ ion-implantation in GaAs on ohmic contact resistance and electrical performances of MESFETs', G Sai Saravanan, K Mahadeva Bhat., HP Vyas, **K Muraleedharan** and AP Pathak, **Radiation effects and defects in solids**, Vol 163 (2008) 737.
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40. 'TEM and 3D Atom Probe Characterisation of Nickel-Base Superalloy DMS4', **K Muraleedharan**, R Balamuralikrishnan, N Das, **J Mater Sci**, Vol 44 (2009) 2218-2225.
41. 'Microstructure and coercivity variation in melt-spun Sm-Co-Fe-Zr ribbons', K Suresh, R Gopalan, DV Sridhara Rao, AK Singh, G Bhikshamaiah, **K Muraleedharan** and V Chandrasekaran, **Intermetallics**, Vol 18 (2010) 2244-2249.
42. 'Modulated Monoclinic Crystal Structure and Large Shape Memory Effect in Nickel-rich Ni_{53.5}Mn_{26.0}Ga_{20.5}', M Ramudu, A satish Kumar, V Seshubai,

K Muraleedharan, KS Prasad and T Rajasekharan, **Scripta Mater.**, Vol 63 (2010) 1073-1076.

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47. 'Electron Microscopy investigations of purity of AlN interlayer in AlGaN/GaN heterostructures grown by plasma assisted molecular beam epitaxy' DV Sridhara Rao, Anubha Jain, Sushil Lamba, **K Muraleedharan**, and R Muralidharan, **Appl. Phys. Lett.**, Vol. 102, xxxx-yyyy (2013), [<http://dx.doi.org/10.1063/1.4805027>]
48. Radiation Effects in Solids

In Press

49. MaM

Communicated

50. '3D atom probe investigation of sub-nanometric clusters in a medium carbon secondary hardening ultra-high strength steel under different tempering conditions', R Veerababu, R Balamuralikrishnan, **K Muraleedharan**, and M Srinivas, **submitted to Metall. Mater. Trans. A**, Jan 2014.

TEM specimen preparation techniques

D. V. Sridhara Rao¹, K. Muraleedharan¹ and C. J. Humphreys²

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Transmission electron microscopy (TEM) is a powerful tool for the investigation of the microstructure of materials, providing crystallographic information and composition at the nanometer scale. For such studies, samples should be transparent to the electron beam. In this review, TEM sample preparation techniques for different classes of materials, such as metals and alloys, multilayered coatings, device structures, nanomaterials and composites are described with illustrative examples. Also, site-specific TEM specimen preparation using focused ion beam (FIB) milling is presented. As specimen preparation involves thinning the sample to *electron transparent* thickness it can result in artifacts, which are briefly reported.

KeywordsTEM; Specimen preparation; TEM foils; electropolishing; ion milling; FIB; artifacts

1. Introduction

In transmission electron microscopy (TEM), a high-energy electron beam (~ 200 keV) interacts with an *electron transparent* (~ 100-150 nm thick) specimen in order to study the microstructure and composition. Preparation of such a thickness is both an art and a science. It needs the devising of suitable methods as well as realising/demonstrating them in a defined process with reproducibility. Also, utmost care is necessary in preparing and handling the specimens, as they are extremely thin and hence prone to bending and breaking.

In this review, we describe techniques for preparing TEM specimens of the following classes of materials, with illustrative examples: metals and alloys (§2); multilayers, semiconductor/metallic coatings, device structures (§3); nanomaterials, tubes/particles, ribbons, mechanical-milled powders (§4); composites (§5); miscellaneous materials including brittle materials (§6); and site-specific TEM specimen preparation (§7). TEM specimen preparation involves thinning of specimens to electron transparent thickness. Hence it could result in artifacts, some of which are described in §8. The different equipment/operating conditions mentioned we have been successfully using in our laboratories.

2. Metals and Alloys

International and National Conferences

(PUBLISHED IN PEER-REVIEWED JOURNALS AS SPECIAL ISSUES OR
CONFERENCE PROCEEDINGS)

A. National Conferences

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