DEPARTMENT OF METALLURGICAL ENGINEERING AND MATERIALS SCIENCE

DHATUKI

DEPARTMENT NEWSLETTER 2020

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Dhatuki, literally meaning "related to metal", is the Department of Metallurgical Engineering and Materials Science's Newsletter. We bring to you the latest edition with a focus on why the future is materials! We hope you enjoy it. Dig in!

WHAT'S INSIDE?

FROM THE HEAD OF DEPARTMENT'S DESK

It gives me great pleasure to note that our students are coming up with the 9th issue of Dhatuki - The Annual Newsletter of the Department of Metallurgical Engineering and Materials Science. This reflects the spirit of the entire publishing team and I am extremely pleased at the quality of the content that has been published. The way the history and future of MEMS have been presented motivates us to work more and make our Department the most preferred one.

I am confident that the current edition of Dhatuki will integrate all the stakeholders of the Department - namely the students, faculty and staff members and that everyone has wonderful semesters ahead filled with momentous news and events. I encourage you all to read this newsletter, enjoy and give your valuable feedback. It is heartening to note that our students have been working hard to bring out this issue, despite the challenging time the world is facing due to the coronavirus scare. Kudos to them and congratulations to their great effort.

Prof K Narasimhan
Head of Department
Metallurgical Engineering
and Materials Science

BACK TO THE FUTURE

Tracing the history from the stone age to today and beyond

By Mrigi Munjal
Third-year Undergraduate
Department Research Co-ordinator

One simply can not discount the importance of materials to human beings. In historical studies, the early eras are classified according to the materials as the stone age, the bronze age, and so on. More could be revealed from the material of interest of that particular era's advancement than anything else. Even today, as the world is evolving, it is vital to note that most of the things that have changed around us in the last decade have been (arguably) due to the progress in materials science more than anything else. Take, for example, the mobile phone which is indispensable to you now; it is the development of the cheap display screen and the advances in semiconductor processing that gave you your dear mobile phone that sits in your pocket without burning a hole in it and falling right through.

Materials have always been a subject of wonder and fascination for the humankind.

And like all things that are associated with curiosity and mystique, there have been some weird beliefs associated with some basic concepts of the subject in the old days. Because, as Arthur Clarke also famously claims, it is easy to confuse advanced scientific concepts with magic. One of the weirdest ones that I have come across has to be from this book called “The New Science of Strong Materials or Why you don’t fall through the floor” by J.E. Gordon (Thank you, Professor Jaya, for the recommendation although I am yet to finish reading it). The most peculiar one was the long-held idea of using the human body for tempering steel swords so that it’s quite literally “quenched from the blood of thy enemies”. (Sounds pretty cool, right? Can’t wait to use my lab group as quenching media for the next Heat Treatment Lab Experiment) .

Materials have been instrumental in shaping the world around us. From the quest of metals driving the economy of the Romans to the stamp-sized semiconductor chips today that can fly aircrafts, predict the weather and spy on our conversations. Materials Science ranges from the roars of the mills to the hiss of the pressure release in the sample holder of the TEM. It spans the sleepers of the railway track to the tip of the ballpoint pen.

And today as the world prepares itself for an energy crisis purgatory, it sets its longing eyes upon materials to save it for them from what it has brought upon itself. Scientists and technologists work day and night to look for cost-effective alternatives to energy storage materials. Materials Scientists are working towards developing Na-ion batteries, metal-air batteries, portable and safe fuel cells, more efficient solar panels among an endless variety of other things.

Elsevier’s Materials Today magazines lists the following 10 as the advances that have altered the course of our daily lives. They have opened up a sea of newer opportunities and challenges.

- The International Technology Roadmap for Semiconductors
- Scanning probe microscopes
- Giant magnetoresistive effect
- Semiconductor lasers and LEDs
- National Nanotechnology Initiative
- Carbon fiber reinforced plastics
- Materials for Li ion batteries
- Carbon nanotubes
- Soft lithography
- Metamaterials

Tracing the history of materials to the future, it is at the minimum, engaging. The innovations in materials today make us wonder if it is, in fact, fact or fiction. Science fiction from less than half a decade ago is materializing (pun intended) and there isn’t a better time to be alive for a materials enthusiast. We find ourselves amid a materials revolution. Scientists are using powerful simulation techniques, as well as sophisticated machine learning algorithms, to propel innovation forward and even point them towards possibilities they had never thought of. Tracing the history of materials science helps us appreciate what it has done for us and what it has in hold for us in the future (that is already here!).

FROM THE SENIORS

Alisha Parveen
Second-year Undergraduate

How was your academic experience in your first year?

Which courses did you find most interesting?

Som Phene: I believe that the first year courses compromise on theoretical rigor to provide enough tools for the "to be engineers". The only course which I found interesting was Quantum Physics (not the course content which was standard modern physics but extra stuff that I discussed with my instructor, under whom eventually did a research project).

Ashutosh Kumar: The courses are introductory and form the basis for later courses in insti life. I liked PH 107 the best, many things were new, we had the basics from JEE, Schodinger's cat etc was very interesting. We carry forward these things in future courses. I liked BB 101 a lot too. I decided I can pursue a future ahead in biosciences area. I Liked both the MA courses in second semester. CS 101 is important if you are going to carry coding skills ahead. I liked the physics labs a lot. Seeing what we actually do in theory in labs was very nice, like diffraction etc.

