For Private Circulation Only

★★★★★ FIVE STAR CHAPTER

ASM International, Pune Chapter

Chapter News Letter

Office Bearers

B. R. Galgali	Dr. Sanjay Arole	Rahul Gupta	Y. S. Gowaikar
Chairman	*Vice Chairman*	*Secretary*	*Treasurer*

Issue No. : 17 | Editor - Udayan Pathak | Chairman, News Letter Committee - Louis F. Vaz | August 2016

EDITORIAL...

It's my pleasure to bring this newsletter to you. Team ASM Pune is committed to excellence! This is reflected in the Awards received by our Chapter. This year, our Chapter received Three Awards viz., Innovative Programming, Communication and Membership Recruitment & Recognition. Congratulations to all of us.

In this issue we have added two new colums – Book Review & Women Metallurgist Speaks. Dr P Pradip reviewed two books, related to Ancient Indian Metallurgy. I am sure you will find this interesting. Ruta Barve of Cummins India, Pune has given her views and experience in the column titled - "Women Metallurgist Speaks". This will be definitely interesting and inspiring to all.

This issue includes the Report & Photographs of International Conference- "Materials & Manufacturing Technology - M&MT 2016 & Exhibition organized by our chapter.

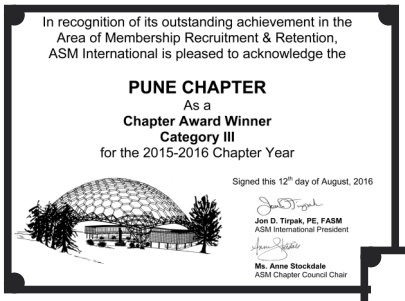
Chapter News will take you through the recent happenings in the chapter – you might have missed a few. Chapter member's introduction provides platform for you to know more about one of the new members Mr. Arun Adiverekar.

With the Best wishes & Happy reading!

Udayan Pathak (Editor)

ASM International, Pune Chapter Bags 3 Awards

ASM Head Quarter has been recognizing Chapter activities through Five Star Awards & Chapter of Excellence Awards. Our Pune Chapter received Five Star Award for consecutive Seven Years and Chapter of Excellence Award for Two consecutive Years. These chapter awards are reorganized since 2012-13. In place of 'Five Star Award" and "Chapter of Excellence award", Chapter awards in various categories like - Student Outreach, Innovative Programming, Young Professional Engagement, Communications, Membership Recruitment and Recognition are instituted. Any chapter can apply for and receive maximum Three Awards. This year we are proud to get three awards viz., Innovative Programming, Membership Recruitment & Recognition and communication . This was possible only due to your continued support to Chapter activities. Our Chairman Mr. B R Galgali received these awards at the hands of John Tripak, President, ASM International during Leadership Days at Cleveland, USA.

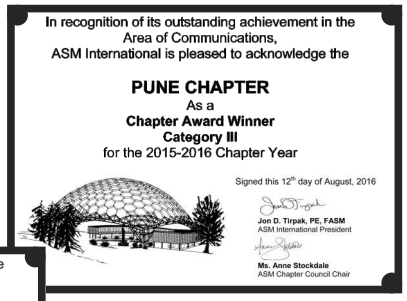

In recognition of its outstanding achievement in the Area of Membership Recruitment & Retention, ASM International is pleased to acknowledge the

PUNE CHAPTER
As a
Chapter Award Winner
Category III
for the 2015-2016 Chapter Year

Signed this 12th day of August, 2016

Jon D. Tirpak, PE, FASM
ASM International President

Ms. Anne Stockdale
ASM Chapter Council Chair

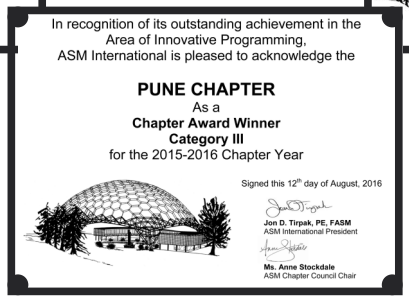

In recognition of its outstanding achievement in the Area of Communications, ASM International is pleased to acknowledge the

PUNE CHAPTER
As a
Chapter Award Winner
Category III
for the 2015-2016 Chapter Year

Signed this 12th day of August, 2016

Jon D. Tirpak, PE, FASM
ASM International President

Ms. Anne Stockdale
ASM Chapter Council Chair


In recognition of its outstanding achievement in the Area of Innovative Programming, ASM International is pleased to acknowledge the

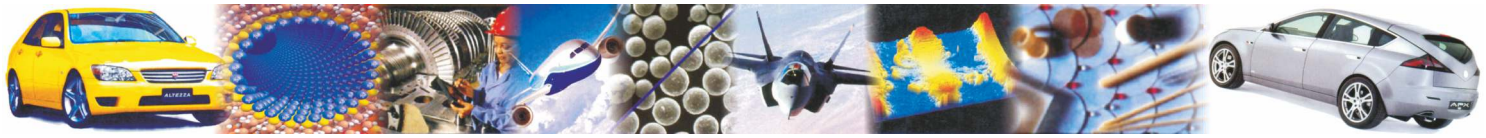
PUNE CHAPTER
As a
Chapter Award Winner
Category III
for the 2015-2016 Chapter Year

Signed this 12th day of August, 2016

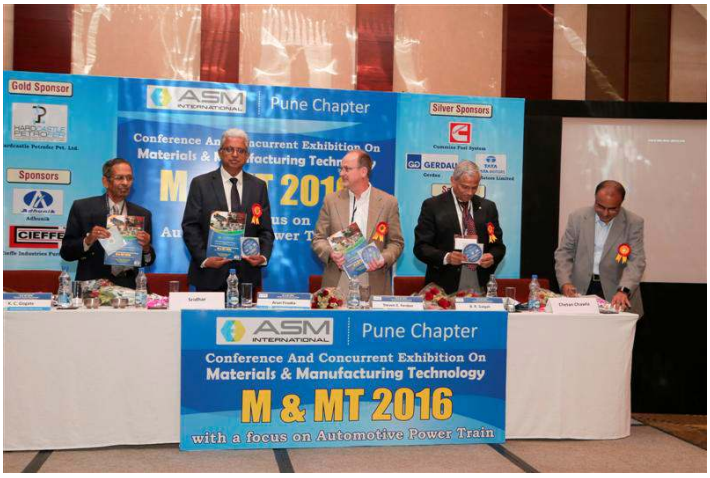
Jon D. Tirpak, PE, FASM
ASM International President

Ms. Anne Stockdale
ASM Chapter Council Chair

In this issue



M&MT 2016 Photo Gallery



Chairman's mail

Dear chapter members

Greetings! !

At the outset I would like to thank each one of you, your colleagues supporting industrial associates for the excellent support extended to our chapter.

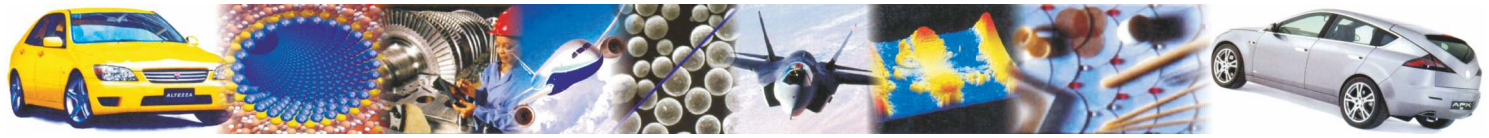
In fact because of all of you our chapter had won 3 awards in various categories & it was a pride moment for me to receive these awards on your behalf at the annual leadership days programme from ASM INTERNATIONAL President Mr John Tirpak.

