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Materials Scientist Interview

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Despite the advancements in modern engineering, traditional metallic materials still dominate structural applications. More than 60% of biomaterials used today are made up of alloys.

Raghunandan Ummethala (PhD), our next pathbreaker, R&D Manager at nanoCaps (Norway), works on process development in order to scale up and commercialize the production of high energy density supercapacitor electrodes.

Raghunandan talks to Shyam Krishnamurthy from The Interview Portal about the huge potential of materials science in both stationary (eg., smart grids) and mobile (eg., electric vehicles) applications.

For students, sometimes the easiest way to build your career is to explore everything as a child or in your youth, and discover what fascinates you the most !

Raghunandan, tell us what were your initial years like?

I come from a family of lecturers in a town called Guntur in the state of Andhra Pradesh. My parents are both retired lecturers, my father specializing in Commerce and my mother specializing in Botany. Most of my uncles and aunts are either professors or scientists. Consequently, my younger brother and I naturally grew up with a profound respect for education. At the same time, our parents ensured we develop an all-round personality by allowing us to train in classical Carnatic music, piano, badminton, and kung fu.

Since the age of six, my brother and I, along with our cousins, used to visit my aunt's physics laboratory every summer vacation. She was a physics professor and a materials enthusiast. My uncle was also a scientist at the defense laboratories (DMRL). With great excitement, they would demonstrate interesting experiments such as magnetic levitation, superconductivity, shape memory alloys, exposure to liquid nitrogen, among others. We were all so intrigued by these experiments that I decided to pursue a career as a professor/materials scientist at a very early stage. I gathered from my aunt that I needed to do a PhD and that professors enjoy an exclusive freedom to take up any subject that interests them and have students help them pursue these projects. Usually, scientists with an affiliation lack this kind of freedom. I loved the idea of engaging in intellectually stimulating work every day and not succumbing to a stereotypical job.

What did you do for graduation/post graduation?

I did my BTech in Materials & Metallurgical Engineering, MTech from IIT Kanpur (Materials & Metallurgical Engineering) and PhD from Technische Universität Dresden.

My MTech thesis work was funded by DAAD, while my PhD work (industrial thesis) was sponsored by Siemens AG (Germany) and BMBF-Germany (Federal Ministry of Education and Research).

What were some of the influences that led you to such an offbeat, unconventional and uncommon career?

With strong determination, I went on to pursue my goal of becoming a researcher, especially in metals and materials. In 2003, I enrolled for my BTech in the Department of Metallurgical and Materials Engineering at Mahatma Gandhi Institute of Technology in Hyderabad. Soon, I realized that most of my 60+ classmates had joined this discipline without much choice. It was then I understood that more than 90% of people around me had no idea what materials science or metallurgy was. Most people held misconceptions that metallurgists excavated ores and rocks from remote, deadly mines. Some even mistakenly thought it was only for men as it involved hard labor. But, thanks to the highly capable and motivated faculty, everyone started to realize how unique this discipline was, and yet how unpopular it was in India. Owing to the good collaborations of our department with external labs, we were sent to prestigious organizations for our bachelor's theses and for occasional visits. The partner organizations included DMRL, DRDO, International Advanced Research Center (ARCI), Vishakhapatnam Steel Plant, Midhani, BHEL, Saint Gobain and many more.

My BTech thesis focused on the chemical vapor deposition of ultra-low friction 'diamond-like carbon (DLC)' thin films on aluminum alloys, which were meant for high wear resistance applications including, but not limited to, automotive pistons, sprockets, and camshafts.

In my final year, I prepared for the GATE exam, a requirement for pursuing a Master's degree at the IITs. I achieved an All-India Rank of 21 and received admission from numerous IITs and IISc Bengaluru. I did not make a choice based on the reputation of an IIT, but rather chose a person that I would like to be mentored by. It was a legendary metallurgist, world renowned for his intellectual work on deciphering the secrets of the Delhi Iron Pillar, Late Prof. R. Balasubramaniam of IIT Kanpur. I was mesmerized by his captivating lecture on the Delhi Iron Pillar, standing tall in the Qutub Minar Complex, that has not corroded in the last 1600 years.