Taksh Satra: I was focused on enjoying the insti life in my first year. I was exploring clubs etc. I loved the maths courses, especially linear algebra.

Ayush Anurag: I found Quantum Mechanics, Calculus, Basics of Electricity and Magnetism most interesting. I found Mechanical Workshop the best. First year is very different from the next few years. Try to work hard in your first year because not only making CPI is easier but the CPI that you make in first year is the basis. WIth little hard work on the basis of your studies in JEE, it is enough to score good marks and guide you in the right direction. The integration etc. which we learnt in these maths courses were useful in our second year.

Pushan Bal: I studied a lot in first semester and had a decent CPI. I really enjoyed the academics. In Second semester, I didn't study a lot. I liked BB 101 and PH 108.

Over the years, many students from Metallurgy have been opting for the Institute Policy of branch change. But there are others, who despite meeting the CPI requirement of 8.0 chose to stay with MEMS. We try to find the reasons behind it by interviewing 5 such students, who coincidentally also happen to be department rankers.

Tell me something about the Department Introductory course.

Som Phene: The content was standard: basically following Callister. I explored a topic of interest through the course project. This was the fun part.

yush Anurag: It starts with phase diagrams and then moves on to different materials as well. I would advise anyone to really get into the course and learn and don't put it on the shoulders of the group members. You will really get to learn things like what is material science, learning new materials and their properties and their applications.

Taksh Satra: I came to know through the DIC that material science has a lot to offer; there is a lot of scope in different topics.

Ashutosh Kumar: The good thing about DIC is it gives a flavour of the 3 years ahead. The project in our DIC was useful as it is similar to the seminar that we do in the third year.

Pushan Bal: The degree of interdisciplinarity was good in DIC: we had elements of chemistry, physics, etc and I came to know about the things we could explore.

What was the reason for you to stay in Metallurgy and not change your branch?

Som Phene: My department has given me much more than I would have ever expected both in and outside courses with my classmates pursuing the most diverse range of interests passionately. I believe this is the best department for those who want to explore their interests beyond courses. Even for those willing to explore fields within engineering or pure science this department being highly multidisciplinary, provides many opportunities. I took all the courses in our department as film courses, for instance, studying Phase Transformations was like studying Twin Peaks in which characters change their phase depending on circumstances.

Pushan Bal: I didn't want to do a job. I wanted to go for further studies. MEMS has a lot of scope for further studies abroad. Also, I knew my CPI would project really high easily.

Taksh Satra: I tried for mechanical during JEE. I liked mech related things. I wasn't interested in chemical, aero, etc. which I was getting easily after my first year. So, I stayed with MEMS.

Ayush Anurag: Metallurgy is very diverse, we can think of research and higher studies. Basics of material science are the basics of mechanical and chemical branches. For example, we have thermodynamics, fluid mechanics, mechanics of materials, etc which are prerequisites of any department. MEMS is the place to go if you are not sure about which branch to change to because it is very diverse. I wanted to go for higher studies, I chose MEMS because CPI is very important for that and it is easier to make good CPI here.

Ashutosh Kumar: I didn't have much of an inclination towards any branch. The course content of MEMS is quite similar to chemical, mechanical, etc. I had an inclination towards bioscience and I wanted to explore both. Knowing that the metallurgy department's curriculum is not hectic, I decided to stay in metallurgy so that I could pursue my interest in biosciences also. There is a course running on biomaterials in the institute. I pursued courses in the BSBE department. We are doing a lot of characterization in metallurgy which actually helped me in bio.

What advice would you share with freshers facing the same dilemma of changing their branch?

Som Phene: I actually don't see the difference in an actor and an engineer - both just work according to meeting expectations subject to conditions which give constraints. It's much above me to see the difference between departments. However, if forced to make distinctions, MEMS provides a strong balance of both scientific study and engineering applications-oriented study. It also provides ample opportunities for those who seek them. The field in itself is very much in demand. Almost every year, many top students from other departments like EE, EP join prestigious graduate schools for a Ph.D. to work in materials - quantum materials, soft matter, and polymers. A lot of other departments depend on materials engineers for their functioning. In fact these days even theory-heavy CS and physics departments and companies like Microsoft interact with materials engineers to build quantum computers. When listening to seniors (even this article) keep in mind that people change a lot with time. I don't have any of the ideals/interests now that I used to have 5 years ago and I'm sure that 5 years later, I will be disagreeing with my beliefs at this point in time. So apart from beliefs, let's look at some facts: I know fewer people who are still doing something related to their undergraduate department than people who have switched. As a final note, some advice that I would have given to myself: I wish I had realized this sooner and given myself the license to explore, travel more and meet new people. Undergraduate is probably the best time of life to explore your own interests before safely settling down. As thermodynamics rules everything, whatever unstable state you are in, is temporary and eventually, free energy will drive you spontaneously to your stable state so given sufficient time, you will end up doing what you like the most. So don't waste too much time thinking about non-existent boundaries and start exploring instead.