All over the world new technology, adsorption &adoption have become buzzwords &ASM can play very crucial role in this .so let us carry forward this goal thru more vigour, voluntarism &enhancing our membership to mutual benefit &for the society at large

Wishing all the best

Bhimsen R Galgali

M&MT 2016 Photo Gallery



ASM Pune Chapter hosted a Conference and Concurrent Exhibition on Materials and Manufacturing Technologies, with a focus on Automotive Power Train on the 24th and 25th of February 2016, at Hotel Hyatt Regency, Pune.

The Conference was inaugurated by the Chief Guest – Mr. Arun Firodia, Chairman-Kinetic Group of Companies. Mr.Firodia gave a very informative talk at the inauguration. The exhibition stall was inaugurated by Mr.Krishnamoorthi, Managing Director-Gerdau India. There were 132 delegates who took part in the Conference. 22 companies had put up their stalls in the exhibition. The exhibition was open to all and the response was good.

In the two days a total of 16 Technical Papers were presented by renowned Speakers of International repute. There was also a session devoted to failure analysis.

Technical Article

Designing Nanomaterials for Vivid Applications

Bharat B. Kale*[1], N. R. Muniratnam[1] and Manjiri A. Mahadadalkar[1]

[1] Centre for Materials for Electronic Technology (C-MET), Ministry of Electronics and Information Technology (MeitY), Government of India, Panchawati, Off Pashan Road, Pune 411008, India. E-mail: kbbb1@yahoo.com

Abstract:

"Nano" is the key word of this era. It is a billionth (10^{-9}) part of some unit scale. Though the literal meaning of the word is 'small'; it is actually dominating the current endeavour of scientific research. With the help of these speciality materials miniaturization of devices is easily achievable. Although many nanomaterials are currently at the laboratory stage of manufacture, a few of them are on the verge of commercialization. Research on nanomaterials has actually changed the perspective of problem solving in many areas. This article gives an insight of colossal world of nanomaterials. The article begins with brief introduction to the necessity of nanomaterials, methods used for its synthesis. Applications of nanomaterials in various fields such as energy storage, renewable energy generation are also discussed in detailed.

Introduction:

Nanomaterials are the solids having dimensions in nano-meter (10^{-9}) range. The properties of these materials are characterised by a specific length scale (less than mean free path of electron), usually in nano-meter dimensions i.e. below ~100 nm. Nanoscience is the study of phenomena and manipulation of materials at atomic, molecular and macromalecular scales, where properties differ significantly from those at a

larger scale [1]. Nanotechnologies are the design, characterisation, production and application of structures, devices and systems by controlling shape and size on the nanoscale. Nanomaterials are the vital link between these two areas. Today, world is witnessing miracles of nanotechnology as technological advancements which were just ideas explored in 1980s, by Dr. Eric Drexler, who promoted the technological significance of nano-scale phenomena and devices through his books like 'Engines of creation: The coming Era of Nanotechnology' and 'Nanosystems: Molecular Machinery, Manufacturing and computation'[2].

If the physical size of material is reduced below this length scale, its properties like mechanical strength, thermal, optical, magnetic, conducting etc. change and become sensitive to its size and shape. The reason for the variation in properties with size of the materials arises due to extremely large surface to volume ratio. The number of surface atoms increases with decreasing particle size. These surface atoms play a dominant role in governing the electronic, optical and thermodynamic properties in nanomaterials. Having size between the molecular and bulk solid-state structures, nanomaterials have hybrid properties, which are not completely understood till today and remains a great challenge to theoreticians as well. The quantum mechanical (wavelike) properties of electrons inside matter are influenced by variations in the nanoscale. It is possible to design nanoscale materials and vary their micro and macroscopic properties, such as charge capacity, magnetization without changing their chemical composition.

Excursion for historical evidences of nanomaterials is an interesting tour in the past centuries, proving the excellence of human intelligence. In fourth-century A.D., Roman glassmakers were fabricating glasses containing nano size materials. The great variety of beautiful colours of the windows of medieval cathedrals, palaces are decorated with such glasses which are made by growing metal nanoparticles such as gold, silver, copper etc. with different particle sizes. An artefact from this period, the Lycurgus cup resides in the British Museum in London. The cup, which depicts the death of King Lycurgus, is made from soda lime glass containing silver and gold nanoparticles. The colour of the cup changes from green to deep red when a light source is placed inside it. The famous Damascus sword owes its strength to the presence of carbon nanotubes (CNTs) which were unknowingly mixed into the steel during processing for making these swords. The use of gold, copper, mercury NPs in the form of '*Swarna bhasma', 'Tamra bhasma' and 'parad bhasma*' (meaning ash of Gold, Copper and mercury respectively), for medicinal purposes started during the vedic period (1000 BC- 600 BC) in ancient India [3]. We have performed the characterisation of *'parad bhasma*' by scanning electron microscope which confirms its nanocrystalline nature as shown in Figure 1.

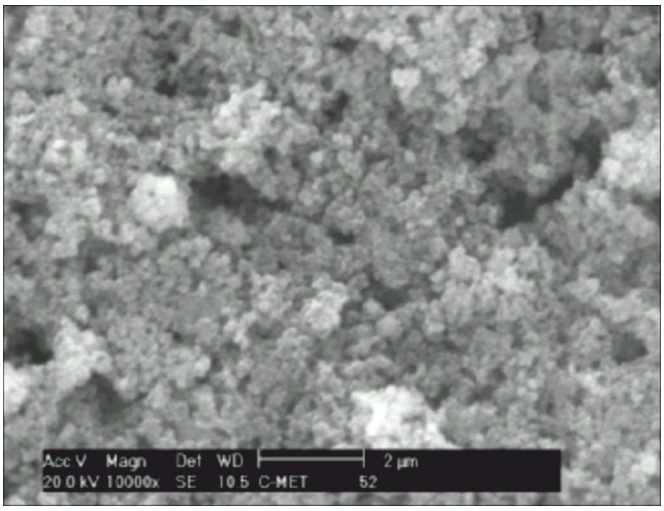
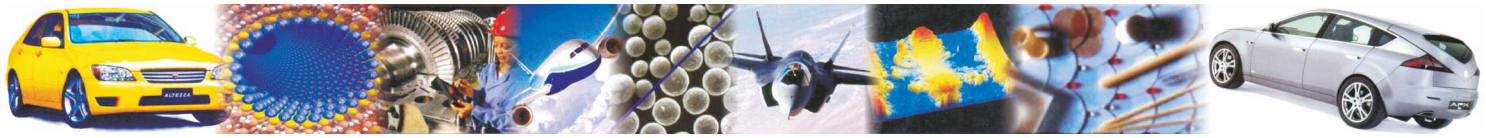


Figure 1: Typical Parad Bhasma micrsotructure of size 50-70nm

In past centuries preparation and use of nanomaterials was luck by chance or accidental phenomenon. But after realising the great potential for various applications of these materials researchers are putting enormous efforts to



discover new, simpler and versatile techniques of making the nanomaterials with desired shapes, sizes and properties. Nanomaterials can be synthesised by growing and shaping the materials by variety of physical, chemical, biological or hybrid methods. All the nanomaterials synthesis are often divided into two broad categories; 'Top down' and 'Bottom up' approach. In 'top down' approach materials are brought down from a larger size to nano-meter dimensions by cutting or shaping it. This involves mainly physical methods such as high energy ball milling, melt mixing, physical vapour deposition, laser ablation, sputter deposition, electric arc deposition, ion implantation etc.

