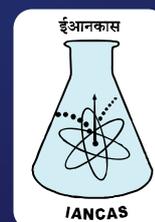


# Nuclear and Reactor Materials



*Edited By*

**Suresh Chandra Parida  
Prasanta Kumar Mohapatra  
Vivek Bhasin**



**An IANCAS  
Publication**

## About the book

Materials play a vital role in sustainable development of nuclear industry. Research and development in this fertile area needs to be augmented both at National Laboratories as well as at University levels. In view of this, clear and concise text books at fundamental level is a useful resource for the beginners. The first such book in India on Nuclear Materials was authored by Dr. D.D. Sood in the year 1996 and its second edition appeared in 2016. This classic book served as a ready reference book and is popular among the fraternity of nuclear chemists, nuclear physicists and materials scientists in the Department of Atomic Energy. Over the years, it is felt that an elaborative descriptions of each chapter would create further interest among the readers in this field which paved the way for the birth of this new book on Nuclear and Reactor Materials.

The authors who have contributed to various chapters in this book are practitioner in nuclear science and technology having experience in research and development. Indian Association of Nuclear Chemists and Allied Scientists (IANCAS) provides the platform for publishing and popularising this book among the scientists, engineers, educationist throughout the country.

We hope this book will provide the essential foundation knowledge to both beginners as well as practitioners in the field of nuclear chemistry, physics and materials science to further research and development in nuclear science.

**Editors**



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**SURESH CHANDRA PARIDA  
PRASANTA KUMAR MOHAPATRA  
VIVEK BHASIN**

**MARCH, 2025**

**Title:**

Nuclear and Reactor Materials

**Editors:**

Suresh Chandra Parida, Prasanta Kumar Mohapatra and Vivek Bhasin

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**Published by:**

Indian Association of Nuclear Chemists and Allied Scientists (IANCAS)

C/o: Radiochemistry Division

Bhabha Atomic Research Centre

Trombay, Mumbai 400 085

India

**Printed by:**

Prudent Art & Fab Pvt Ltd

A-221, TTC Industrial Area,

MIDC., Mahape, Navi Mumbai - 400701

**First Edition:** 2025

**ISBN:** 978-81-977536-2-6

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## Preface

The notable work of physicist Enrico Fermi on irradiation of Uranium with neutrons in 1934 for exploring heavier elements, the subsequent work by chemists Otto Hahn and Fritz Strassmann in the year 1938 on chemical separation of Barium in the Uranium-neutron bombardment experiment, and the scientific explanation of the events by physicists Lise Meitner and Otto Frisch in 1939 lead to the discovery of "Fission" in Uranium. This discovery orchestrated to a scientific renaissance in the field of nuclear chemistry and nuclear physics and lead to the development of the first nuclear reactor "Chicago Pile" (CP-1) which was built under the west stands of Stagg Field at the University of Chicago on a squash court and went critical on December 2, 1942. A variety of materials were used in this reactor; uranium in both as metal as well as in the oxide form as the fuel, carbon in the graphite form as the moderator, atmospheric air as the coolant, cadmium as the control material, and wood as the structural material.

Compared to Chicago Pile, the modern Generation-IV reactors have seen a plethora of changes in materials design pertaining to fuel, moderator, coolant, structural materials, etc., in addition to other engineering design features. With the ever increasing demand for nuclear energy, which is considered as one of the Green Energy sources, materials play a vital role in sustainable development of nuclear industry. Research and development in this fertile area needs to be augmented both at National Laboratories as well as at University levels. In view of this, a clear and concise text book at fundamental level is a useful resource for the beginners. The first such book in India on Nuclear Materials was authored by Dr. D.D. Sood in the year 1996 and its second edition appeared in 2016. This classic book served as a ready reference book and is popular among the fraternity of nuclear chemists, nuclear physicists and materials scientists in the Department of Atomic Energy. Over the years, it is felt that an elaborative descriptions of each chapter would create further interest among the readers in this field which paved the way for the birth of this new book on Nuclear and Reactor Materials.

While naming the book, we have considered that nuclear materials refer to any source material or special fissionable material as defined in the Statute of the IAEA (International Atomic Energy Agency); whereas reactor materials refer to the various types of materials used in nuclear reactors; including fuel and fertile materials, cladding, structural components, moderators, reflectors, coolants, control materials, shielding materials, thermal insulation materials, and structural materials.

The authors who have contributed to various chapters in this book are practitioner in nuclear science and technology having experience in research and development. The book contains eight chapters. Chapter 1 deals with introduction, Chapter 2 deals with Thorium, Chapter 3 with Uranium, Chapter 4 with Plutonium, Chapter 5 with Zirconium, Chapter 6 with Beryllium, Chapter 7 with Boron, Graphite and Heavy Water and finally Chapter 8 with Rare Earth Elements. Indian Association of Nuclear Chemists and Allied Scientists (IANCAS) provides the platform for publishing and popularising this book among the scientists, engineers, educationist throughout the country.

We hope this book will provide the essential foundation knowledge to both beginners as well as practitioners in the field of nuclear science to further research and development in this important area.

**Editors**

## About the Editors



**Suresh Chandra Parida** is currently the Head, Product Development Division of Bhabha Atomic Research Centre, Mumbai, India. His areas of expertise include thermodynamics of materials, actinide chemistry and hydrogen storage materials. He is a professor at Homi Bhabha National Institute. He has more than 90 publications to his credit. Dr. Parida is the Vice-president of Indian Association of Nuclear Chemists and Allied Scientists.



**Prasanta Kumar Mohapatra** is the former Director, Radiochemistry and Isotope Group of Bhabha Atomic Research Centre, Mumbai, India. His research interests include separation of actinides and fission products using novel extractants, novel solvents like ionic liquids and novel separation techniques including liquid membranes. Dr. Mohapatra is the President of Indian Association of Nuclear Chemists and Allied Scientists.



**Shri Vivek Bhasin**, is currently the Director, Bhabha Atomic Research Centre, Mumbai, India. He has contributed in the area of development of nuclear fuels, nuclear reactor components designing and structural integrity assessment of power reactors. He has more than 300 publications to his credit.