



Chapter News Letter



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EDITORIAL . . . ✍



Avinash Arankalle
Editor

Dear Readers,

On behalf of ASM International Pune Chapter and myself HAPPY NEW YEAR 2023 greetings – healthy and prosperous.

ASM International runs in my blood vessels because I started courier in metallurgy buying ASM Handbook Vol.1 when I got first stipend as a student of engineering college. Proud being one of the founder members of Pune chapter and conducted the first ever educational program on “Metallurgy for Non-metallurgist” in Pune. Hence writing an editorial column of Chapter Newsletter is a great privilege and honor. However, the pen in hand is not pushing me ahead without expressing deep throat in mind and condolences for the sad demises of well-known metallurgist, first Vice Chairman of ASM International Pune chapter Mr. C. V. Tikekar. The newsletter covers up in memorium by no one else but by Dr P. G. Renavikar to tribute – a guru, mentor and his friend for over 50 years in Tata Motors. Let his soul remain in peace in heaven.

Down of 2023 and rise of 2023 years, we had three technical talks – i) Advanced missile launching systems by V V Parikar, ii) Magnesium a futuristic material by Prasad Phale and iii) a special presentation on role of failure analysis in reliability improvements by Atul Gokhale. The Newsletter summarizes the outcomes of these lectures. In Students' Outreach, MA Chapter was inaugurated at KLS Gogate College of Engineering Belagavi is another highlight of this Newsletter followed with three days Metallurgy for Non-metallurgist course.

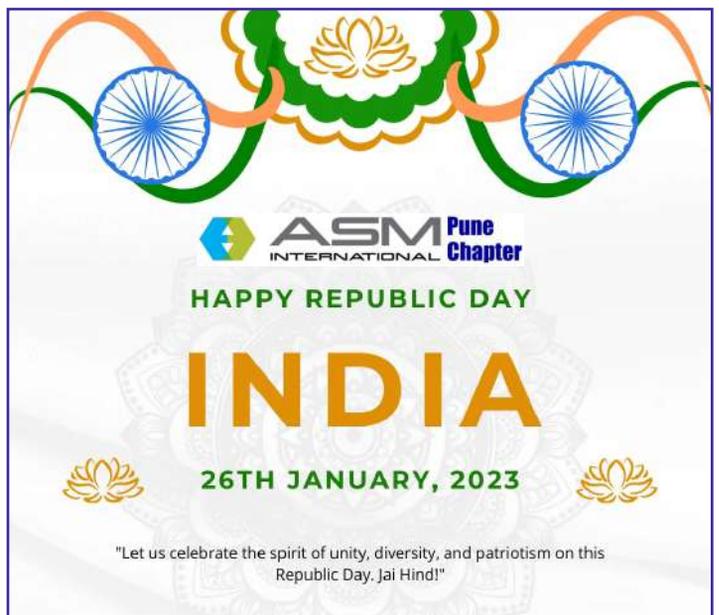
We welcome new ASM International Pune Chapter and wish they will get benefited with knowledge gain from the chapter activities.

Avinash Arankalle, Editor

Faculty and Adviser in Engineering Materials. Former Deputy Director, ARAI FID, Chakan. Over 45 years in the specialized field of material selection, testing & characterization, failure analysis.

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"Let us celebrate the spirit of unity, diversity, and patriotism on this Republic Day. Jai Hind!"

ASM International Pune Chapter

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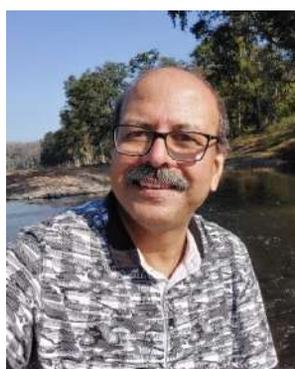
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From Chairman's Desk

India, the largest democracy in the world, is proudly celebrating 74th Republic day on 26th January 2023. This new year is going to be very eventful for all Indian ASMians, more specifically from Pune Chapter. Our Immediate Past Chairman, Mr. B. R. Galgali has taken over as Vice-Chairman, ASM India National Council. Our mentor Mr. Pradeep Goyal, FASM will be taking over 2023. Indeed, this is a matter of pride for all responsibilities multi-fold towards Pune Chapter has already identified to expand our membership. Me and my join this membership drive and add at least year.

We resumed Students Camp this year Mr. Rahul Gupta and our office executive success at Govt. Polytechnic Pune. Ms. S. Bandal, Principal, GPP supported for



Udayan Pathak, FASM

as the first Indian President of ASM in Oct of us, at the same time it enhances our spreading ASM activities in India. ASM certain geographical areas and corporates colleague EC members appeal to you to one member each in Pune Chapter this

after a gap of three years. Mr. D. G. Chivte, Nita took great efforts to make this a grand Namita Kadam, HoD Metallurgy and Dr. V. success of the camp.

We will be celebrating the 3rd edition of Women's day in March 2023 with a fresh and attractive format. Our Women@Materials Engineer team is geared up for the same.

For making our chapter more vibrant, I appeal to all to participate in chapter activities.

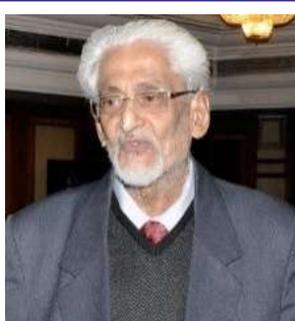
IN MEMORIAM

It is with heavy heart that I am writing this eulogy for late Mr. C.V. Tikekar, who left us for heavenly abode on 24th November 2022.

After obtaining B. E. (Metallurgy) degree from College of Engineering Pune in 1954, Mr. Tikekar spent his entire professional career in TELCO (now Tata Motors), first in Jamshedpur and later in Pune until his superannuation in 1992. He held various senior positions in his illustrious career and handled many responsibilities like Chief Metallurgist, Head of Foundry Division and Head of Auto Production. During the nascent years of Steel and Automobile Industry in India, he played critical grades of Carbon and Alloy steels mainly to DIN specifications because of Due to his herculean efforts, it was large numbers with low costs since very expensive in those early years of high esteem by Automobile as well as

After his retirement, he joined Kirloskar in establishment of Kirloskar Ferrous

I knew Mr. Tikekar for more than 50 years. in later years as we both lived in Telco Sr. person, had keen interest in music, Indian philosophy and recent technologies. He was the first Vice Chairman of Pune Chapter of ASM International when it was formed in 1991 under the Chairmanship of Mr. Baba Kalyani. During his tenure, he organised many technical lectures and seminars.



Late Mr. C.V. Tikekar

major role in indigenous development of conforming to international specifications, Telco's collaboration with Mercedes Benz. possible to manufacture heavy vehicles in availability of imported steel was poor and Indian economy. He was therefore held in Steel Industry.