On the other hand, it is also possible to start with atoms or molecules, bringing them together to make the required particles of nano-meter size. This is known as 'bottom up' approach. This involves chemical, biological as well as hybrid methods of synthesis such as chemical reduction, hydrothermal, sol-gel, reverse micelles, template assisted synthesis, using biomembranes, DNA, enzymes and micro organism, electrochemical, chemical vapour deposition, particles arresting in glass, zeolites or polymers, micro emulsion method etc. Using these numerous synthesis techniques nanomaterials in various forms such as colloids, clusters, powders, tubes, rods, wires, thin films etc. are exhaustively prepared and studied by researchers all over the world. The selection of technique for synthesis also depends upon type of material of interest viz. Zero-dimensional (quantum dots), one dimensional (nanotubes, nanorods), two dimensional (nanosheets), three dimensional (nanospheres). Recently, we have demonstrated 3-dimentional flower, nanoprisms and nanowires of $CdIn_2S_4$ synthesised at different reaction conditions shown in figure 2. Self-assembly approach, in which assemblies of NPs are obtained by obvious behaviour of atoms or molecules in solution to form supramolecules and Bio-mimicing is also the fast emerging areas of research to dig up materials which can be useful, cost effective and better than previously available materials. In this article, different methods for synthesis of nanomaterials required for specific applications are discussed.

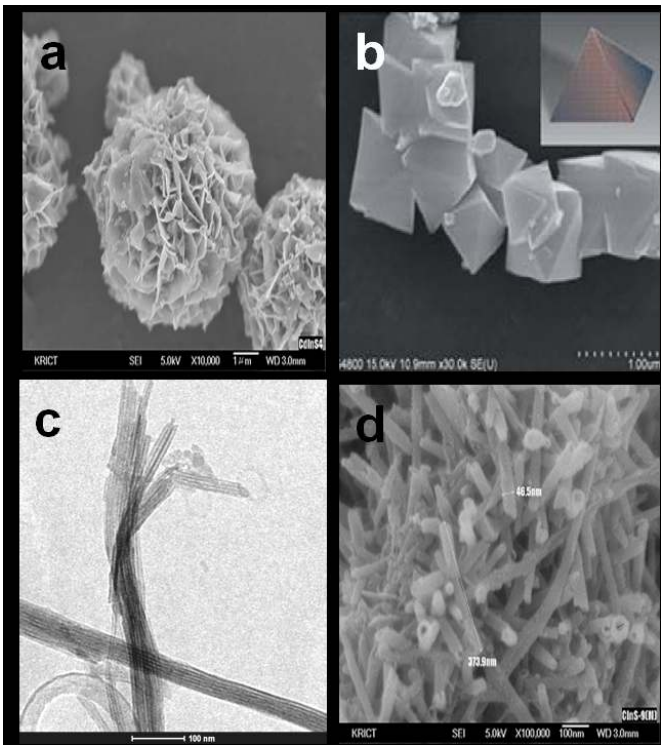


Figure 2: FESEM images of (a)3-dimentional flower (b)nanoprisms (c & d) nanowires of $CdIn_2S_4$ synthesised at different reaction conditions.

Energy Storage (Li-ion batteries):

Lithium-ion batteries (LIB) are essential for electric/hybrid vehicles, portable electronic device, and large scale power storage systems. It can also be used for economic and effective storage of electricity generated from solar, wind and nuclear energies. The principal performance criteria for these rechargeable batteries are safety, cost, charge-discharge cycle life, amount of energy stored per cycle at a given power requirement and environmental impact. New materials which can fulfil all these criteria are in high demand as electrodes, separators as well as electrolytes. Commercial graphitic anodes have low reversible capacity (372 mA h g^{-1}) hence, we are focussing on

the development of new electrode materials having high specific capacities and cyclabilities. More recently, binary metal sulfides/oxides such as MoS_2, MoO_2, CoS_2, In_2S_3, In_2O_3 etc., have been reported as possible alternatives to existing anode materials because of their higher capacities. We have synthesised graphene composite of ternary metal chalcogenides such as $CdIn_2S_4$ and $ZnIn_2S_4$ as an anode for (LIB) using simple one step hydrothermal route [4, 5]. Aqueous solutions of $ZnNO_3$, $In(NO_3)_2$ and thiourea are taken in stoichiometric preparations and calculated amount of GO is added to it. This reaction mixture was kept at 150˚C in an autoclave for 30 hours to obtain $ZnIn_2S_4$/graphene composite. The beauty of this method is both formation of $ZnIn_2S_4$ and conversion of GO to graphene takes place simultaneously. 3-dimensional hierarchical architecture of $ZnIn_2S_4$ nanopetals on the surface of multilayer graphene sheets is obtained. Schematic representation of stepwise formation mechanism is shown in Figure 3. It confer the charge capacities, 590 and 320 mA h g^{-1}, after 220 cycles as compared to their initial reversible capacities of 645 and 523 mAh g^{-1}, respectively when used as anode for LIBs. It shows high reversible capacity, excellent cyclic stability, and high-rate capability. The excellent performance is due to the nanostructuring of $ZnIn_2S_4$ and presence of a graphene layer, which acts as a channel for the supply of electron during the charge-discharge process.

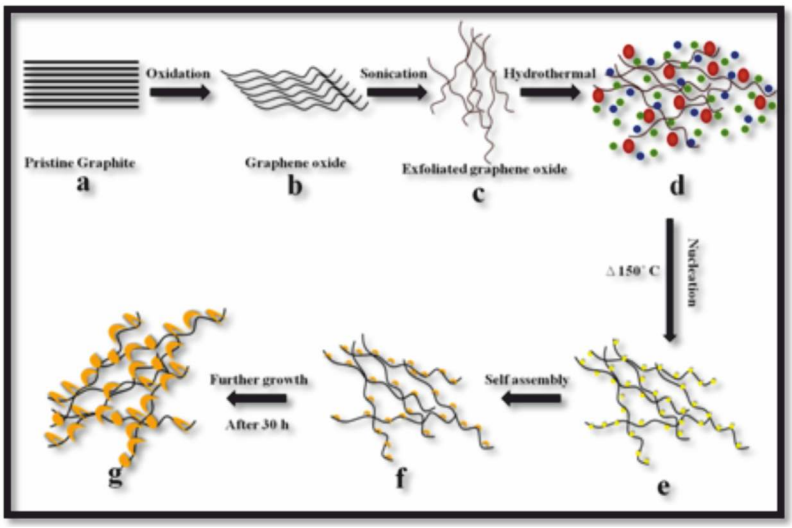
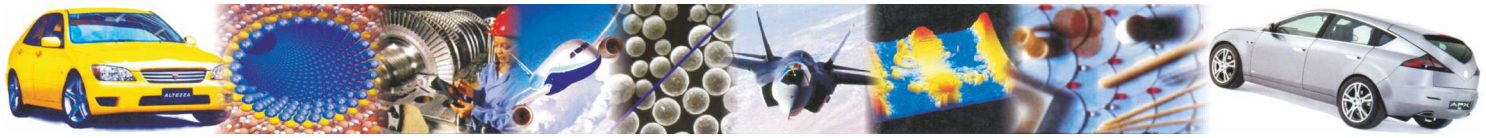


Figure 3: Schematic of formation mechanism of $ZnIn_2S_4$/graphene composite

Hydrogen Generation:

Hydrogen is future fuel. It is the most basic element and abundantly available in nature. It can provide emission free energy which can be a superior alternative for fossil fuels. It is an environment friendly fuel as compared to nuclear energy, gasoline, coal etc. The energy obtained from hydrogen is very powerful and efficient. It can propel spaceships at the same time it is safer than any other similar product to achieve such an energy-intensive task. It can be used in fuel cell to produce electricity with heat and water as only byproducts. Unlike non-renewable energy sources hydrogen can be produced on demand. Many industrial processes generates hydrogen from water and fossil fuels are use to break hydrogen from oxygen which involves emission of green house gases. To avoid these negative aspects; solar hydrogen production using nanomaterials has emerged as a novel trend. These nanostructured materials which are popularly known as photocatalysts utilize solar light to produce hydrogen from water, Hydrogen sulphide, glycerol etc. Many metal oxides, chalcogenides and their composites with polymers, carbanaceous materials are efficiently being used as solar light active photocatalysts. We have synthesised mesoporous MoS_2 honeycombs nanosheets using Solvothermal method. Ammonium heptamolybdate and thiourea are taken in stoichiometric proportions and dissolved in methanol. Reaction mixture is kept at 150˚C for 24 hours to obtain these beautiful mesoporous



MoS_2 honeycombs nanosheets which further annealed in inert atmosphere at 400˚C. FESEM images of MoS_2 honeycombs nanosheets are shown in figure 4. This synthesised material when used as photocatalyst for H_2S splitting generates 12555 $\mu molh^{-1}$ hydrogen. Crystallinity, surface structure, morphology, band gap are the key properties of this photocatalyst which makes it potential candidate for hydrogen production. This eco-friendly way of generating hydrogen is ultimate remedy to satisfy ever increasing energy demand.

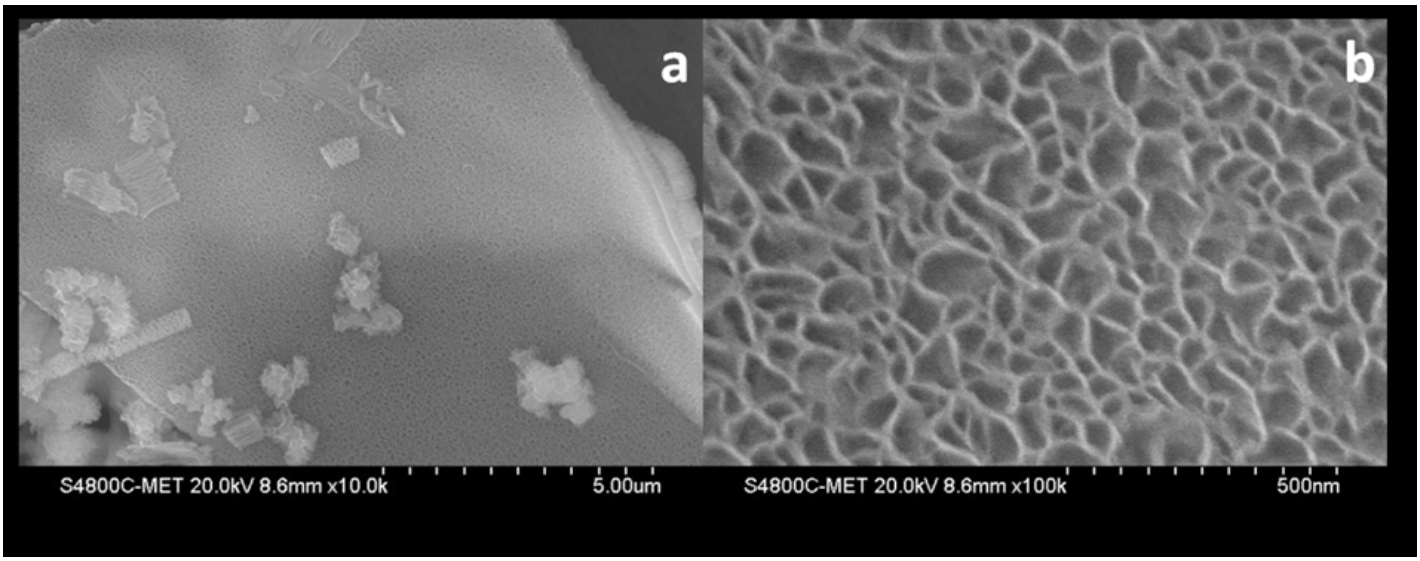


Figure 4: FESEM images of MoS_2 honeycombs nanosheets

Growth of semiconductor quantum dots in glasses for optical applications:

Semiconductor quantum dots (QDs) are important materials for numerous fundamental and applied areas of nanotechnology because of their unique physical and chemical properties. The effective control over size, shape and morphology of QDs during synthesis is very crucial to impart the desired properties in materials. To overcome this problem, we use a suitable confined matrix such as silicate, borosilicate, germanate glass to accommodate semiconductor nanoparticles. This glass matrix play an important role in surrounding semiconductor nanoparticles, structural phase transition and conferring unusual optical properties. Cadmium chalcogenide (CdX(X=S,Se,Te)) based glass nanocomposites show band gap energies covering a wide range of wavelengths from ultraviolet to near infrared region exhibiting high photoluminescence quantum yield. These Cd chalcogenide silica glass nanocomposites due to their sharp band gaps (yellow-to-red) used as cut off filters, phosphor, photovoltaic cell, field effect transistor, hetero-junction laser, acoustic amplifier, etc. Figure 5 shows various CdS glasses used as optical cut off filters synthesised in our laboratory.

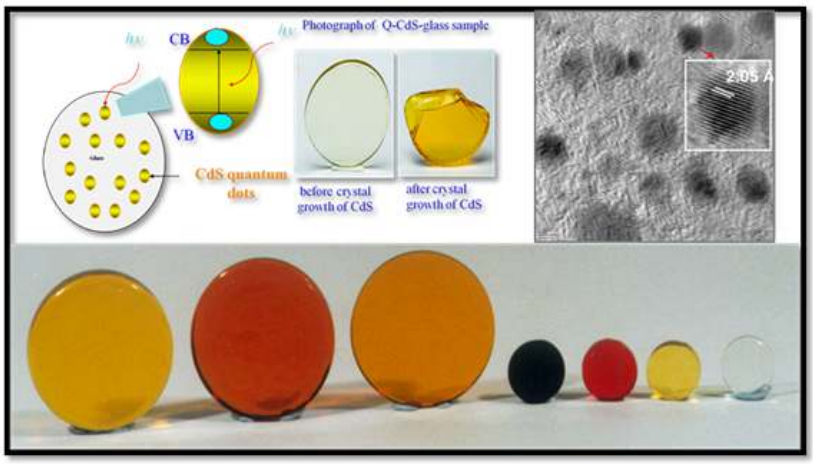


Figure 5: CdS glasses used as optical cut off filters

Conclusions:

Nanoscale phenomenon has already been applied in the form of product by our forefathers. This includes typical gold, silver nano coatings on stainless steel. The size quantization effect has been used to obtain different colours in glasses. The unique *ayurvedic* medicines which are generally used to treat primary diseases like viral infections and stomach problems the nanostructures are wisely used in *ayurved e.g. Parad Bhasma* or *kajjali.* Different shapes and sizes of nanomaterials play important role for variety of applications e.g. $CdIn_2S_4$ nano flowers, nano prisms, nanotubes for variety of applications. We have demonstrated application of such nanostructures in Li-ion batteries and hydrogen generation.

Acknowledgements:

Our group members are Dr. Milind Kulkarni, Dr. Sanjay Apte, Dr. Ravindra Sonavane, Mrs. Sonali Naik, Mr. Jalinder Ambekar, Dr. Rajendra Panmand, Dr. Ram Kalubarme, Dr. Ashwini Bhirud, Dr. Sunil Kadam. BBK is thankful to all these members for their contributions.