Ayush Anurag: It is all subjective. It depends on your future goals. If you don't have much of a perspective I would suggest MEMS because the curriculum is chill compared to electrical, chemical, etc if you want to pursue non-core or do your startup etc. You will have a lot of free time. With a little effort, you will be able to get a good CPI. If you want to go for higher studies, choose MEMS because CPI is very important for that and it is easier to make good CPI in meta dept. If you are more interested in engineering than science, it is better to change your branch because our department is more scientific. Don't get pressurized because of your batchmates are changing Branch. Just keep exploring things that you like. Try to explore different things. You don't know what you may like after 2-3 years. Don't get stuck to any notion of any department being better than others.

Pushan Bal: One course is too less to judge. If you don't enjoy DIC, that doesn't mean you won't enjoy the rest of the curriculum. If there is some department you genuinely like, you should definitely go for it. But, general perception is that MEMS is a very chill branch but that is not true. I know at least 7-8 people in my batch who are challenging this perception. At least 7-8 people from my batch have done foreign internships and they are competing with students from departments like CS etc. Very few people may like meta in the beginning but you have to wait and grow with the department. Don't just change branch because of the perception about meta. Materials Science is so interdisciplinary; from here you can go to biology or to any form of engineering - aero to mechanical or even to core sciences like physics. So, staying in meta is an added advantage. I have enjoyed my 3 years in meta.

What did you learn the most pursuing MEMS at IIT Bombay?

Ashutosh Kumar: One should never think that if one has good CPI, one should change branch. It may be possible that you may not like your new branch. There have been cases where people regret after changing their branch. It's very early for freshers to decide because you don't know much about other departments and DIC is not that helpful in making a decision. But our department is not too hectic, so you have the option to pursue your other interests. I actually liked staying in meta. It is never too late to start anything, so even if you stay in meta and then start liking something else, you can always pursue your interests from scratch again.

Som Phene: I have learnt to unlearn the stuff that we are told to "learn". While learning stuff by repeatedly doing it is easy, it's really the unlearning that takes more effort. Moving out of our biased views and the comfort zone is difficult. Dropping the usual tools and constructing a new tool for studying some unknown material is difficult. There's always a material where you cannot apply the "learnt theory". Say for example the idea of negative refraction by Veselago (for which he was fired) which was considered to be not physically realizable has now completely been standardized by engineering of metamaterials. Even High Temperature Superconductors which are not expected as per BCS theory of superconductivity have been experimentally demonstrated which leaves open questions for physics to answer. Studying a real material is much more complicated than working with simplified models of spherical atoms arranged in a lattice. There's no guidance, one has to create order out of the mess by oneself. One has to understand the character of a material by suitable techniques of characterization. When they fail is where the real fun starts.

Ayush Anurag: I learnt that you need to persevere to achieve anything. The amount of choice you have in the institute is pretty high. Try to think what you want to do, be open to new options. I had lot of free time and research options pursuing metallurgy.

Taksh Satra: Check for your liking. If you can face it properly, you can explore different departments. In India, we don't have much scope of meta but outside we have a lot. One of my friends who was doing his internship in the US from Chemical Dept. was told by his prof that if he had taken metallurgy, it would have been better. Materials Science is much more respected that Chemical Engg. abroad. Many seniors may misguide you because they don't like meta. Don't just talk to them. Talk to those who like it too.

Ashutosh Kumar: Courses are not hectic, we can pursue new avenues. Our department has gone very deep in research aspects. For further studies and research, our department is very good. Curriculum is flexible and interdisciplinary which is not the case in several other depts.

Pushan Bal: If you talk to our professors one on one you realize they are very smart and knowledgeable. Our profs are very chill and understanding. I loved the profs in our dept. Suppose you want to do a dual degree project in an industry, profs in our dept will allow that which is very rare in other depts.

I enjoyed the experimental techniques learnt. I loved that aspect of research. If you give us an XRD plot, we will show you the crystal structure from the peaks; we will show you the grain size from the FWHM; we will show you the strain in the lattice from the peak shifting; we will show you purity of sample from area under the peaks. These things are very typical of an engineer and I enjoyed learning these experimental techniques.

Taksh Satra: Our dept enjoys multidisciplinarity. We learn electrical, mechanical, magnetic properties etc. at the same time. We have a lot of choices. I got a direction towards which I want to head. Biggest advantage of being here was being with smart people who knew a lot.