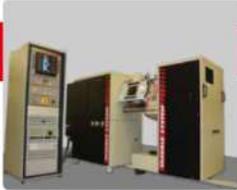
group as Director and played a major role foundry and other companies.

He was my Guru, Mentor and a good friend Officers Society Pimpri. He was a lively

In his demise, Metallurgical community has lost an eminent Metallurgist. The loss would be felt for long time!

May his soul rest in peace! Om Shanti!!

Dr.P.G. Renavikar



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Technical Talks

1. Design Challenges, Technology Needs and Development Methodology for Advance Missile Launching Systems'

About the Speaker: by **Mr. V.V. Parlikar** a distinguished Scientist and former Director of R&DE(E), a premier system engineering laboratory of DRDO located in Pune. He is being working for more than 37 years and successfully designed and developed more than 50 major engineering systems and equipment for a variety of military requirements and applications.

Date and Place: November 2022; Firodia auditorium hall, Institute of Engineers, Shivajinagar, Pune

Brief coverage of the Talk

The technical talk covered up various Missile Systems for the design and development of indigenous missile launchers. He emphasized on – the performance needs, operational aspects, challenges involved, system and subsystem levels in design for mechanical, structural, electrical, electronics and automotive



subsystems. Many examples and case studies were presented describing methodology and the production approach adopted successfully during design and development of advanced missile launchers by the eminent speaker Mr. VV Parikar.

2. “Magnesium, the futuristic material” by Mr. Prasad Phale, ARAI, Pune

Date: 29th December 2022; Around 136 participants attended the lecture and many of them were active in asking doubts

About the Speaker: Prasad Phale is BE (Metallurgy) from Govt. College of Engineering, Pune (COEP) in 2002. Currently he is working with ARAI, as a Deputy General Manager, Fatigue and Materials Center of Excellence. He is working in the field of material characterization of metallic and polymeric materials, process development and validation. He has many publications in his field of interest. Earlier, he worked in Hindustan Aeronautics Ltd, in the field of coatings and welding.

Brief coverage of the Talk

Magnesium's inherent unique properties such as light weight, high specific stiffness and strength, excellent damping characteristics, good castability & machinability, good weldability etc. make it ideal candidate for replacement in many automotive parts as alternative to steels and aluminium. Though, higher costing limits its extensive usage in small and medium range automobiles, its applications in aerospace and defense are significant. This presentation provides brief insight on evolution of magnesium material in near future. The presentation covered the basics of magnesium, characterization techniques, heat treatments, alloys and their applications, forming and forging techniques, future trends with respect to alloys and processes to enlighten visibility of this futuristic material in automotives. It also included glimpses of ongoing work at ARAI along with further scope of development with auto industries in this arena.

3. “Role of Failure Analysis in Reliability Improvements”

Date and Venue: 30th of January 2023 (Physical as well as online presentation)

About the Speaker: Dr. Atul Gokhale is a BE Metallurgy from COEP Pune; MS and PhD in Materials Science and Engineering from the University of Florida, USA. He is currently working as a Sr. Consultant, X-ray CT System Implementation in V. J. Technologies Inc., Bohemia.

Brief coverage of the Talk

A good failure investigation can significantly shorten the path to reliability improvement of mechanical or electro-mechanical components, assemblies or systems. Many in the engineering community are either unaware of this strategy or skeptical of using it. Dr Gokhale analyzed the reasons and possible solutions and described a 7-step framework for a failure investigation. He illustrated the entire process with 3 case studies.

TECHNICAL ARTICLE

Stiff, Light, Strong And Ductile: Nano-structured High Modulus Steel

By

H. Springer, C. Baron, A. Szczepaniak, V. Uhlenwinkel & D. Raabe

Preamble

Innovative materials and processes play important roles in architecting the performance of auto parts and vehicles running on the roads. A lateral thinking invokes idea – can steel be lighter like titanium with a high strength and high modulus? – Yes, the technical article is a food for thought for HCV parts such as cross members, rails and axles in the future.

Lightweight design is the major frontier to increase performance and efficiency of transportation systems and machines. The main selection criterion for load bearing materials is their strength, which allows for reducing the wall thickness and thus weight of the components. As nearly all components of machines and transportation systems are intended to bear load without permanent plastic deformation, their yield strength (YS) is more important than the ultimate strength (UTS). Ductility, i.e., the ability to undergo plastic deformation (here noted as the total elongation; TE), is vital for forming operations during the manufacturing of parts and as a safety reserve for accidental overloading for example in a crash situation¹.

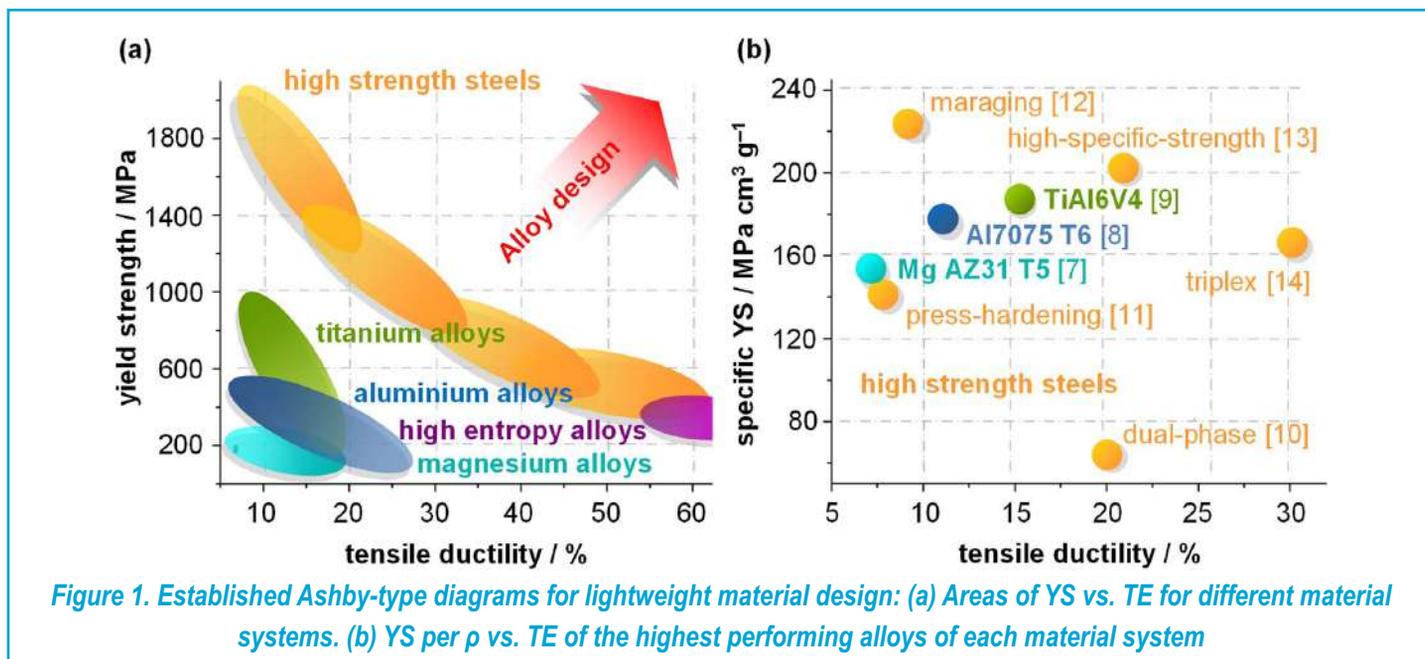


Figure 1. Established Ashby-type diagrams for lightweight material design: (a) Areas of YS vs. TE for different material systems. (b) YS per ρ vs. TE of the highest performing alloys of each material system