References:

1. Nanoscience and nanotechnologies: Opportunities and Uncertainties, The Royal Society and The Royal Academy of Engineering, London, (2004)
2. E.K. Drexler: Engines of creation: The Coming Era of Nanotechnology, Oxford University Press, Oxford (1990)
3. C. L. Brown, G. Bushell, M.W. Whitehouse, D.S. Agrawal, S.G. Tupe, K.M. Paknikar, E.R.T. Tiekink, Gold Bull. 40 (2007) 245
4. S. B. Kale, R. S. Kalubarme, M. A. Mahadadalkar, H. S. Jadhav, A. P. Bhirud, J. D. Ambekar, Chan-Jin Park, B. B. Kale, Phys. Chem. Chem. Phys. 17 (2015) 31850
5. M. A. Mahadadalkar, S. B. Kale, R. S. Kalubarme, A. P. Bhirud, J. D. Ambekar, S. W. Gosavi, M. V. Kulkarni, Chan-Jin Park, B. B. Kale, RSC Adv. 6 (2016) 34724
6. S. R. Kadam, D. J. Late, R. P. Panmand, M. V. Kulkarni, L. K. Nikam, S. W. Gosavi, Chan-Jin Park, B. B. Kale, J. Mater. Chem. A. 3 (2015) 21233

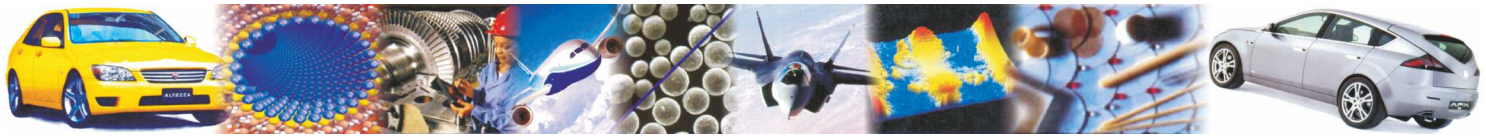
Author:

Dr. Bharat B. Kale

Director, Centre for Materials for Electronic Technology (C-MET), Ministry of Electronics and Information Technology (MeitY), Government of India, Panchawati, Off Pashan Road, Pune 411008, India.

He has over 25 years experience in nanomaterials synthesis for various applications such as photocatalysis, energy storage, solar cells, thermoelectric etc. He has more than 200 international research articles to his credit. He has filed for 30 patents & given many international presentations. Beside research his hobbies include badminton and music.

E-mail: kbbb1@yahoo.com



CHAPTER NEWS

Metrology In Product Quality & Role of Laboratory Accredition

A Technical Presentation on Metrology In Product Quality & Role of Laboratory Accredition by Mr. Nitin S. Kshirsagar Gen. Manager – QA & Calibration Technology (Head – Calibration Laboratory) WIKA Instruments India Pvt. Ltd., Pune

was held on Wed 3rd Feb 2016 by ASM Pune Chapter

Mr. Kshirsagar explained the meaning of Metrology, its evolution, and the definition of internationally accepted units of measurement. He also explained how World reference standards are maintained and how secondary standards are cloned from these reference standards.

The talk was well received by the audience.

Mr. Kshirsagar giving his presentation

1 Day Workshop on Nitriding Processes & Vacuum Heat Treatment was held jointly by ASM International, Pune Chapter and ARAI, Pune on 26th February 2016.

The Workshop was conducted by two International famous Speakers, Dr. Zoltan Kolozsvary and Mr. Gerald Hiller. The course provided an overview on the use of surface engineering processes and vacuum heat treating technologies to enhance the properties of steel. Modern approaches to surface engineering through vacuum carburizing, nitriding and nitrocarburizing were also discussed.

Product life in different service and environmental conditions were also discussed.

Faculty and Participants of the Workshop.

Metallurgy for Non Metallurgist

3 Day Proficiency Improvement Program on Metallurgy for Non Metallurgist was conducted by ARAI-Pune and ASM International-Pune Chapter and was held from 25th to 27th April 2016, at ARAI, Chakan, Pune.

The main aim of the program was to enable participants to gain understanding of fundamentals of metallurgy and bridging the gap between theory and practice. This training provided concise knowledge of metallurgy with a focus on industry applications.

This ASM course imparted an important knowledge for those who are not metallurgists, and it covered up metallurgy from history of metals to its fabrication into usable products.

The Faculty for the program comprised of Senior Materials Engineering Professionals from Industry & Senior Educationists.

SHOT PEENING – HOW TO CONVERT CUSTOMER EXPECTATIONS INTO REALITY

A Technical Presentation was held by ASM International Pune Chapter & M/s.Precicut Engineers, on “Shot Peening – How to convert Customer expectations into reality” on 11th May 2016 by Mr.Amit Aradhye, MD - Precicut Engineers.

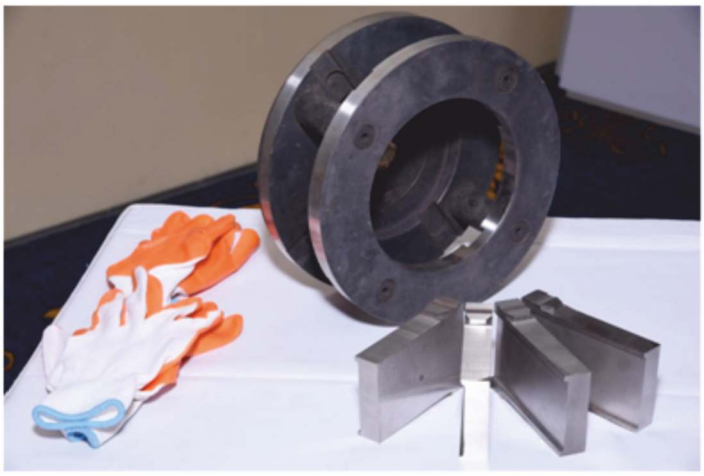
Mr. Aradhye gave a brief introduction to shot peening basics. In his short presentation he covered the following topics :

- Understanding the process standards and customer expectations.
- Mapping to match customer expectations with equipment and process.
- How to select an optimum shot peening equipment.
- Process establishment, process & equipment audits, process sheets.
- Process Optimization.
- Preserving equipment fitness for years of consistent shot peening results.

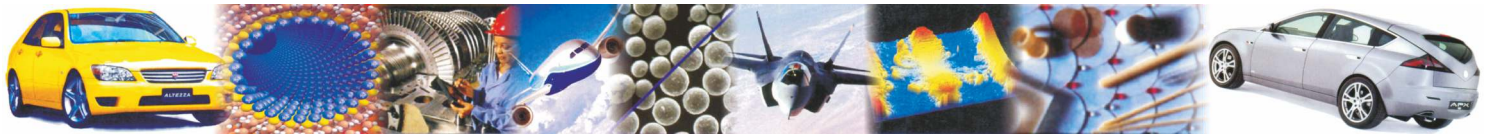
The presentation was well received by the audience, so much so that the question and answers session was dragged into the net-working dinner.

The audience at the presentation

Mr.Aradhye listening to a question.



Components of shot peening machine displayed



Latest developments in Nano based Metallurgical Coatings" by Dr. Milind Acharya

ASM Pune Chapter has started a new initiative of "knowledge sharing and networking meetings" , preferably once in a month.

The first such meeting was held on 22nd June 2016. at ASM International Pune chapter office. The topic was on "Latest developments in Nano based Metallurgical Coatings" by Dr. Milind Acharya

Dr. Milind Acharya in his presentation spoke on the latest development in Nano based Metallurgical coatings. He went on to explain how these coatings have helped industry and mankind in the day to day use of this technology.

His presentation was well received by the audience.