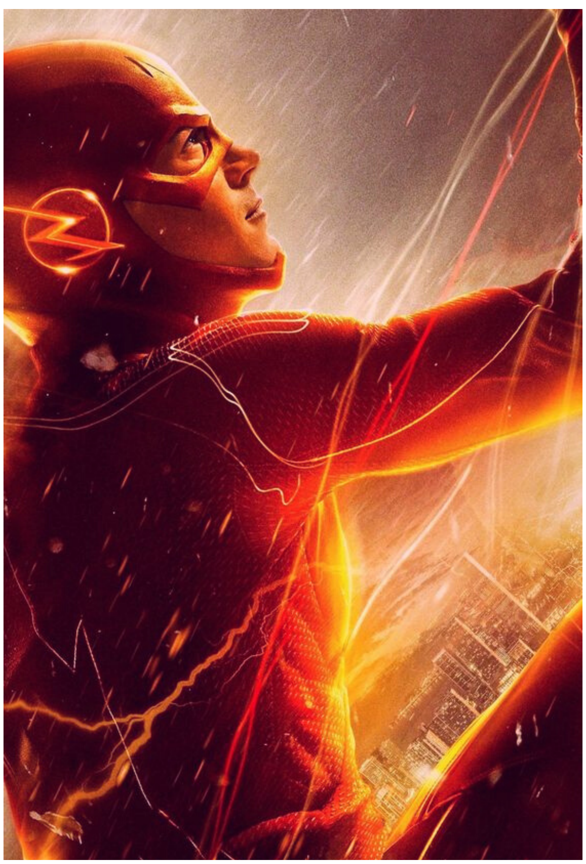
FICTION OR FUTURE

-Aryan Mishra, 2nd Year UG

Enjoying fictional excerpts demands a suspension of disbelief, especially for people who tend to have a scientific bent. Who doesn't love the idea of escapism through means of fantasy, rather than being held captive by infrangible chains of reality? Like any other fictional creations, superheroes might not be at the forefront of technology. But science indeed has come a long way into making some of the chimera plausible and bringing our childhood dreams into coherence. In fact, the fun lies in a wonderful juxtaposition in using well-considered logical scientific arguments, to scrutinize and explain the otherworldly stuff.

Modern advancements in material science have narrowed the gap between fiction and actuality when it comes to some facets of our favorite characters. Development of military super suits incorporating composite materials like reinforced Kevlar, extensive efforts on the fabrication of futuristic materials such as the artificial stronger-than-steel spider silk, memory materials, programmable polymers, etc., the world has been made acquainted to an assortment of super materials in the recent past. This op-ed tries to bring some light to a few such materials and delves into their connection to the heroes we all are in awe of.

"Silica-based quartz sand fabric. Abrasion-resistant. Heat resistant. It's what they use on the space shuttle to prevent it from burning up on re entry."
-Bruce Wayne, Justice League (2017)



FLASH'S SUIT

Super Durable Material

When Barry Allen, a forensic scientist working with the Central City police force, gets struck by lightning in an accident, he wakes up to discover that he can connect to the "Speed Force" – a mystical force that allows him to be the fastest man alive, the Flash! The humankind has always been enthralled with speed. Imagine being able to run at incredible speeds. Imagine never being late for the lectures. Well, unless you also attain a superheroic penchant to lie-ins - "With great power, comes great responsibly." Oops, wrong universe! But every superhero has his kryptonite. As the Flash pootles around the city, saving people and fighting rogues, he's not running in a vacuum. This is where things start to heat up, literally. As the Flash forces his way through the big sea of air, he's pushing millions of air molecules together, increasing the pressure on them. Higher the pressure, higher is the increase in temperature due to adiabatic heating. So, what would The Flash's suit need to be made out of in order to protect him from going up in flames?

Enter: Nextel. Stronger than aluminum, fireproof, and able to withstand meteoroids. Developed by the age-old pioneer in material science, 3M, Nextel is the wonder ceramic fabric that protects NASA's Space Shuttles and keeps satellites from getting smashed to pieces upon re-entry. Ceramics are known for their incredible strength and superior heat resistance. Ceramic fibers are made by super-heating chemicals like silica until they are molten and then spinning them into hair-like strands. These strands can then be chopped up and mixed in with other chemicals to make new compounds or woven into useful fibers. But fire isn't the only thing Nextel is good at stopping. Engineers with NASA's Marshall Space Flight Center in Alabama and Johnson Space Center in Texas discovered Nextel's impact protection ability. It turns out that combining the fiber with Kevlar, a material used in bulletproof vests, produces a fabric that is more impact resistant than even aluminum plating. This property can be easily incorporated in the super suit to counter the energy transferred from the impact of millions of air molecules as our superhero sonic booms away – yet another advantage to the Crimson Comet!