Figure 1a shows that advanced iron (Fe) based alloys, i.e., high strength steels, with their fine-tuned microand nanostructures offer a unique combination of strength and ductility often superior to aluminium (Al), magnesium (Mg) or titanium (Ti) systems and even to new material concepts such as high entropy alloys. However, the elevated strength of steels comes at the price of high density (ρ). Consequently the specific YS (i.e. YS/ ρ) of high performance Mg, Al and Ti alloys is often the more adequate measure for comparing them to high strength steels commonly used in the automotive industry, such as dual-phase or press-hardening steels(Fig. 1b). Only highly alloyed and thus expensive steel concepts such as maraging or the recently developed lightweight steels which are based on significant density-reduction via additions of up to 12 wt.% Al, show corresponding superior property combinations when related to ρ .

Focusing exclusively on the further improvement of YS, ρ and TE, though, neglects another important design key factor, namely the stiffness of materials, expressed by their young's modulus (E). It determines the deformation of a given part in the elastic regime irrespective of its strength, and thus for example the buckling resistance of an aero

plane wing or the deflection of a transmission part. However, this most critical material property is often simply taken as a given intrinsic property, which can only be affected marginally – and often detrimentally – by alloying additions and mechanical or thermal processing. In Fe and Al alloys, for example, only chromium and rhenium or lithium, respectively, are known to raise the stiffness slightly, while almost all other alloying elements decrease it. The presence of strengthening defects such as dislocations and internal interfaces also typically lowers the stiffness. Interestingly, the specific modulus, i.e., the E/ρ ratio, of all established metallic structural materials – from Mg alloys to lightweight steels – is with about 26 GPa cm³ g⁻¹ almost identical. As low E values need to be compensated by a larger wall thickness, the original weight saving potential provided by established “light” materials is thereby often eliminated.

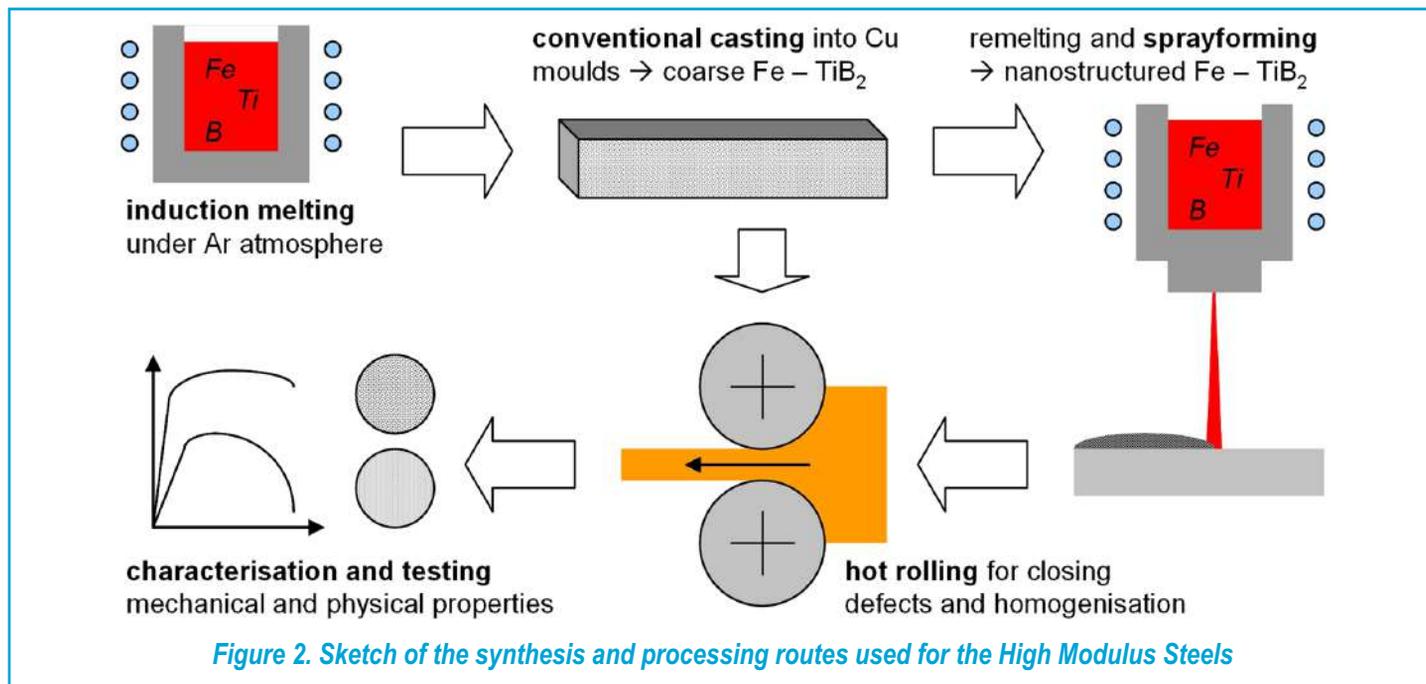
A promising pathway to overcome these alloy and design limits, and in particular to raise the specific modulus, lies in creating composite microstructures, i.e. blending light and stiff particles into strong and ductile metallic matrices. Corresponding Fe-based composites, also termed High Modulus Steels (HMS), are especially attractive because of the possibility to exploit the numerous phase transformations of steels to tune the mechanical performance and keep the raw material and production costs to a minimum. Ti-diboride (TiB₂) is an ideally suited particle phase, as it is not only very effective in the current context (E of 515 GPa and ρ of 4.52 g cm⁻³) but also enables synthesis of such composites in-situ via liquid metallurgy, a key factor for cost efficient mass production. However, while Fe – TiB₂ based composites indeed allow achieving favourable physical properties, their mechanical performance is yet unsatisfactory, i.e. both strength and ductility have so far been too low compared to other lightweight materials. This is due to the formation of comparably large (several μm) and inherently brittle particles of detrimental morphology, promoting crack initiation. Those particles precipitate from the homogeneous liquid phase as thermodynamically stable solidification products, and therefore cannot be refined via established dissolution and precipitation procedures, as applied for example to carbides in tool steels or intermetallic phases in Al alloys.