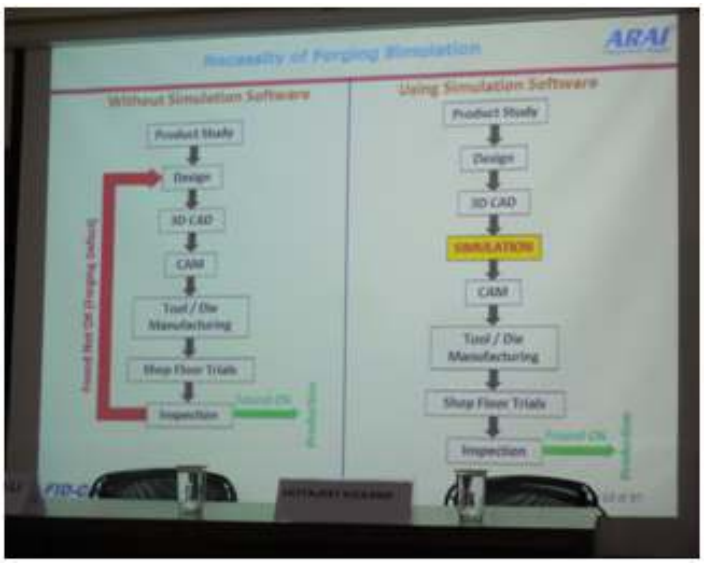
Dr. Acharya being felicitated at the end of his presentation.

Forging Simulations by Mr Satyajeet Kulkarni

As part of the"Knowledge sharing and Networking Meetings" ASM International Pune chapter conducted its second such monthly meeting on 20th July 2016.

Mr. Kulkarni from ARAI, Chakan, gave a very interesting and detailed lecture on forging Simulation.

Mr. Kulkarni seen delivering his lecture



One of the slide being presented

Women Metallurgist Speaks

What part of your job do you like most?

Subjectivity in responses of metals & heat treat processes to various conditions, makes my job interesting and challenging. Such work level challenges have always been an inspiration to re-join work on every Monday.

What is your engineering background?

I did my bachelor's degree in Metallurgical Engineering from College of Engineering Pune. I joined Cummins India Ltd as Graduate trainee engineer and worked in heat treatment shop for a year gaining a valuable hands-on shop-floor work experience. Later, worked in Materials Science Lab for little over three years and was responsible for Diesel Engine Valve Train components for Failure analysis, Metallurgical inspection, Supplier developments etc.

Ruta A. Kher - Barve
MSE & Engineering Quality Lead - CFSI Cummins Ltd.

With this 4 years stint in Materials Science World, I moved to a role in Supplier Quality function, where my experience from metallurgical world was an added advantage. I worked on development of various components of Diesel Engine like turbocharger, crankshafts, camshafts and on various metallurgical processes like Forgings, Castings, Phosphating and precision machining processes. My work involved mainly supplier quality related activities which gave me insight in supplier processes as well.

After working in Supplier Quality for 6 years, I reconsidered on returning back to my core field of Materials Science &took a role as Materials Science Engineering lead in Cummins Fuel Systems India. Here I support product development engineers to choose appropriate materials & heat treatprocesses for various components. Working with Suppliers to develop special heat treat processes for fuel system components has always been a challenge. In addition, working with steel mills to establish material source for fuel system components has always been a knowledge enriching activity. I also work on ferrous and non-ferrous materials, special purpose coatings, forgings, foundry, washing & cleaning processes….on and on… With every milestone I reach, yet there is so much to learn and explore in this magical world of materials science.

What attracted you to engineering?

When in school, I always liked Maths, Physics and Chemistry. In my family almost all of them are from engineering background. May be the basic inquisitiveness, always leading to the question "Why?",dragged me to engineering, to know much about "How".

How many people do you work with?

I work with different teams like product development teams, supplier development teams and supplier representatives. So it's actually kind of difficult to count.

If a young person approached you for career advice about pursuing engineering, what would you tell them?

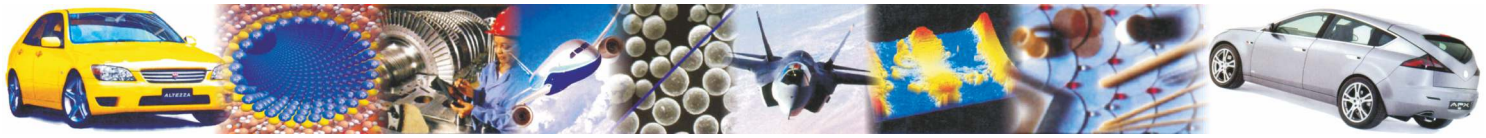
I would definitely encourage young students to join engineering and pursue it as their career only if they have thorough liking for it. I would advise them with a line from hindi movie “3 Idiots”, “Kabil bano, kamayabi apne app milegi”. I feel engineering to be more of a "passion" than "knowledge", since the knowledge always increases, the more passionate one becomes. Engineering colleges give a base to all their students, but it's always the passion that one carries which helps one learn& grow the knowledge with appropriate application, which thereby becomes a "Skillset".

Hobbies?

Love to participate in car rally and collect coins. I'm voracious reader and a jewellery freak.

Last book read?

“Lean in” by Sherryl Sandberg. Take away for me from this book is “Nobody feels 100% ready when an opportunity arise. So stop thinking you're not ready. Lean in.”

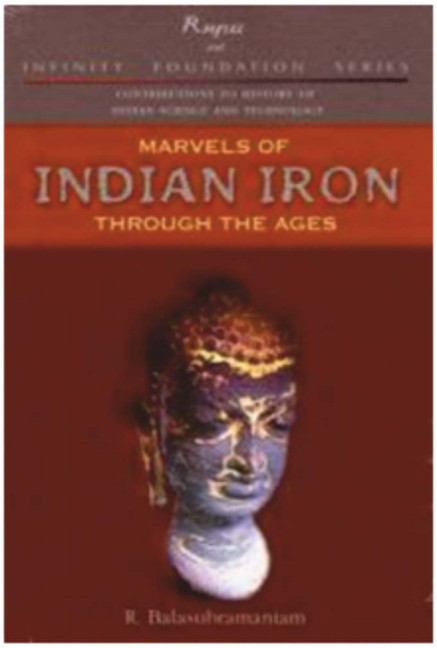


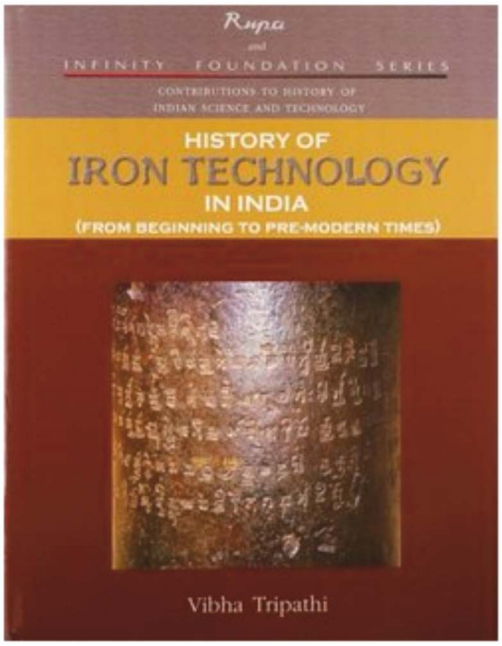
The Rise and Fall of Ancient India's Iron and Steel Metallurgy

Pradip reviews two new books on the history and products of ancient Indian iron and steel technology.

Infinity Foundation Series - Contributions to History of Indian Science and Technology Rupa and Co.