BATMAN'S CAPE

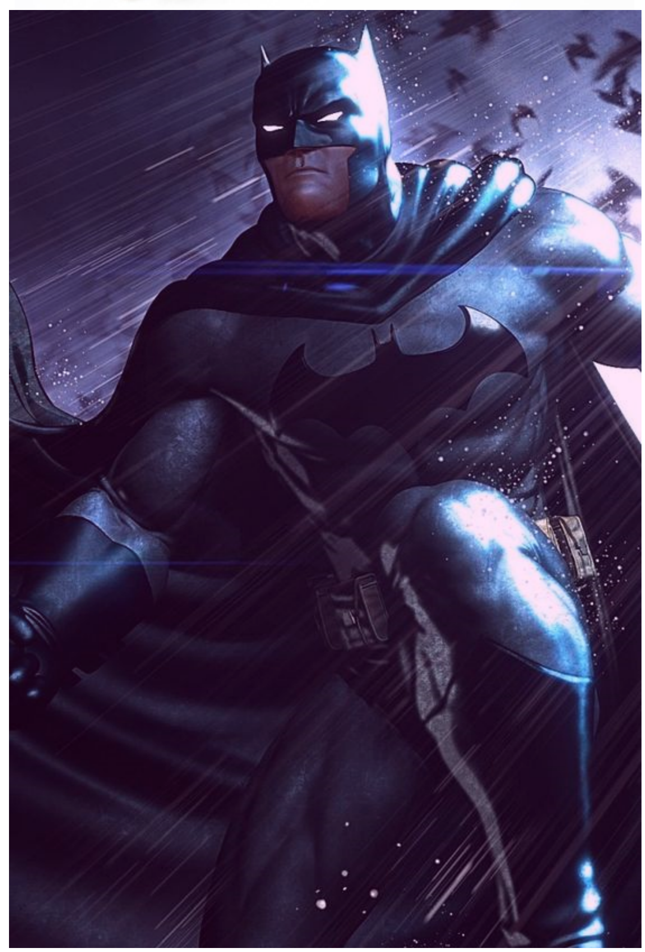
Shape Shifter Material

The Dark Knight, humanity's timeless hero, has stood as a symbol of determination, bravery, and justice to generations of fans. Batman continues to leave his mark in the hearts of every pop fiction lover as the single most popular superhero. Bruce Wayne, an ordinary - okay, a really rich ordinary man, wasn't blessed with any flamboyant powers. He rather used his beaucoup bucks to develop his awe-inspiring arsenal of gadgets, which aid his enshrouded crime-fighting vigilante persona.
Amongst the plethora of these gadgets that don his suit, the most notable one, the pièce de résistance, is the Bat-Cape. It lives up to expectations of the caped heroes cult's vogue. But unlike other clichéd capes, it has the ability to turn into a glider instantaneously, allowing the opulent daredevil to scour the streets dressed like an actual bat. Wingsuits and gliders are no longer a thing of the past. The trick is getting that awesome cape-to-glider transition. So, what kind of material should be employed to make the shape-shifting cape we all fan-girl over?

"It's called memory cloth. Regularly flexible, but put a current to it, molecules realign. Becomes rigid."
-Lucius Fox, Batman Begins (2005)

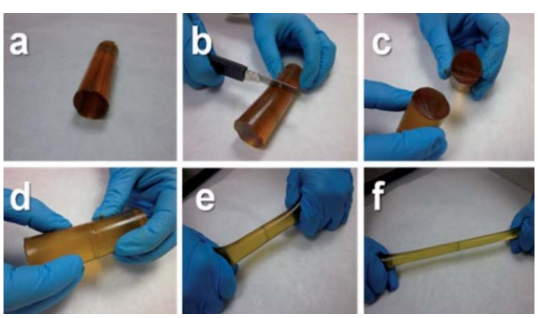
There are certain "smart materials" that possess the property of shape memory. One such material is Nitinol. Nitinol is an alloy composed of Nickel and Titanium. It has a tendency to revert to any programmed base shape that it has "memorized" when an external trigger (like heat, electricity, or light) is applied. When Nitinol is heated to a high temperature (500◦ C), the molecular structure of the alloy can be programmed to attain a specific base state. After this, at low temperatures, the alloy can be deformed into almost any possible shape, but when it is heated past a certain transition temperature, it returns to its original base state.

Nitinol, being electro-active, can be an excellent option to be used to create the structural skeleton of the cape, which gets triggered by a burst of electrical current passing through an internal framework of circuits, transmuting the cape into a glider at the push of a button. At the same time, some parachute material could be used to help impart the glide. Collaboration is the key to success in science and engineering, and material science is no different. When reinforced with Kevlar, the cape can also be made bulletproof, stab-proof and fire-resistant, lending more similitude to the Caped Crusader.



WOLVERINE'S REGENERATION

Self Healing Polymer



One of the gruffest, most irascible, totally cynical and brooding member of the X-Men ever to grace the team with his presence, Wolverine sets the ultimate benchmark for anti-establishment heroes. Wolverine, a warrior with a violent disposition, is well known for his indestructible razor sharp claws made out of the strongest fictional material and belligerent fighting skills. But beyond the shadow of a doubt, the most beneficial and formidable of his powers is his innate ability of regeneration. How cool would it be to face any danger with aplomb and be able to heal quickly? Accelerated healing may seem like a far-fetched abstraction currently, but science is closer than expected to let humans unlock this power.

If there's such a thing as an experiment which perchance leads to a ground breaking discovery, a recent effort in the lab of Stanford Professor Zhenan Bao might fit the bill.

Researchers at Stanford University under the supervision of Professor Bao, have developed a new wonder material, a polymer film that has the ability to repair itself when subjected to cuts, scratches or punctures. Unlike run-of-the-mill polymers which require a solvent or heat treatment to repair, the Wolverine-inspired material can heal itself even at temperatures as low as -20°C. The Fe-Hpdca-PDMS polymer film can rearrange its molecules when cut, repairing itself in just a couple of hours. In fact, when the severed ends are placed beside one another, the material quickly reattaches them after only five minutes.

This polymer, being extraordinarily elastic, can also stretch to 100 times its original length. By varying the amount or type of metal ion included, the above properties can be further enhanced. They also showed that they could make this new elastomer with metal additives twitch by jolting it with an electric field, causing it to expand and contract without being degraded. The capability to stretch and self-heal rather rapidly makes the elastomer extremely resilient, the voluntary twitching action, and the fact that it is low-cost, transparent, and non-toxic into the bargain, gives it an upper hand over the pre-existing materials as a potentially useful artificial muscle, opening the door to promising applications.

In addition to its long-term potential for use as artificial muscle, this research dovetailed with Bao's efforts to create artificial skin, might be used to restore some sensory capabilities to people with prosthetic limbs.

As we set forth towards being a technologically advanced civilization, we begin to realize that the things that are conventionally considered to be unfeasible might not be entirely outside the realms of the physical possibilities that operate within our world. We come across several innovations these days that are beyond our wildest imaginations, which are on their way to bestow a realistic dimension to our pipe dreams. The purport is not to create hyper-informed science-fiction fanatics, but rather to inculcate some encouragement to think about the limits of what is possible and gain a better taste of material science in a convivial manner.