Objective. We have developed a new combined alloy and synthesis concept which makes it possible to overcome this trade-off between excellent physical properties and detrimental mechanical performance. Our approach is based on coupling the in-situ formation of TiB₂ of suited alloy compositions with efficient microstructure refinement through accelerated solidification kinetics, in a setup which is capable of mass production. The resultant nano-structured Fe – TiB₂ HMS is of dramatically improved strength compared to conventional steel composites without sacrificing ductility, while exhibiting a higher stiffness/density ratio than any of the currently used high performance materials.

Experimental details. Synthesis and processing. Our concept is demonstrated on an Fe – Ti – 2.4 B alloy (wt.%), which corresponds to about 13 vol.% of TiB₂ in a ferritic Fe matrix. While larger particle fractions can be easily achieved through higher Ti and B concentrations, the chosen eutectic composition exhibits with ~1400 °C the lowest melting temperature in the Fe – TiB₂ pseudo-binary system, and thus more cost effective production. A charge of 4 kg based on pure metals were molten in a vacuum induction furnace under argon (Ar) atmosphere and cast into a cylindrical copper moulds of 30 mm internal diameter, with a cooling rate of about 10 K s⁻¹, which is comparable to conventional steel production conditions (solidification rate of about 5 to 10 K s⁻¹) such as in continuous casting.

We identified spray-forming as the optimum synthesis technique to achieve the desired massive microstructure refinement of the composite material, as it represents an industrially established liquid metallurgy synthesis technique capable of high volume production at very fast solidification kinetics. A 200 mm long section (about 1.15 kg) was re-molten under Ar (melt temperature about 1550 °C, i.e. 150 °C above the liquidus temperature) and sprayed with 20 bar Ar pressure and a deposition rate of about 72 kg h⁻¹ onto a rotating tube (low C steel, 90 mm outer diameter, sandblasted surface, positioned 140 mm below the spray nozzle). The spray-forming process exhibits three differing cooling rates, i.e. during flight of the droplets, during impact and on the substrate. In the upper temperature regime, relevant for the solidification and thus for the formation and growth of the TiB₂ particles from the liquid during the first two solidification phases, the cooling rate is in the order of 104 K s⁻¹. Subsequent to

the deposition the tube-substrate was removed by lathing, leaving a ring of about 20 mm width and 8 mm thickness. An 80 mm long section of the spray-deposited ring was hot rolled together with a section of the as-cast billet (machined to identical cross-section as the sprayed ring) to a thickness of 2 mm at 1100 °C and cooled at air to room temperature. Hot rolling was performed to remove any porosity and non-equilibrium metastable phases possibly left after the primary synthesis. Both conventional and spray-formed materials are thus of identical chemical composition but underwent different solidification kinetics. A sketch of the synthesis and processing chain is shown in Fig. 2.



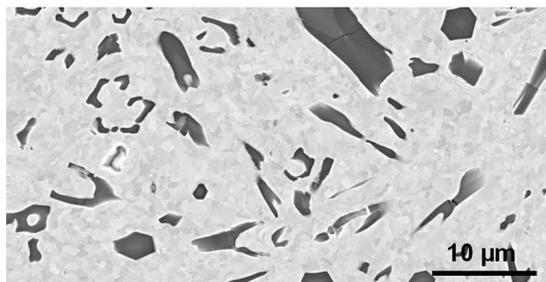
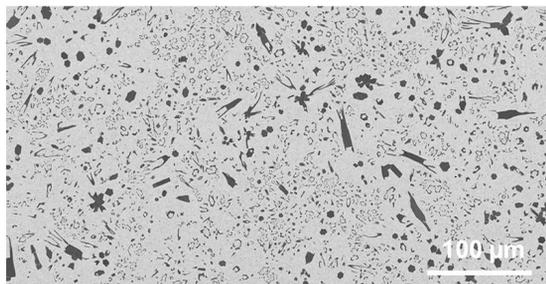
Characterization. Microstructures of both materials were characterised on cross sections prepared by standard metallographic techniques with scanning electron microscopy (SEM; Zeiss Merlin with a Gemini-type field emission gun). Phase identification for conventional HMS was performed with electron backscatter diffraction analysis (EBSD; EDAX detector and TSL OIM 7.2 software) in the SEM. The nano-structured HMS was characterized using transmission electron microscopy (TEM; Jeol JEM 2200FS operated at 200 kV on samples prepared with a focused ion beam system (FIB; FEI Helios Nanolab 600i). E values were determined by a GrindoSonic MK5 “Industrial” excitation system (flexural vibration resonance) on rectangular specimens (20 mm long, 5 mm wide), while ρ values were measured on machined chippings under protective atmosphere in a gas pycnometer (Micromeritics Accupyc 1330). Tensile testing was performed parallel to the rolling direction on dog-bone shaped samples with gauge dimensions of 5 mm length and 2 mm width at an initial strain rate of 10–3 s⁻¹ with digital image correlation to assess the strain.

Results

After the primary synthesis (Fig. 3) the conventionally produced HMS (Fig. 3a) exhibits a typical as-cast microstructure with about 15 vol.% of TiB₂ particles of irregular shape and size (1–15 μm in diameter) and number density of about 0.06 μm^{-2} evenly dispersed in a ferritic matrix with a typical widely irregular $\alpha\text{-Fe}$ grain size distribution. The spray-formed material (Fig. 3b) exhibits microstructural features on a nano-metric scale. Only few pores can be observed, and the fine-grained ferritic matrix contains a high number of darker features of irregular morphology, corresponding to TiB₂ particles as well as metastable phases. After hot rolling (Fig. 4), the microstructure of the conventionally produced HMS remains virtually

unchanged, with only slight spheroidisation of the TiB₂ particles and recrystallization of the ferritic matrix to a grain size of about 15 μm (Fig. 4a). The rapidly solidified spray-formed material, on the other hand, remains nano-structured (Fig. 4b) with a ferritic matrix grain size of about 400 nm. Furthermore, no metastable phase could be

(a) conventional HMS (as cast)



(b) nano-structured HMS (as deposited)