- Marvels of Indian Iron through the Ages by R. Balasubramanian (2008)
- History of Iron Technology in India - From Beginning to Premodern Times by VibhaTripathi (2008)





It is a well acknowledged fact that the level of societal development is closely linked to the development of iron and steel industry. It is no wonder therefore that the world production of steel today is around 1.4 billion tons per year, also emphasizing the importance of this technology to us in India. The production of iron ore (iron oxide), the basic natural raw material required to produce steel is more than two billions tons per year. Today, India is the fourth largest producer of iron ore (after China, Brazil, Australia) and the third largest consumer of steel (but consuming only 60 million tons of steel as compared to China which is consuming close to 500 million tons with a comparable population).

India is exporting around 50% of its iron ore production currently.

Despite India being a large producer and consumer of steel, it is not considered the source of new technologies today. It is therefore important to note that this was not case until the advent of British East India Company. Two books published recently on the iron and steel technology in ancient India up to Pre-British times are an important contribution to documenting the rise and decline of this technology in India. While the modern iron and steel technology was patented and commercialized in Europe in the mid-nineteenth century, our Indian craftsmen, more than two thousand years back, had mastered this technology of making excellent iron and steel. It is this fascinating saga of world class technological products being manufactured and exported to other parts of the world which is captured in the two recent volumes published as a part of the Infinity Foundation Series.

History of Iron Technology in India (From Beginning to Pre-modern Times), authored by VibhaTripathi, an eminent historian from Banaras Hindu University, covers the long span of Indian history stretching over three and a half millennia from the first half of the second millennium BCE to pre-modern times. It traces the development of iron technology from the humble beginning when Indian artisans melting relatively low temperature metals like copper, copper - zinc (brass) and copper - tin (bronze). They hit upon the process of producing iron and also evolved it into an advanced

technology and a flourishing industry, thereby becoming a supplier of the best iron and steel, on a tonnage scale, to all parts of the world.

With a systematic review of the recorded evidence, VibhaTripathi demolishes the myth that iron reached India through diffusion from the West as late as the sixth-fifth century BCE. She argues that there was an independent origin and development of iron ore mining, extraction and manufacturing technology rooted in the raw materials available in India. Well recognized occurrence of iron is reported around 1500 to 1000 BCE in all parts of India.

Tripathi refers to Arthashastra, a treatise on statecraft composed in the 4th-3rd century BCE, authored by Chanakya during Mauryan times. It mentions iron as "Kalyasa". There is even a discussion of mines as an important source of income for the Mauryan state. It mentions the post of superintendent of mines to supervise and manage the mines. It lays down the duties of the director of mines in detail.

In the sixth-fifth century BCE, Sushruta began surgery using surgical tools made of iron requiring precision and quality of the highest order. Varahamitra in his "khadgalakshanam" dated 550 AD, elaborated on the carburization and hardening processes of iron swords. Classification of different kinds of irons is included in the famous RasRatnaSamuchhaya, a tenth-twelfth century text on alchemy. For example, KantaLoha, TikshnaLoha and Munda having distinct properties are well documented in the text.

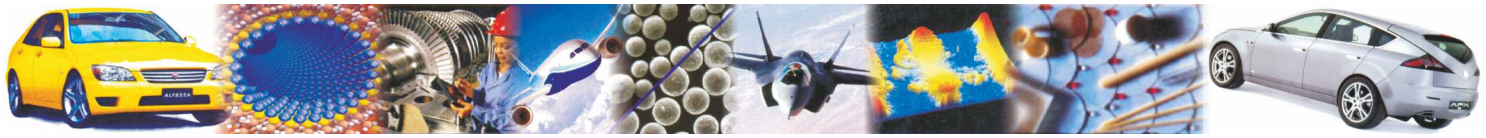
Iron production was sufficiently developed in India by the 4th-5th century CE. There was a flourishing trade between India and Iran, Iraq (Mesopotamia), Indonesia, China and Africa. There are references to rich Indian traders living in Mesopotamia. India received gold in return for export of copper, tin, lead and solid steel ingots, spices, drugs, cotton cloth, leather goods, precious stones and timber. The Indian metallurgical industry was one of the most advanced industries in the world at that time, according to VibhaTripathi.

Iron technology reached new heights of excellence during the Gupta period (3rd-to-6th centuries CE). Massive iron based artifacts such as the Delhi iron pillar testify to the level of metallurgical skills mastered by Indians. The processes such as rapid cooling, carbon alloying, quenching, tempering, hardening and forge welding were known to them. Large lead baths were being used to achieve uniform heating of a bundle of wrought iron bars to the forging temperature.

India is endowed with rich iron ore deposits and hence iron ore mining was being carried out in different parts of India for more than two thousand years. According to Dharmapal there were several important centres of iron ore mining, smelting and manufacture spread over from Kumaon-Garwhal to Assam, Hyderabad, Karnataka, Orissa, Bengal, Tamil Nadu and Madhya Pradesh. VibhaTripathi has referred to the documented evidence about the flourishing iron and steel industry in the late nineteenth and early twentieth century. Wages for workers were paid in kind. For example ordinary workers received 2-3% of the produce. The persons in charge of smelting house and forging house on the other hand received six and eight percent of the produce respectively.

Professor Balasubramaniam (Bala), a well known metallurgist from IIT Kanpur, in his book **Marvels of Indian Iron Through the Ages**, has documented the marvelous creations of the Indian craftsmen, the massive iron pillars, beams and cannons produced in different parts of India by forge welding the lumps of heated iron. The most famous example of the status of Indian technological excellence in the past is the magnificent Delhi iron pillar weighing seven tons, which remains an object of technological curiosity even today.

The fact that these massive iron objects have not corroded even after more than two thousand years has also been explained in terms of contemporary scientific understanding by Bala in this book. Furthermore, the book also contains a section on



the world renowned Wootz steel technology invented by Indians.

Forge-welded and non-corroding iron pillars and beams

As illustrated by Bala in the book, Indian artisans in the early days had not found a way to attain

a temperature of 1540 degrees centigrade (the temperature at which iron melts) and hence they could not cast iron (as they had done for copper, brass and bronze, for example by the famous lost wax process invented in India). Hence they practiced forge welding. The lumps of iron (containing traces of slag) were heated and fused together by a process known as forge welding.

This process to produce iron objects of a large diameter and weighing several tons is very well illustrated by Bala in the book. Documentary evidence is provided to substantiate the way these pillars, beams and cannons were manufactured and transported.

The famous iron pillar in Delhi was set up by the iron smiths in India in the Gupta period in a place called Udaygiri near Vidisha and Sanchi around 400 CE. It was later moved to Delhi by Iltumish in 1233 CE. The excellent corrosion resistance of iron pillar is attributed to the presence of phosphorous (using high phosphorous containing iron ores) in the reduced iron. Similar technology was used to produce an even longer pillar (13 meters) lying in three broken pieces in front of the Lal Masjid in Dhar, situated near Indore in Madhya Pradesh. Dhar was the capital of Malwa founded by King Bhoja (1010 - 1053 CE). Archaeological study indicates that the Dhar pillar was also erected during the Gupta period.

Another famous iron pillar at the Mookambika temple in Kodachari hill, located in a town near Mangalore, also belongs to the same era. The iron beams lying in the Surya temple at Konark are of even larger dimensions. These iron beams were used to support the roof stones of the famous temples at Bhubaneswar as well as Puri. In fact non-corroding iron beams were being used extensively in building temples in Orissa dating back to the sixth and thirteenth centuries CE.