Suman Mondal
PhD Student

Towards an end product approach

While the definition of Research is well known, Research in itself is diverse and an arguably difficult topic to discuss. Often Research in a domain can only be understood by a handful of people all over the world. A close-to-home and rather famous among them would be the solutions of one of the well-known Ramanujan problems solved from his notebook recently nearly after a century of his death[1][2]. One reality of research is that during its course, the ground-breaking moments are rare. Research is incremental as we try to understand and address one aspect at a time.

Isolated research is becoming more and more of a thing of the past, as departments, as well as industry demand, have become more fluidic and interdisciplinary. The global phenomenon is shifting towards increasing collaboration and involvement of diverse expertise within groups. While experimental collaboration over facilities has been prevalent, a combination of experiment as well as developmental capabilities have started to become more and more important with industrial demand being more towards a finished product rather than just improvements over previous devices or processes presently prevalent in industries.

Our department has progressed through the years, contributing immensely towards the larger Research & Development (R&D) objectives of the Institute as well as the nation. We boast of a wide variety of research within our department, from Corrosion, metal forming, microstructural engineerings, energy devices research like Solar cells and Li-ion batteries, to polymer physics, superconductivity, thermoelectrics, as well as theoretical calculations, modelling and simulation, and Machine learning in materials science. While we have a lot of research themes within this, making it impossible for one article to cover every aspect, we, therefore, decide to delve into a research sector which has been receiving increased attention over the last few years, i.e., Biotech [3]. In the context of a larger theme of end product development in research, we try to understand the intricacies, challenges and Do's and Don'ts with the help of **Prof. Dipti Gupta**, who heads the Plastic Electronics and Energy Laboratory (PEEL) at IIT Bombay.

1.Research Area

My Lab research interest these days is in flexible electronic sensors for Biomedical as well as other industrial applications. Presently, in the Biomedical Domain, we're working on two main projects— the development of wearable electrophysiological electrodes and blood pressure monitoring devices. The primary reason for working in this domain is because there's a need and an equivalent demand for point-of-care diagnostics. Such diagnostics benefits us in having better results and increases the ease of drawing inferences due to continuous monitoring. A practical desire is to have devices that are comfortable, soft and bio-compatible. In research, we fabricate devices with materials such that the substrate must be biocompatible. Later it's impregnated with nano-materials, likely carbon-based, and then tested for stretchability since we want to have a conformable contact with the skin without losing the electrical properties. The materials are studied based on these strategies and characterised by their electrical, electro-mechanical, transmissive and receptive properties. The lab also compares them with the standard electrodes in the market and looks for different sensor designs. Recently, we are working on a project in collaboration with a neurosurgeon where we are looking to design an electrode that can be inserted into the brain. This research is a new direction for us, and the idea too seems quite promising.

2.Facilities

I don't like students confining themselves to just my labs, and encourage them to explore various labs in the department as well as outside, as that will generate diverse ideas and experience. My lab has facilities mostly related to fabrication and electrical characterisation, which are our main strengths. We have physical and chemical vapour deposition facilities in fabrication as well as sufficient electrical characterisation facilities. We also do printing for mass manufacturing.

3.Recognition and Student Exposure

Almost every year, one or two students visit internationally renowned labs across the globe by my encouragement and their passion. The recent examples would be students going to Canada's Simon Fraser University and North-western University for a year. In the past, they've visited labs in South Korea, Sweden, Australia, and Taiwan too. The reason for this is not the labs' facilities, which are excellent over here also, but student exposure. I have students hailing from humble backgrounds, so the experience and exposure is a crucial benefit for them.

4.Approach

My focus is application development. We look into different challenges and stages in product development. Our department has several diverse expertise. Talking about just my domain, I think there's a good scope of improvement [in the overall research]. Industries have approached us for the development and utilisation of our research, but what they need is a complete marketable product packaged with everything— electronics, hardware, software, IoT, data analysis. They don't want prototypes. My approach to this challenge is hiring students who have expertise in these diverse areas and enhance collaboration.

5.Suggestions

Based on my professional experience, one drawback in the students is that they don't strive for original ideas. There's a trend to perform a literature survey and come up with solutions that can frankly be described as 'Nobody has done this, so that's why I'm doing it'. It's a fool's errand to do so. They should instead come up with a reason for why they're doing it. That 'thinking aspect' is often missing.