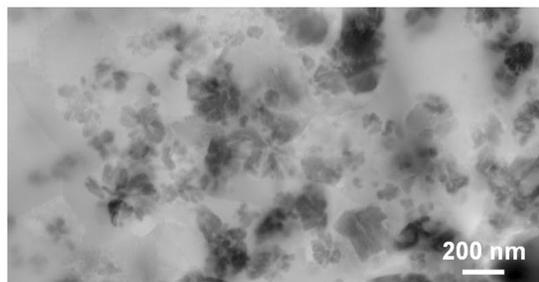
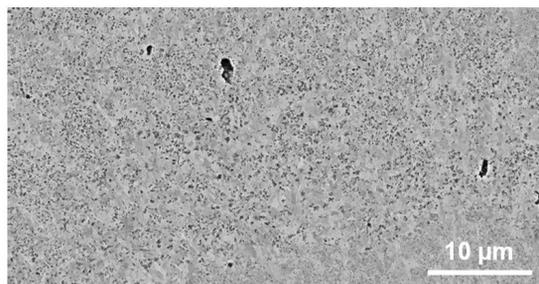
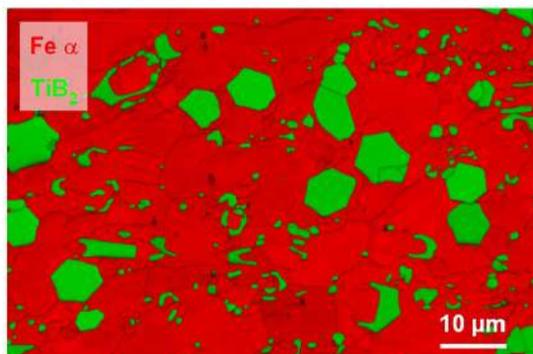
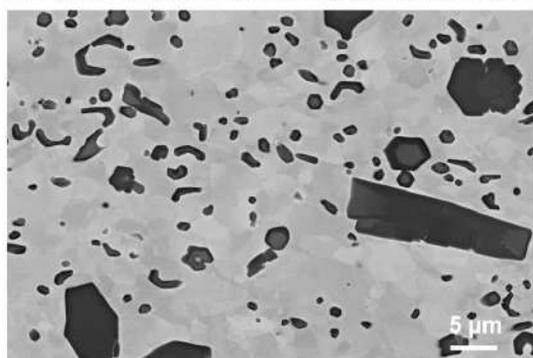
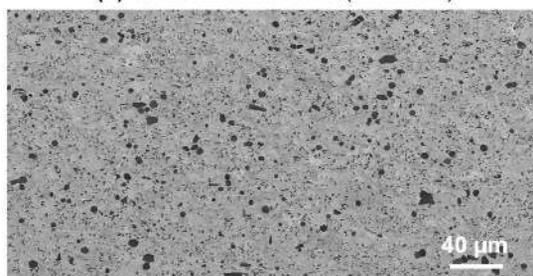


Figure 3. Microstructure characterisation results as SEM BSE and STEM BF images of High Modulus Steels after the primary synthesis by (a) conventional casting and (b) spray-forming

(a) conventional HMS (hot rolled)



(b) nano-structured HMS (hot rolled)

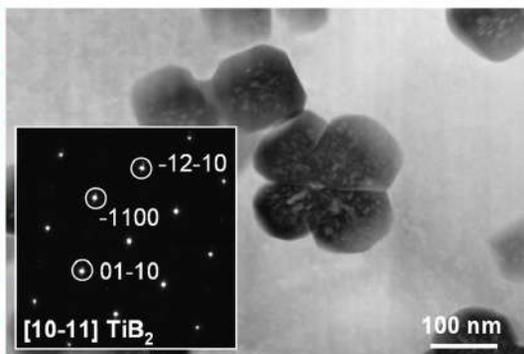
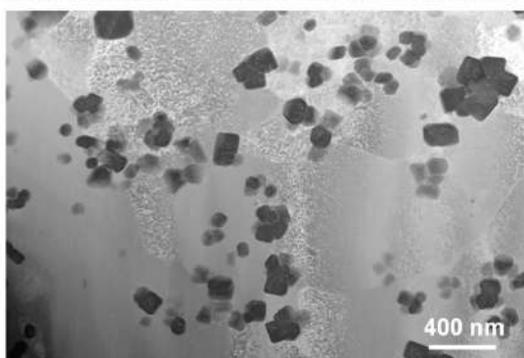
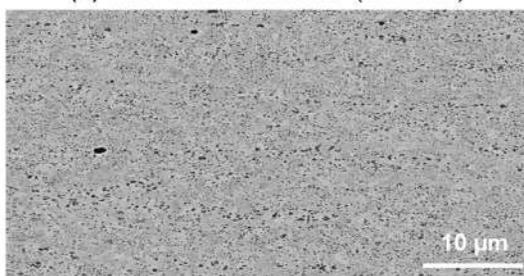


Figure 4. Microstructure characterisation results as SEM BSE / EBSD and STEM DF images of High Modulus Steels after hot rolling for (a) conventional casting and (b) spray-forming. The effective nano-structuring of both particles and matrix through spray-forming is evident

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detected anymore, but a high number density ($12.87 \mu\text{m}^{-2}$) of extremely small (about 50–200 nm in diameter) and spherical TiB₂ particles of similar volume fraction as the conventional material. High resolution characterization reveals that some of the TiB₂ particles appear as small clusters, possibly as an effect of sympathetic nucleation, and contain Fe-rich inclusions.

The very efficient nano-structuring achieved by the rapid solidification in the spray-formed material translates into an extremely favorable property profile (Fig. 5a). Compared to the conventionally produced reference material, both YS and UTS are about doubled without sacrificing TE, reaching the mechanical property level of advanced high strength dual-phase steels (Fig. 1a), yet at 5% reduced ρ and 13% higher E. The pronounced strengthening is not only caused by the refined particles, which are now small enough to effectively interact with dislocations as the carriers of plastic deformation, but also through the severe reduction of the matrix grain size (Hall-Petch effect). The latter mechanism is especially important as it has the advantage of improving the materials strength without lowering its impact toughness. Strengthening of conventional Fe – TiB₂ composites through additional plastic deformation such as cold rolling is difficult, as the larger particles easily fracture in the process and thus the material embrittles.

