



05.10.1940 - 31.08.2008

Dr. Placid Rodriguez Memorial Lecture - 2023

by

Dr. Komal Kapoor

Chairman & Chief Executive
Nuclear Fuel Complex
Hyderabad

on

Role of Texture in Fabrication and Performance of Alloys in Nuclear Applications

October 05, 2023 | 15:00 hrs |

Sarabhai Auditorium, IGCAR Kalpakkam

Webex details

Meeting ID: **2641 987 8723** | Password: **iFKJceca627**

Webex link

<https://iitm.webex.com/iitm/j.php?MTID=ma2ba2f9bcd7ddc737f0757746770ac4>

PRELIMINARY 2023

Dr. Placid Rodriguez Memorial Lecture - 2023



Organised by
Kalpakkam & Chennai Chapters of
The Indian Institute of Metals



IIM
The Indian Institute of Metals
Metallurgy Materials Engineering

About PRML

To perpetuate the strong scientific spirit and the value system which Dr. Placid Rodriguez practiced during his life time, “Dr. Placid Rodriguez Memorial Lecture” was instituted by The Indian Institute of Metals (IIM), in 2009, under the pioneering leadership of [Late] Dr. Baldev Raj, then Director, NIAS, Bangalore and former President, IIM. Since then, this event is being organised annually by the Kalpakkam and Chennai chapters of The IIM.

Dr. Placid Rodriguez, born in Quilon, Kerala on October 5, 1940, obtained his B.Sc. from Kerala University, B.E.(Metallurgy) from the Indian Institute of Science, Bangalore, M.S. from University of Tennessee, USA, Ph.D. from IISc and MBA from IGNOU. He joined the Department of Atomic Energy in 1960 and moved to The Indira Gandhi Centre for Atomic Research, (then known as Reactor Research Centre) in 1974. He established one of the leading metallurgical research laboratory at Kalpakkam. He was Director of IGCAR, Kalpakkam from 1992 to 2000. Subsequently he served as the Chairman, Recruitment and Assessment Centre, DRDO, Delhi and Raja Ramanna Fellow and AICTE-INAE Distinguished Visiting Professor at IIT, Madras.

Dr. Placid Rodriguez had an exemplary career of four decades, leading research in metallurgy, materials development for fast reactor programme of our country, shaping up human resources in defence programme and academic institutions. Dr. Placid Rodriguez has been a member of Editorial Board of several reputed international journals in Metallurgy and Materials Science and was the Chief Editor of Transactions of The Indian Institute of Metals. Dr. Placid Rodriguez served as the President of many leading national, professional institutes. Dr. Placid Rodriguez has been a recipient of many national and international awards. He has been a Fellow of many prestigious Academies of our country.

Dr. Placid Rodriguez passed away in Chennai on 31st August, 2008.

Previous Placid Rodriguez Memorial Lectures have been delivered by

- **Prof. Atul Chokshi**, Indian Institute of Science, Bangalore (2009)
- **Prof. Seeram Ramakrishna**, National University of Singapore (2010)
- **Dr. Srikanth**, Director, NML, Jamshedpur. (2011)
- **Prof. B.S. Murty**, IIT Madras, Chennai (2012)
- **Prof. Indranil Manna**, Director, IIT Kanpur (2013)
- **Dr. Amol A. Gokhale**, Director, DMRL Hyderabad (2014)
- **Dr. G. K. Dey**, Associate Director, Materials Group, BARC, Mumbai (2015)
- **Dr. A.K. Bhaduri**, Director, IGCAR, Kalpakkam (2016)
- **Dr. U. Kamachi Mudali**, Chairman & Chief Executive, HWB, Mumbai (2017)
- **Dr. Samir V. Kamat**, Director General, (Naval Systems) DRDO (2018)
- **Shri. S. Somnath**, Director, VSSC, ISRO, Trivandrum (2019)
- **Dr. Surya R. Kalidindi**, Georgia Institute of Technology, Atlanta, USA (2020)
- **Dr. B. Venkatraman**, Director, IGCAR Kalpakkam (2021)
- **Dr. Debashish Bhattacharjee**, TATA Steel (2022)

Curriculum Vitae



The Indian Institute of Metals
Metallurgy Materials Engineering



Dr. Komal Kapoor **Chairman & Chief Executive** **Nuclear Fuel Complex** **Hyderabad**

Dr. Komal Kapoor is the Outstanding Scientist & Chief Executive of Nuclear Fuel Complex (NFC) and the Chairman of NFC Board.

Dr. Kapoor is a Metallurgical Engineer from the 33rd batch of BARC Training School, Mumbai. Subsequently, he was posted to NFC and served in various capacities for more than three decades. He has obtained Doctorate degree in Metallurgical Engineering and Materials Science from the Indian Institute of Technology (IIT), Mumbai. Dr. Kapoor is an Adjunct Professor in Homi Bhabha National Institute (HBNI), Mumbai and the Guest Faculty at the University of Hyderabad (UoH).

Dr. Kapoor possesses extensive knowledge of nuclear fuel cycles and materials. His research work has led to the development of several critical nuclear materials which are of great technical importance.