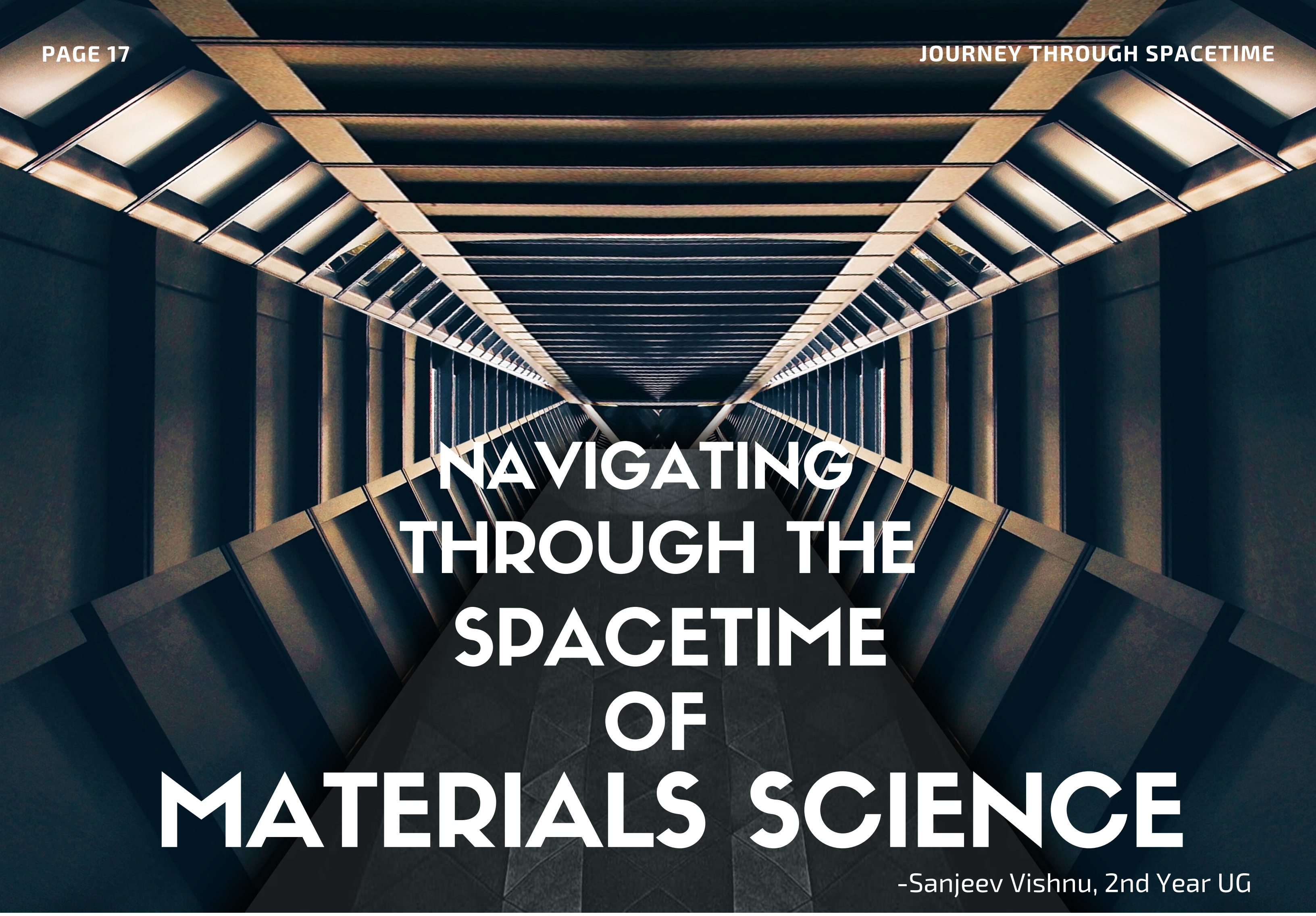
6.Sharing your Experience

There's an issue that students don't know of all the available areas, due to humble backgrounds and underexposure. Still, whatever problem one chooses to pursue, pick that up from your interest which is pertinent to maintain a long term interest in the field itself. But interest from a stranger's perspective isn't enough—once you pursue something, you must motivate yourself to excel in that. However small or big a problem, if you devote yourself, apply yourself to think of creative solutions in and around it with some practical feasibility, you will be able to solve any kind of complex problem. My simple suggestion would be that whatever you pursue, immerse yourself into its devotion, and exhaust yourself in its understanding with significant interests. All areas are phenomenal, but your interest in an area will make it worth [to pursue].

7.Advice

I would say that I want students to apply themselves in applications development. As a department, we do quite well in materials research. But I think we don't look for applications, however small yet practical, which feels like an incomplete answer to me. The study would be much more engaging and exciting if this happens too.

[1] American mathematicians solve Ramanujan's "deathbed" puzzle. The Hindu. Dec 30, 2012.
[2] Mathematician Untangles Legendary Problem. Science Daily. Apr 5, 2005.
[3] How Indian biotech is driving innovation. Nature Spotlight. Dec 12, 2018.



NAVIGATING THROUGH THE SPACETIME OF MATERIALS SCIENCE

-Sanjeev Vishnu, 2nd Year UG

Let's journey through the spacetime of the discipline Materials Science which is lately creating ripples in the field of Engineering. Why has this turned into a buzzword?

To understand its origin, we have to sail back 9000 years. In fact, history has been classified according to the dominant material used in that era. The Stone Age, the Bronze Age and the Iron Age suggest that mankind's development was predominantly dependent on its evolution in metallurgy. The more our ancestors learnt about materials and the easier it was to extract metals, life became easier. They soon learnt that metals combined in different proportions result in materials with different properties. Without realising they had created one of the first fields of engineering which would later be called Metallurgical Engineering.

Fast-forwarding to a couple of hundred years back, Mechanical Engineers who had until then were studying the properties of alloys to build structures were quite confused when they found out that alloys though identical in their composition gave rise to various mechanical properties. This proved to be an unusually challenging problem and soon they could figure out that the methods employed in manufacturing also decided its properties. Little did they know that this would grow into a discipline of its own. Schools had started incorporating metallurgy oriented towards mining.