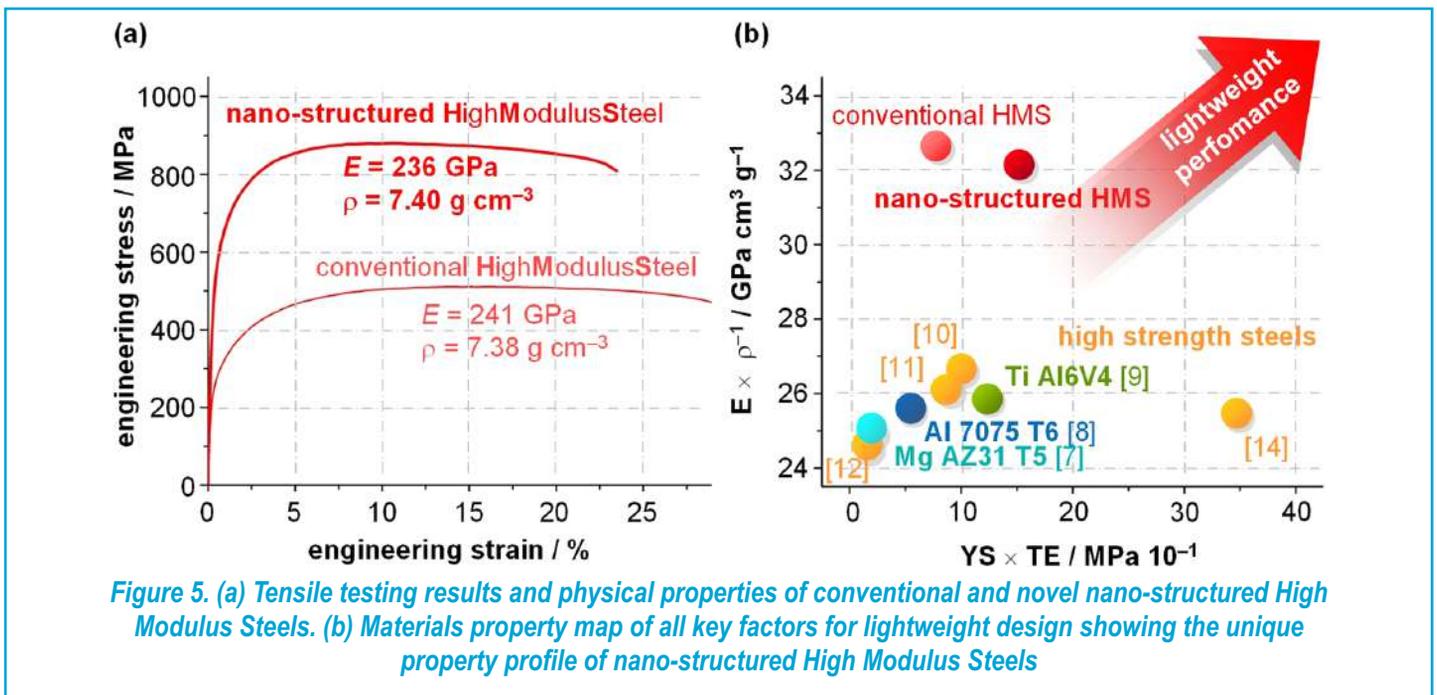


Figure 5. (a) Tensile testing results and physical properties of conventional and novel nano-structured High Modulus Steels. (b) Materials property map of all key factors for lightweight design showing the unique property profile of nano-structured High Modulus Steels

Discussion

Despite the comparatively lean alloy composition and simple synthesis suitable for mass production, the property profile of the here presented nano-structured HMS is superbly suited to open novel pathways for lightweight design. The observed favourable mechanical properties appear to be mainly caused by the pronounced size reduction and spheroidization of the in-situ formed TiB₂ particles through the rapid solidification kinetics of spray-forming. While the volume fraction of the particles remains similar, there is now much less interfacial stress concentration compared to the conventionally produced alloys with their much larger and sharp-edged particles (which are also often clustered and pre-cracked). Furthermore, the number density of particles is substantially increased, as is the density of grain boundaries within the also refined matrix, and the particles are small enough to effectively interact with dislocations during deformation. All those factors together appear to enable to increase strength without deteriorating ductility of the composite structure. The effective contribution of each individual mechanism to this property improvement, though, requires more in-depth investigations in future works with in-situ microscopy and concerted modelling techniques, in order to fully clarify the underlying microstructural phenomena.

Figure 5b summarizes all material properties which are essential for evaluating a material's suitability for weight reduction¹. We have chosen tensile ductility (i.e. the total elongation in tensile testing) as it comprises the full deformation regime and thus also gives an insight into the damage tolerance of materials. The map reveals that all other high performance materials cover a wide range of mechanical properties, yet have a very similar stiffness/density ratio. The nano-structured High Modulus Steel, on the other hand, has not only excellent mechanical properties, but its about 25% increased specific modulus offers up to now entirely untapped potential for realising weight-critical applications: The energy efficiency of a wind turbine for example can be increased as the stiffer material offers a higher resistance against buckling and thus the tower can be build higher. The drive shaft and rotors located at the top can be lightened at identical elastic and plastic deflections, saving material and effort for installation as well as increasing their performance.

The property profile of nano-structured HMS can be even further improved in the future, as alloying additions can be utilised to increase its strength (e.g., via small amounts of other precipitating phases, albeit at reduced ductility) and enable functional properties such as increased corrosion resistance (e.g. Cr and Mo additions). Interestingly, these materials are also ideally suited for the rapidly growing field of additive manufacturing of near-net shaped parts, as the high cooling rates of the commonly used Laser-based 3D-printing devices should enable to achieve similar microstructures as in our spray-forming process. While certainly less cost efficient than large volume liquid metallurgy processes such as block- or strip-casting, spray-forming is typically of less effort than solid state powder metallurgy processes utilized for composite material synthesis. The alloying costs associated with the comparatively large Ti concentrations can be significantly reduced by utilising in-situ reduction of Ti oxides in the melt. Nano-structured HMS thus open a wide spectrum of novel pathways towards the next generation of materials for lightweight design: stiff and of low density, but strong and ductile, while lean and cost effective.

Welcome to New ASM Members



Mr. Nitin Avinash Joshi

Mr. Nitin Avinash Joshi;
General Manager –
Manufacturing – Special
Processes at GE India – GE
Aerospace, Pune. He is M
.Tech – Manufacturing
management from BITS Pilani
and BE Metallurgy from
COEP, Pune. Possesses over

28 years' experience in steel mill, OE automotives –auto component, Aviation manufacturing and Quality management. His areas of expertise are : Heat treatment of alloy steel and special steels ,Chemical processes ,Metal Joining- Brazing , Vacuum Brazing ,Aerospace Quality management , Aerospace special processes , Training and skill development.

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Welcome Nitin to ASM International Pune Chapter Group

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Special Evens of ASM

Students' Outreach Program

The Materials Advantage (MA) Chapter at KLS Gogate College of Engineering Belagavi was inaugurated by Shri. Rao, Industrialist from Belagavi who is the Managing Director of Kavaata Valves, Belgaum. Principal Dr. Jayant Kittur, HOD Dr. Harshit Kulkarni, Dr. VN Satvik and Prof Mahesh Kori were also present apart from Udayan Pathak, Rahul Gupta and Mr. Chivate from the ASM International Pune Chapter.



The inaugural function was followed with the three days course on “Metallurgy for Non-metallurgist”. 52 students of 3rd year mechanical engineering of the college and 10 Industrial professionals attended the course. Faculties of ASM International Pune Chapter covered up the theory along with practical concepts, applications, The interactive



teaching enhanced the knowledge, process of understanding, learning and creative applications to solve practical problems of all participants.

STUDENTS MATERIALS CAMP

ASM International Pune Chapter organized Student Materials Camp In association with Metallurgy Department of Government Polytechnic Pune (GPP) on 2nd December and 3rd December 2022.

52 Students participated in this unique program. 3 groups of students were made.

Students Material camp aimed to provide a unique opportunity to First year Diploma students to explore & to understand the world of Material Science and see the application & use of Materials in everyday life. This Camp provided the participants with a great fun learning experience to understand the behaviour and properties of Materials.



