# SAMSONOV MEMORIAL INTERNATIONAL LECTURE SERIES ON INORGANIC MATERIALS

## 9th Annual Lecture

**DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING**
**INDIAN INSTITUTE OF TECHNOLOGY KANPUR**

# Rare Earth Permanent Magnets: Where Do We Go from Here?


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**Day : 4th March, 2020** | **Place : L-16** | **Time : 5:30 PM**

## About the Speaker

Dr. Gokhale did his B Tech in Metallurgical Engineering from IIT Bombay in 1978, and MS and PhD in Metallurgical Engineering from University of Pittsburgh, USA in 1980 and 1985, respectively. He served in DRDO for 30 years, retiring as Distinguished Scientist and Director, Defence Metallurgical Research Laboratory, Hyderabad in July 2015. At DMRL, he led research on aluminium lithium alloys for Light Combat Aircraft and INSAT series satellites, aluminium alloy components for torpedoes, crash resistant aluminium foams, additive manufacturing, and very high temperature materials for hypersonic vehicles. In August 2015, he was re-employed as Professor in the Department of Mechanical Engineering in IIT Bombay, where he teaches courses on "Processing of Aerospace Materials" and "Structural Materials". He is pursuing research in processing and oxidation of niobium alloys, shock and blast mitigation by foams and sandwich structures, damage assisted machining of Ni base superalloys, etc.

He has been recipient of several awards from the University of Pittsburgh, DRDO, National Research and Development Corporation and the Indian Institute of Metals, and is a Fellow of the Indian National Academy of Engineering. He serves on national committees of NITI Aayog, the Ministry of Defence, Department of Science and Technology, Indian National Academy of Engineering, National Institute for Foundry and Forge Technology etc. He is the Chairman, Steering Committee, Aeronautical Research and Development Board, DRDO since January 2017. He is the Chairman of Research Council of National Metallurgical Laboratory Jamshedpur and Vice-President of the Indian Institute of Metals.

## Abstract


The advent of rare earth permanent magnets(REPMs) brought considerable level of revolution in the electrical industry that was never visualized to be feasible with conventional magnets such as alnicos, hard ferrites etc. Among various REPMs, a combination of high remanence (Br~ 9-14.6kG), large coercivity (Hci~12-25kOe) and, thus, maximum energy density / energy product [(BH)max.~ 18-54 MGOe], useful for realization of high device performance coupled with maximum device miniaturization, is derived from SmCo5, Sm2Co17 and Nd-Fe-B.Therefore, electric vehicles, wind power generators, memory devices, medical diagnostic equipment, rockets and missiles, mineral enrichment equipment are all critically depend on the availability of REPMs in large quantity and also in high quality.The synthesis of REPMs involves various steps which include mineral beneficiation, rare earth oxide production, conversion to metals and alloys, processing the alloys into magnet products and finally applying coating for corrosion protection. India is endowed with moderate deposits of rare earth ores, and has established production capabilities for rare earth oxides and other compounds from the mineral. While extraction of pure rare earth or alloy of rare earth iron/cobalt from its oxide/salts has been reportedly carried out in some national laboratories, its end use in making magnets for practical application has not yet been demonstrated. However,laboratory scale development of magnets based on Sm-Co and Nd-Fe-B alloys,starting from imported rare earth metal and rare earth alloys, has been demonstrated and its practical use in some strategic devices has also been successfully tested and verified. With widespread application of Nd-Fe-B magnets which offer very highenergy density(35-54MGOe) at affordable cost, a few firms in the country engaged in procuring these magnets in bulk form from China and routinely selling them after carrying out cutting/machining operations as to meet the size and shape as per user requirement.

In aiming to indigenise the development of rare earth magnets in the country, particularly Nd-Fe-B as it portends large scale usage, a few technology gaps remain, which include oxide to metal production, metal to magnet commercial production, product innovation and magnet recycling. Also, recovery of other rare earths not used in magnets but useful elsewhere is not practiced within the country.

The talk will give highlights of the different links in the rare earth ore-to-product value chain. It will discuss proposed ways to close the critical technology gaps, as well as suggest policy interventions to make the Indian product internationally competitive. Finally, the role of the Indian scientists and engineers in shaping future science and technology of rare earth permanent magnets will be presented.


## Professor G.V. Samsonov (1918-1975)

Professor Grigorii Valentinovich Samsonov was born on 15th February 1918 in a town near Leningrad (now St. Petersburg). After earning his first degree at the Nonferrous Metals Institute in Moscow, he joined Soviet Navy. At the end of the Second World War, he was stationed in the Soviet occupied zone of Austria. It was here he became intimately connected with the extensive refractory metal and their compounds. After the cessation of the war, Samsonov returned to Moscow and resumed his higher studies and research under the guidance of Professor M. A. Merson (Institute of Steel and Alloys), a noted powder metallurgist of the then USSR. After completion of his Ph.D. degree, Samsonov joined the Institute of Metalkeramika (powder metallurgy) in the Ukrainian Academy of Science at Kiev as a senior scientist. The Institute was later renamed 'Institute of Materials Problem'. Within few years, he was elevated to the post of Deputy Director. Simultaneously, he was invited to head the Powder Metallurgy Department of Kiev Institute of Technology. Samsonov's scientific activity began with the synthesis of inorganic compounds. Soon he extended his area in the study of structure-properties-processing-performance relations of inorganic materials. By structure he included all types: electronic, atomic, micro- and macro, although the electronic structure fascinated him the most. To achieve this goal he insisted on the crucial bond between chemistry and physics. Samsonov authored nearly 1500 papers and authored/edited 50 books and monographs. One of the seminal books authored by Samsonov is 'Configurational Model of Matter'. Probably, there is no paper on refractory compounds, where he is not referred. The inorganic compounds in which Professor Samsonov contributed were carbides, nitrides, borides, silicides, germanides, selenides, phosphides, etc. He has also investigated in detail the hard cermets based on refractory compounds. His numerable past students are spread throughout the world.

## About the Donor

Prof. Gopal Shankar Upadhyaya joined the department of Metallurgical Engineering (now Materials Science and Engineering) at the Indian Institute of Technology Kanpur as Professor in the year 1976. Prior to that he was Associate professor at the University of Roorkee (now IIT Roorkee) from 1964-1975. He was awarded doctorate degree from the Kiev Institute of Technology, Ukraine in 1969 under the guidance of internationally renowned Materials Scientist Professor G.V. Samsonov. Professor Upadhyaya's publications list exceeds 300 papers and 16 authored/edited books. He has served on the Advisory Boards of practically all the major conferences and journals in powder metallurgy. Professor Upadhyaya's past graduate and doctorate students are actively engaged in powder metallurgy research and industry. After retiring from IIT Kanpur (in 2001), Professor Upadhyaya currently resides in Varanasi.

**Previous Speakers**

2012 : Professor E.J. Mittemeijer (Max Planck Institute for Materials Science, University of Stuttgart, Stuttgart, Germany)

2013 : Professor G.S. Upadhyaya (Formerly, Professor IIT Kanpur)

2014 : Professor R.A. Andrievski (Institute of Problems of Chemical Physics, Russian Academy of Sciences)

2015 : Professor K.A. Padmanabhan (Formerly Director IIT Kanpur)

2016 : Professor H. Danninger (Technische Universitat Wien, Vienna, Austria)

2017 : Professor P. K. Rohatgi (University of Wisconsin– Milwaukee, USA)

2018 : Dr. S. V. Kamat, (Defence Research Development Organization, India)

2019 : Dr. Janusz S. Konstanty, Professor at AGH-University of Science & Technology, Krakow, Poland