Dr. Kapoor is also responsible for numerous research collaborations with various national and international institutions in Nuclear Engineering. For his invaluable contributions in this field, Dr. Kapoor has been conferred with the several prominent Awards and Honours. He has to his credit over 100 Publications in National/International Journals of repute and Symposia.

Dr. Kapoor serves on the Boards of Uranium Corporation of India Limited (UCIL) and the Indian Rare Earths Limited (IREL) and the Council Member of Atomic Minerals Directorate (AMD).

Dr. Kapoor is the Chairman of Indian Society for Non-destructive Testing (ISNT) Hyderabad Chapter, Vice-President of Indian Institute of Metals (IIM) Kolkata, Vice-Chairman of Indian Institute of Metals (IIM) Hyderabad Chapter, Vice-President of Society for Failure Analysis (SFA)-India, Life Member of Indian Nuclear Society.

Role of Texture in Fabrication and Performance of Alloys in Nuclear Applications



Dr. Komal Kapoor

Chairman & Chief Executive, Nuclear Fuel Complex, Hyderabad

Abstract

Crystallographic texture in polycrystalline materials is known to have a significant impact in fabrication and performance of alloy components. Alloys used in Nuclear Application are subjected to highly demanding conditions during its duty cycle. The fabrication routes are developed to tailor the properties by obtaining favorable crystallographic texture. This paper elucidates the role of processing in development and evolution of texture and its influence on material properties in Zirconium, Iron and Nickel-based alloys finding applications in nuclear domain.

Various manufacturing stages in Zirconium alloys from Sponge production; hot working by forging and extrusion; cold working by rolling, pilgering, and drawing and heat-treatment result in preferred orientation of grains known as texture. One of the most critical failure mechanisms for Zirconium alloys is the delayed hydride cracking (DHC). The texture influences the threshold stress intensity (K_{IH}) for crack propagation and the velocity of the crack propagation (V_c) under the DHC. Similarly, the irradiation enhanced creep and growth are influenced by texture.

The formation of texture in Zirconium alloys varies based on the microstructure. A comparison study of texture in Zr-based single (Zircaloy-4) and two phase alloy (Zr-2.5Nb) revealed that cold working of the two-phase alloy with soft β phase along α - α boundary does not alter prior texture, whereas high constraint of grain-to-grain interaction in single phase Zircaloy-4 results in orientation changes thus altering texture.

It was observed that texture in Zr-2.5Nb material remains unaffected by the initial ingot processing routes although the microstructure, tensile properties at the final stage are affected by the process schedule adopted for manufacture of the ingots. Processing of these tubes involves thermo-mechanical steps affecting the morphology of the metastable β -Zr phase. On the contrary, the final texture remains same as that obtained in the last hot processing step (extrusion in this case) and independent on the prior hot working routes for the ingots.

Texture formation during TIG welding in the fusion (FZ) and the heat-affected zone (HAZ) was studied. Exposure to high temperatures (above ~ 1170 K) during welding takes the FZ and HAZ in β phase and on rapid cooling, martensitic transformation to supersaturated α maintaining orientation relationship, $\{110\}\beta // (0001)\alpha$ and $[111]\beta // [11\ 20]\alpha$ in the presence of thermal stresses leads to texture formation in HAZ and FZ.

Development of texture as a function of cold work and annealing temperature was studied in extruded and annealed Fe-based advanced steel alloy bar of 18Cr Oxide Dispersion Strengthened (ODS). Deformed tubes of 18Cr ODS was found with alpha and gamma fibre texture with excitation of different components depending on amount of cold work. Substructure initiates at 1150°C and texture transformed from alpha/gamma fibre to near $\{011\} \langle 100 \rangle$ (Goss)/ $\{011\} \langle 21 \rangle$ (Brass) orientation. It is suspected that the texture transforms through high energy boundaries of high mobility associated with a misorientation range of 15 - 45° .

The morphology of the intergranular carbides formed during thermal treatment found to have a strong dependence on the grain boundary character distribution GBCD in the microstructure. High temperature faceted carbides were found to improve the IGC resistance.

Dr. Placid Rodriguez Memorial Lecture - 2023

05 October 2023 (Thursday)

15:00 hrs

Sarabhai Auditorium
IGCAR Kalpakkam



PROGRAMME

Welcome Address

Dr. M. Vasudevan

Chairman, IIM Kalpakkam Chapter
Associate Director, MDTG, MMG, IGCAR

About PRML Series

Prof. M. Kamaraj

Chairman, PRML Committee
Dept. of Metallurgical & Materials Engg.,
IIT Madras

Presidential Address

Dr. B. Venkatraman

Distinguished Scientist & Director
IGCAR

Introducing PRML Speaker

Dr. G.V. Prasad Reddy

Secretary, IIM Kalpakkam Chapter
Head, CSS, MMD, MMG, IGCAR

PRML 2023 Lecture

Dr. Komal Kapoor

Chairman & Chief Executive
Nuclear Fuel Complex, Hyderabad

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Vote of Thanks

Dr. V. Karthik

Convener, PRML
Head, HMTD, MMG, IGCAR

Kindly join for High Tea at Foyer after the event

-PRML Committee

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