Besides the interesting metallurgy, being an 'archeo'-metallurgist, he also showed us how his team investigated the history of the pillar: who commissioned it, where, when and how it was manufactured, and its actual purpose. This led me to give up my plans for studying abroad and seek mentorship from Prof. Bala. I joined Prof. Bala's Corrosion lab for my Master's thesis, where I worked on studying the corrosion behavior of novel titanium alloys. With Prof. Bala's encouragement, I secured a DAAD (German Academic Exchange Service) fellowship and conducted further experiments at TU Dresden, Germany, for nine months. Upon my return, I successfully defended my thesis, but sadly, Prof. Bala passed away, leaving a lasting impact on me. Subsequently, I pursued my PhD at a public and popular research center, the Leibniz Institute in Dresden, where I worked on carbon nanotubes, which are hollow tubes, nearly 50,000 times thinner than human hair.

The broad focus of my PhD work was to develop cold electron guns, which were in turn meant to be used in the generation of x-rays for medical imaging. Carbon nanotubes are arguably the sharpest materials on the planet that show a unique ability to emit electrons due to an amplified electric field around its tip when an external potential is applied. Siemens AG invested in replacing the traditional tungsten pins (worked on the principle of electron emission under excessive heat) with carbon nanotubes (worked on the principle of electron tunneling under the influence of potential gradient) for their mammography devices. Our group was successful in exceeding the technical objectives set by the company.

How did you plan the steps to get into the career you wanted?Tell us about your career path

For many pursuing a PhD in science or technology, the line between education and employment becomes somewhat blurred. I completed my PhD in 2014 but didn't step into my first regular job as an Assistant Professor until 2020. During this time, I embarked on a journey known as a 'postdoctoral,' essentially serving as a transitional phase between the PhD and employment. During the PhD, one typically learns how to engage with literature, identify challenges within a specific domain, devise systematic experimental plans, analyze results, and ultimately address the challenges or at least find new ways to fail. What you acquire during the postdoctoral phase, which is often absent during the PhD, is the ability to identify topics relevant to the current times or society, write proposals to secure grants to fund experiments, manage finances and personnel, and drive projects towards the finish line. The postdoctoral stage equips you with these skills, setting the stage for becoming an independent group leader or academician.

Accordingly, following my PhD, I pursued two postdoctoral positions, one at the Leibniz Institute in Dresden, and the other at the Tallinn University of Technology, in Estonia, then I worked as a guest researcher at the University of Hyderabad in the very lab where I witnessed all the cool Physics experiments as a kid.

My second postdoctoral assignment in Estonia was on the additive manufacturing of metallic materials. I conducted parametric studies on the process optimization for 3D printing titanium-based alloys, simultaneously for biomedical and energy applications. I fabricated and tested bulk titanium alloys as potential hard tissue replacements. At the same time, I printed commercially pure titanium (Ti) 3D mesh-like scaffolds, that were later meant to be oxidized to titanium dioxide (TiO_2) and then lithiated (lithium titanate) for use as anodes in Li ion cells. I made significant progress in my research in both the fields of energy and health during my productive time in Estonia.

How did you get your first break?

It is sort of a butterfly effect, with every event playing a pivotal role in shaping what I am today. I'm continuously experiencing a lot of first breaks into new arenas, and I honestly remain uncertain about what the future holds for me.

Between 2020 and 2022, I held my first full-time position as an Assistant Professor at NIT Andhra Pradesh. Until then, my experience had been primarily in conducting academic research, with less exposure to research that could be readily translated into application in the real world. An opportunity presented itself when a professor in Norway approached me with a challenging role, wherein I was tasked with scaling up the production of an innovative nanostructured electrode designed for batteries and supercapacitors. I accepted the role initially as a Technology Researcher and subsequently earned a promotion to the position of Research and Development Manager. Now, I possess a reasonable understanding of both fundamental and commercially applicable research methodologies. I continue to cherish teaching and mentoring, given the substantial number of Master's and PhD interns joining our company. Additionally, I find great satisfaction in advising my former and potential students in their career planning.