The Program was inaugurated by Mrs Namita Kadam, HOD Metallurgy Department GPP, Mr D G Chivate, Mr Rahul Gupta from ASM Pune Chapter

In Student Materials Camp, Students were showed various experiments on various subjects listed below:

1. Pyrometry and calibration of temperature measuring equipment, Sensors by Mr Hemant Zaveri.
2. Corrosion basics by Mr Rahul Gupta

3. NDT Techniques by Mrs Vaijyanti Datar
4. Joining of Metals by Mr Vineet Marathe
5. Heat Treatment of Metals, low, medium carbon and alloy steels, Annealing, Normalizing, Hardening and Tempering by Mr Shrikant Kulkarni
6. Mechanical Testing on steel and Aluminium alloy samples, Tensile, Impact testing and Hardness Testing on standard samples by Mrs Nita Gaykar
7. Metallography and Microstructure of various metals, alloys. Actual practical on samples for polishing, Lapping, Etching by Mr Prashant Pachve

Students were provided with Course Material, ASM Caps and 2 days Breakfast and Lunch.

On the last day participants were asked to present group presentation from all 3 groups.

Valedictory Function was held in GPP. Mr Udayan Pathak, Mr D G Chivate, Mr Rahul Gupta from ASM, Mr Sanket Chikshe from PVG College of Engineering and Mrs Namita Kadam from Government Polytechnic Pune were present.

The certificates of the participation were distributed to the students.

The Student Materials Camp 2022 was coordinated by Mr D G Chivate and Mrs Nita Gaykar.

Newsletter Chairman's note:

Welcome everyone to the new year 2023! We seem to have recovered from the effects of COVID and both the industry and economy seem in good shape. This year's first newsletter is fortunate to have Mr. Arankalle as the editor and ASM Pune hopes to bring you more meaningful and interesting content in the upcoming newsletters. I invite editors for the 2023 newsletters. It is an excellent opportunity to showcase your thoughts to a broader audience and interact with our team.

This year, we are also planning to introduce some novel ideas regarding information about elements of the periodic table and the Women's day newsletter. Up till now, we have focused on interviews of women in metallurgy at senior positions, scientists or researchers. However, we have some unique and strong ladies amongst us who work in the shopfloor, as supervisors or quality heads. They too have their own special role to play and are an integral part of the workforce. We will also be showcasing their stories soon.

ASM International Pune chapter always encourages feedback, both good and bad! We sincerely hope that you contribute your time for it so that we can strive to improve. Enjoy reading!

Dr. Kruttika Apshankar-Kher

Chairman Newsletter,

ASM International, Pune Chapter

Volunteer yourself for your Chapter!

For more efficient working & expanding network of your ASM International Chapter, please support your chapter by offering your time. Lot of avenues to choose areas of your liking. Options are - Membership Development, Education Programs, Students Outreach, Member Service, Website, News Letter, Technical Program and Social Events. Contact ASM International Pune Chapter asm.pune@gmail.com

Women in Metallurgy

Dr. Sarika Phadke-Kelkar is leading the battery development program at KPIT Technologies Ltd. She is experienced in initiating and leading ambitious, cutting-edge research projects in the domain of advanced materials, solar cells, and batteries, in building and leading diverse teams, and deploying research into prototypes. She is successfully leading the sodium-ion battery research since the past few years at KPIT and has also worked at NCL and Honeywell.

Dr. Kelkar, tell us a bit about your educational qualifications and what motivated you to get into the field of materials science.

Well, my basic degree is actually in Instrumentation and Control from COEP. After I married and went abroad, I decided to pursue MS in the same field at Rutgers University, New Jersey. When I had gone to Rutgers Campus to complete some admission related formalities, by chance, I happened to come across a very interesting display section of the Materials Science and Engineering Department. That display fascinated me; it contained all sorts of applications of advanced materials right from dental implants to fiber optic cables, textiles for military to semiconductor chips, various ceramic powders used to make paints and coatings. I met the graduate director of the department to know more about this field. Soon after I got accepted for an on a research project related to solar quite expensive, so we were developing a cells using titanium dioxide-based diffused sunlight and can be integrated PhD, I also worked part time at Honeywell industrial outlook of materials academic research. I always wanted to pursued my post-doctoral research at Dr. Satish Ogale, on photo-electro-generation. During this time we KPIT sponsored project, for automotive KPIT in a similar project in 2015.



Dr. Sarika Phadke-Kelkar

discipline and decided to pursue MS in integrated MS-PhD program and worked cells. At that time Silicon solar cells were cheaper solution - Dye Sensitized Solar materials which can work even under efficiently with building facades. During Specialty Materials. It gave me an development and I liked that better than come back to India, so after PhD, I National Chemical Laboratory (NCL) with chemical water splitting for hydrogen developed an electrolyser prototype for a application. Later I started my career at

How do you see the contribution of your research and products that you are developing at KPIT, in the Indian as well as the world scenario?

Let me give you a background first. Although KPIT focuses mainly on service offerings of software and hardware technology solutions for automotive industry, we invest significantly in indigenous research and product development. For the last 8-10 years, we are working very passionately on clean energy and clean transportation technology solutions. In this endeavor, we are developing low cost, sustainable and technologically advanced solutions in electric powertrain, electric motor, hydrogen fuel cell, hydrogen generation and batteries. This started with electric power train development for pure electric buses. From the very start we were very clear that we wanted to work on public transportation vehicles rather than private vehicles since public transportation will make a greater impact.

In the battery development program, our focus has been on developing a battery technology that is based on easily available (earth abundant) materials. See, currently the workhorse battery technology after lead-acid batteries is Lithium-ion. According to the Paris convention and Kyoto protocol, every country has decided zero-emission targets. Now, the targets which India has with regards to vehicle emissions and power generation, is to

convert roughly 30% of private vehicles and 70% of commercial vehicles to electric vehicles by 2030. 500 Giga Watts of renewable power is the target for power generation. Now in order to meet both these ambitious targets, Batteries play a very very important role. Considering the targets for electric vehicles, India alone would need at least 100-200 Giga Watt hours of battery systems. Since renewable resources like solar and wind are intermittent in nature, they also need some kind of storage if we have to effectively use them. Only for vehicles, by 2030 the global battery demand is going to be 2-3 Tera Watt hour.

Currently, lithium, cobalt and nickel are the main materials in a lithium-ion battery. All the three are critical metals. If we talk only about Lithium, it is available only in 4-5 countries like Chile, Bolivia, Australia, China, Austria and Argentina to some extent. Even though Lithium may be available in plenty, extracting and processing it to a grade that is acceptable for batteries is very challenging and time consuming. As the demands go up, we are going to be facing a shortage soon enough. Cobalt extraction poses even more serious problems since it is available only in Republic of Congo. So when we started out 8 years ago, we decided to develop an alternative battery technology which can alleviate this potential crisis to an extent. That is why we started developing Sodium-ion batteries which is in reality technologically older than Li-ion battery, and for which supply chain could be much stable and robust across geographies. Over the last two years, there is a huge momentum about Na-ion battery commercialization in India as well as worldwide. The key manufacturers of Li-ion batteries have also announced that they will soon be starting Na-ion battery research and production.