Forge-welded iron cannons of India

According to Bala, the forgewelded cannons truly represent the mastery of iron ore mining, extraction and manufacturing technology of Indian blacksmiths. As opposed to cast iron cannon technology developed in Europe, Indians practiced forge welding technology and produced large cannons from direct-reduced wrought iron. Bala has described in detail the technology as well as the history of some of the most massive forge-welded iron cannons in the world which are scattered all over the Indian subcontinent - Thanjavur, Dhaka, Murshidabad, Bishnupur, Jhansi, Assam, Tripura, Gulbarga, Bijapur, Bidar, Golconda, Hyderabad, and many Deccan forts. The cannon technology was a crucial element in the rise and fall of several dynasties in India such as Mughals, Marathas, Sikhs and Rajputs. It is certain that the latest technologies prevalent in Europe were also known to Indians.

For example when the British defeated Tipu Sultan in 1799, they were astonished by the quality of his cannon. Nine hundred and twenty seven cannon were captured after the fall of Srirangapatnam in 1799. European colonizers used superior cast iron cannons and also systematically destroyed the forge-welded cannons from the Indian forts, according to Bala.

The above-mentioned examples illustrate the level of technological maturity achieved by Indian artisans and suggest the existence of a flourishing industry capable of producing iron and steel in hundreds of tons. It may be interesting to note that the British rated Indian iron highly and used it in preference to the iron produced by their own industry in making the famous "tubular bridge" in early nineteenth century across the Menai Straits in UK. It has also been recorded that 50 tons of Indian steel were used in the construction of the famous London Bridge in UK.

Wootz Steel

One of the greatest technological achievements to originate from the Indian subcontinent is Deccan Wootz Steel, often referred to as "the wonder material of the orient". The world famous Damascus swords were made of Wootz steel and these were considered to be the most prized possessions and gift items (certainly more precious than gold and silver) by the aristocracy. There is no evidence to show that any of the nations of antiquity besides the Indians were acquainted with the art of making steel. The word Wootz is a distortion of the Kannada-Telugu word Ukku, for steel.

Quintus Curtis records for example that a present of steel cakes was made to Alexander of Macedonia by Porus after his defeat in 326 BCE. Sir Robert Hadfield, a metallurgist, has reported on the possibility of the use of the chisels made of Indian steel and Indian craftsmen in the construction of the massive Egyptian pyramids.

Wootz steel is an iron carbon alloy containing 1 to 1.8% carbon produced by the crucible melting process invented in India. The basic process, even though not fully understood, consisted of heating direct reduced iron with other ingredients including charcoal contained in a closed clay crucible. The crucibles containing steel were carefully cooled so that the metal solidified at the bottom of the crucible. The Wootz steel cake was of high quality. That the cooling of the crucible was crucial was well known to Indian metallurgists of that era since different ways of cooling in the furnace itself, in dry sand heaps, in moist clay, or by quenching with water are all well documented. Carburization of iron to controlled levels of carbon is thus the key to manufacturing Wootz steel. This technology was mastered by Indians quite early in the history of civilization, as early as 810 BCE. Studies indicate that the crucibles excavated in Tamilnadu date back to 250 BCE.

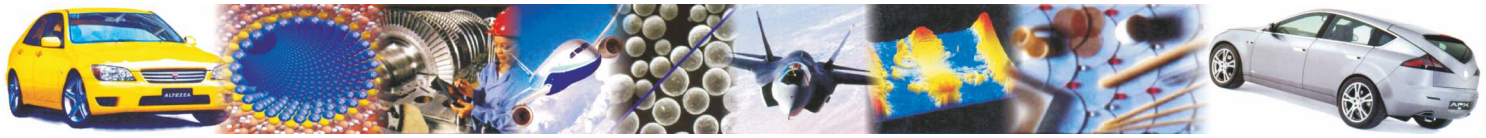
The blades made of Wootz steel showed an intricate wavy pattern on the surface. A judicious combination of high strength and excellent formability in steels to be able to make sharp blades remains a technological challenge to this day. In fact the rigorous research conducted to understand and master the Wootz steel technology in Europe laid the foundations of modern metallurgy.

Decline of Indian iron and steel industry in Pre-British era

Both VibhaTripathi and Balasubramaniam also discuss the possible reasons of the decline of the iron and steel industry in India. Tripathi has a separate section in her book where she brings out the possible reasons of the decline and death of the indigenous iron and steel industry in India with the advent of the British colonialists. It is interesting that the steel plants which were commissioned in the late nineteenth and early twentieth century in India were based on imported European technology and had no connection with traditional Indian technology perfected over centuries.

According to VibhaTripathi "With industrialization and imperial designs of foreign rule a decline set in…….. The iron industry could not withstand the onslaught of the colonial forces working against its interests in a planned way. Once the blast furnaces came into existence in Britain, production started at a much cheaper rate…It could hardly compete with the cheap British pig iron being imported. …. The laws enforcing non-felling of trees in the forest deprived the charcoal based indigenous iron industry of its very basic raw material. It made production of iron impossible. The powerful lobby in Britain succeeded." The colonizers succeeded in enslaving the Indian sub-continent in every sense of the word by systematically destroying the manufacturing capacity of India.

Both the authors also ascribe the decline to the reluctance of master craftsmen to document the technological secrets and to share the knowledge with others except with their favored apprentices. Hence some of the technologies could not be developed further and declined with the decline of



the fortunes of the select group of families who knew the process secrets.

Tripathi and Bala passionately plead for supporting research into and revival of the ancient Indian method of making high strength, non-corroding, crucible steel and converting them to sharp cutting objects requiring high levels of formability. It is hoped that research on these topics by Indian professionals will unravel not only the technological mysteries of steel making but also the socio-economic and political circumstances which led to the decline of the Indian manufacturing industry. This analysis of the historical facts may also equip us to compete today in a world facing challenges of technology denial by big powers to those who need it.

Both the books have high production values with good visuals, and the series editor Dr D P Agrawal, Infinity Foundation and Rupa Books need to be complimented for providing such valuable books on the history of Indian science and technology.

Reproduced from GadarJari Hai
http://www.ghadar.in/gjh_html/

Dr. Pradip is a well known Metallurgist and Material Scientist and a Fellow of Indian National Academy of Engineering, Pune

Know Our Members

Arun Adiverekar is currently working as General Manager & Head – Corporate Quality Assurance at Kirloskar Pneumatic Co. Ltd, Hadapsar, Pune. (www.kirloskarkpcl.net)

His Qualification is DME, AMIE (Mech Engg), GDMM & MBA in Materials Management. He has over 32 years of experience in Precision Cutting tools / Engineering, Automotive Ancillary & Automotive Engines mfg & Engineering Industry.

Arun has worked earlier for 7 years with Greaves Cotton Ltd(a Thapar Group Co), an Automotive Engines manufacture as Head QA & Corporate MR for ISO/TS 16949. He was responsible for 3 plants for Quality, Mgmt Systems, New products development & Mfg. Excellence. Earlier he was 5 years with Endurance Systems Pvt. Ltd, (a Bajaj Auto Group Co.), an Automotive Ancillary as Head –Technical & QA. He has managed 3 technology transfers/ collaboration, ISO 9000 , QS9000 Mgmt Systems & Supplier development.

Earlier he was 14 years with Forbes Gokak Ltd (a TATA Group Co), a Precision Cutting tools & Engineering Products manufacturer as Head - D & Dev. Managed Plant & Machinery procurement, re-engineering, import substitution & New Product Development.

He has globally travelled extensively; his business acumen fosters strategies for global sourcing, JV and technology-transfers with flair of world-class QMS practices.

Arun is a Lead Auditor for ISO, EMS & OHSAS Mgmt Systems, and Certified CII Assessor for Business Excellence Award Assessment. He has Implemented Integrated Management System (IMS) & acquired NABL Accreditation to Metallurgy Laboratory at KPCL.

He may be contacted on:

adiverekarad@kpcl.nethttps://in.linkedin.com/in/arunadiverekar