In the 20th Century, the advent of materials and the realisation of the possibility of creating new materials stirred excitement amongst scientists who were primarily focused on chemistry. As we all know this enabled people to fly.

The idea that the potential of materials could be much higher than humans had been thinking soon spread through the scientific community like a wildfire. With the World Wars and the giant leaps in the field of computer science, the stage then had people delve into the microscopic world.

Since this field had many parallels to metallurgy as both studied composition and manufacturing, Metallurgy turned into a subset of Materials Science. This can be seen evidently through the changing names of the same discipline offered in the Massachusetts Institute of Technology. In 1967 the department name changed to the Department of Metallurgy and Materials Science and in 1974 to the Department of Materials Science and Engineering. Prominent universities around the world including IIT Bombay changed its title to Department of Metallurgy and Materials Science, fondly called MEMS :p

Needless to say, Silicon chips have changed the way we look at the world forever. It wouldn't be wrong to say every technological achievement's barrier ultimately lies in materials. Take a look at these - Sputnik's launch into outer space (1957); lasers (1958); silicon single crystals grown for semiconductors (1960); man landing on the moon (1969); soft contact lenses (1972); computed tomography scan (1972) and magnetic resonance imaging (1981) diagnostics; personal computers introduced (1981) and World Wide Web available to the masses (1991); not to mention the end of the Cold War in 1989. These are the most significant events occurred in our recent history and each of them is accompanied by ingenious developments in materials.

Machine Learning, Big Data, Neural Networks the other big words in the current scientific scene has made simulations possible. Today, we are able to run millions of simulations (thanks to artificial intelligence) which has exponentially reduced the time needed to try out new compositions, processes and analyse failure, fatigues et cetera. New Materials are viewed as breakthroughs and there has never been a better time than now to innovate and solve problems through amazing materials. Put in the right words " We are in the midst of a materials revolution".

The field has branched out into multiple streams such as Ceramics, Nanotechnology and Advanced Materials with each having cemented a strong position in the future of technology. The future is likely to be dominated by nanomaterials. Nano-structuring is considered very effective to improve numerous different material characteristics — mechanical, electrical, magnetic, optical, and biological.

As we all know, the most important crisis we are facing right now is climate change. Moving away from fossil fuel, we need materials which store energy or can be used to produce energy. Thus, there has been an increase in the need for environment-friendly materials which supports sustainable development. There is a growing need for biomaterials i.e materials which can be injected into the human body and can act as catalysts for the effective functioning of enzymes. Expeditions to Mars and the Moon is a clear indication that the future will contain super materials which will make dreams come true. Terrestrialization of Mars or intergalactic travel will be possible only when the present Materials Scientists and Engineers invent new materials.

WHAT AFTER MEMS?

A. On-campus placements

There are various companies that recruit Metallurgical Engineers and Materials Engineers. Some of the recent ones that have been recruiting from campus are -

muRata
INNOVATOR IN ELECTRONICS

JINDAL
STEEL & POWER

BHARAT FORGE

JSW Steel

Reliance
Industries Limited

JFE

HITACHI
Inspire the Next

AIRBUS

SONY

TATA STEEL
#WeAlsoMakeTomorrow

vedanta
transforming elements

APPLIED
MATERIALS®

B. Higher Education

Some of our recent graduates have decided to give the on-campus placements a miss in pursuit of higher studies for a career in Academia or better opportunities in the Industry. Some of them have secured admits from prestigious universities in programs like PhD, MS and MEng.

Stanford University

Penn
UNIVERSITY of PENNSYLVANIA

Massachusetts Institute of Technology

CORNELL UNIVERSITY FOUNDED A.D. 1865
Cornell University

Carnegie Mellon University

University of Waterloo

UCLA
University of California, Los Angeles

END NOTE

Ever since its inception in 1958, our department has evolved largely in many spheres, be research, academics, administration, labs, and many more fronts. Having been a part of it for the past four years, when I sit and look back at my time spent here, I experience an ineffable surge of nostalgia and pride. Hence, I would like to convey a message, through this medium, to the freshmen and sophomore students of our department: There's a lot to explore in our department, lots of learning and research opportunities, excellent lab facilities and professors who are always willing to help students with their research work or even everything else. Managing this department's multiple gears would be impossible without an efficient and supportive administration, headed by the ever-helpful Head of Department, Prof. Narasimhan, who's always willing to interact with students and help us out in any possible way. 'Learn, innovate, grow and contribute to the maximum possible extent.'—that should be the mantra. It is really tough to find such favourable conditions along with a fabulous peer group. So, why not make the maximum use of it?!

I can't appreciate enough of the guidance and vision that my colleagues, Siddharth Mehta, Mrigi Munjal, Rishabh Raj, have offered and the phenomenal efforts of the Editorial Board: Alisha Parveen, Sanjev Vishnu, Aryan Mishra, Ankita Mankar, and Suman Mondal. The persistence of Board was all to forge this piece for the betterment of the future MEMS Department students. I also urge the readers to provide some constructive feedback to the Editorial Board so as to make the future issues more interesting, informative and enjoyable.

Hoping you might have enjoyed reading this.

Param Shah
Department General Secretary, 2019 - 2020

EDITORIAL BOARD

Meet the team behind this edition.