Wow ! Sodium-ion batteries seem quite hot right now. Are there any other advantages of using them over Li-ion batteries?

Yes! In general Sodium-ion batteries are safer and have wider temperature tolerance. Beyond that, the chemistry that we have developed has a couple of other technical advantages as well. Since we were working on electric bus development, we had a lot of data related to the operation of intra-city electric buses. We studied the battery charging and operation patterns in typical metro cities in India. We noticed that if the bus works on Lithium-ion batteries, since it takes at least 2-4 hours for the battery pack to charge, the bus will have to be charged only at night, at the depot. The bus usually drives, on an average at least 200 km daily, with a typical route length of 40 kms. After every 40 km loop, it takes a 15-20 mins halt at the terminal. Thus, the bus will require a battery pack which can give a range of 200 km and weighing at least 1-1.5 ton, making it bulky and expensive. Taking into account the above problem, we started working on a battery chemistry which could be charged for short trips in a short time, say 20 mins. This battery could be charged at terminals for 2-3 times during the day. So in such a case the installed battery pack can be much smaller, hence cheaper. The same pattern could maybe be applied in future to 3 and 2-wheelers which would drastically reduce its upfront cost of the battery pack. The charging patterns need to be studied carefully to give optimum solutions. A single generic solution will not work. The faster and more frequent charging should not affect the battery life., so we are targeting a battery life of 4000-6000 cycles which will get charged in 20 minutes.

With this objective in mind, we started from scratch, and developed cathode and anode materials, and electrolyte formulations. We collaborated with Dr. Satish Ogale at IISER-Pune. This was a very productive and interesting collaboration where we got to learn a lot from each other. In India we don't find many successful examples of Industry-Academia collaboration, which is very critical for fast-paced development of such a nuanced and multidisciplinary system of Battery. We worked simultaneously on materials and devices. Since there was not a single Li-ion fabrication facility in India, we set-up our own cell fabrication prototype line. So far, we have scaled up the material synthesis processes, and have developed cells of around 15 Ahr capacity, which deliver the targeted performance, and presently we are working on building larger modules and packs. The senior leadership at KPIT, Mr. Ravi Pandit and Mr. Tejas Kshatriya, have been very deeply involved in this endeavour. This is entirely Mr. Pandit's vision due to which we have come along so far.

Can you specify on how you decide which advanced materials to use for specific applications?

That depends mainly on the performance parameters. For example, once we decided that we need fast charging and longer cycle life. Now when you go back to battery as a device, you apply these requirements and decide. Simply put, a battery consists of an anode, a cathode and an electrolyte. If we take fast charging as a parameter, we need to develop the cathode and anode material which have good electronic and ionic conductivity, good diffusion properties, right particle size (surface area). The electrolyte as well need to be tuned to have right conductivity and viscosity. What exactly is materials science? It is correlating materials synthesis and properties with performance requirement of the application. So by this approach cathodes and anodes are selected and stabilized separately first and then they are clubbed into the device and balanced and tested for compatibility as a battery. We are now also expanding our application base. For each application, the performance requirements such as charging time, cycle life, operating temperature, weight, volume, cost is different. So we will have to optimize the materials accordingly. We are confident that our batteries are applicable to many other applications.

Your team at KPIT seem quite poised to deliver! May I ask what problems or challenges you faced in scaling up?

Indeed, there were many challenges along the way! At every stage of scaling up; half cells (cathode and anode separately), to full cells (clubbing cathode and anode), from button cells to larger capacity pouch cells, we had to re-tune/refine material synthesis protocols and compositions. When we were synthesizing material for the cathode, we used to make small batches in a tube furnace. Once the quantity requirements increased, we had to get involved in the complete design of the furnace which was frankly speaking not our expertise. Gas flow dynamics and thermal cycles to obtain the maximum yield per batch of the material was very challenging. As far as cell scale-up is concerned, the anode and the cathode materials are in the form of powders which are coated on the base materials as slurries and then stacked together. In every step of this process, we had to re-tune and re-optimize this entire process. The current profiles in the electrode changes as its size/area changes. Environmental conditions like temperature, humidity also play critical role in material and cell fabrication. But I must say that this has been a very exciting and fulfilling journey!!! As I mentioned earlier, with the volumes of demand of batteries, soon there will be large scale manufacturing of batteries in India. There are going to be several parallel industries associated with batteries, for active raw materials for cathode and anode, as well as passive materials that go into the battery, such as aluminium casing, electric connectors, binder, separator etc. I would like to draw the attention of our young readers to this point. There will be huge opportunities in the upcoming years in the field of batteries. They should keep their eyes and ears open and explore new opportunities in this domain.

As a materials scientist, how much are you into Industry 4.0 and machine learning?

Good question. To be honest with you, in our journey so far, we have mostly been experimenting. Going ahead, we want to utilize more and more machine learning (ML). The basic thing which you require for ML is data and we have just started to gather reproducible data. Our chemistry is getting finalized and we hope we will be able to gather better data hereafter.

The next few years are going to be very interesting in India. There are fantastic upcoming opportunities and I would encourage every youngster to become an entrepreneur. Clean energy is a very potent field and has a multi-disciplinary approach. Make the most of it!

Cleanliness Analysis for Contamination Estimation

Particle Size Analysis System

- Fully compliant with the latest standards (ISO 16232)
- Automatic system with complete filter paper scanning , classifying non metallic , metallic and fiber particles and measuring their size.
- Options with stereo and metallurgical microscopes .
- Measurement of height of particle.
- Easy to use and quick to perform.
- Report Development According to user requirement.
- Access to measured particle data for further data processing



Model - CLEAN-EST

PARTICLE TEST REPORT.											
Customer	ABC										
Part No.:	A124N	Recd Date:	04-Jun-18								
Report No.:	1672	Department :	QA Lab								
Sample ID:	ABC	Test Date:	05-Jun-18								
Analysis:	Particle	Standard Specification:	As per ISO 16232								
Magnification	100X	Filter paper Size:	47 mm								
No. of Fields :	5	Scanning Area	30 mm								
Particle Size Analysis											
Size ranges(µm)	1_35	36_60	61_100	101_150	151_250	251_280	281_300	301_500	501_800	801_3000	Total Count
Metalic	4	0	0	0	0	0	0	0	0	0	4
Non Metallic	111	3	0	0	1	0	0	0	0	0	115
Fibres	27	1	0	0	1	0	0	0	0	0	29
Metalic Particles			Non Metallic Particles				Fiber Particles				



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