What were some of the challenges you faced? How did you address them?

I realized three common challenges in all jobs:

Challenge 1: Giving our best.

I learned with experience that one needs to build knowledge from the grassroot level before advancing to a managerial position. In my present role, I break the hierarchy and make myself available for any kind of task my team/company needs.

Challenge 2: Maintaining healthy relationships with colleagues.

Once I broke the hierarchy, I became closer with all the employees. Outside work, we occasionally gather with families for some fun activities, sports, and food.

Challenge 3: Maintaining the elusive work-life balance.

Excessive workload can negatively impact family life and personal well-being, whereas a lackadaisical approach at work can hinder one's career progression. So, I dedicate myself to work with absolute commitment from 8 am to 4 pm on weekdays. Beyond these hours, I am one hundred percent with family or engrossed in my hobbies. While life is not ideal, naturally there are exceptions, but I am always conscious of the work-life balance and make continuous efforts to achieve it.

Where do you work now? Tell us about your current role

I am currently working as a Research Manager at a Norwegian Battery/Supercapacitor company. We have developed the world's best electrode for supercapacitors (supplies 3-4 times higher energy than the existing supercapacitor of the same size) in our lab. We are now working hard to scale up the production and commercialize the electrode.

What are the skills required for your role? How did you acquire them?

This task needs a thorough knowledge on how to fabricate and test different nanomaterials. It also needs some basic knowledge of physics and chemistry. Most importantly, the manager needs to be able to delegate their team of researchers to different areas in the workflow chain, train them and make swift progress. Everyday is a learning curve for the entire team. We try, we fail, we think outside the box and that is how we are zeroing in on the target. What I love about this job is that I have a lot of freedom in implementing my plans, I work with people of different professional and ethnic backgrounds, and most importantly, learn something new every day. It is satisfying because of two reasons: a) my work directly impacts the carbon footprint on the earth and b) I get to mentor many interns and researchers, and thus give back to society.

How does your work benefit society?

The health of humans and the health of the planet- this is what my work broadly addresses. My main area of research is on materials for energy and materials for health. We (our team) strive hard to find sources for alternate energy and investigate them thoroughly with a deep analysis on their long-term consequences. For instance, the electrode we are developing adheres to the futuristic 'dry fabrication' process, wherein we avoid the usage of toxic solvents and disruptive binders that are used extensively today. We not only save a large amount of energy during fabrication, but also deliver at least 3 times more energy than the best cell available today of the same size. In more technical terms, we are able to triple the volumetric capacitance (charge storage per volume of the cell) without any compromise in the gravimetric capacitance (charge storage per mass of the cell). So, it has a huge and potential to be used in both stationary (eg., smart grids) and mobile (eg., electric vehicles) applications. Currently, the source for our patented carbon nanotubes electrode technology is acetylene gas, while we have already started testing purified biogas as a replacement, in efforts to make our production and the electrode more environment-friendly.

On the other hand, as a hobby, I am involved in research on traditional metallic materials as they always continue to amuse me. Despite the advancements in modern engineering materials, traditional metallic materials still dominate structural applications. More than 60% of biomaterials today are made of alloys. The rest are polymers, ceramics, and composites. I am particularly interested in studying the mechanical properties and corrosion resistance of such alloys and related coatings.

Tell us an example of a specific memorable work you did that is very close to you!

During my Master's program at IIT, the private contractor of our hostel canteen employed a group of young boys. None of them had basic education, but they were working inside one of the premier education institutions. Irony but not surprising! They expressed interest in learning English and Maths from me. Despite my motivation to teach them, my proficiency in Hindi was limited at the time. Additionally, they could spare only between 3 am to 5 am in the morning as the canteen operated between 2 pm to 2 am, seven days a week. For about three months, I committed to waking up at 3 am and taught them basic English and Maths. They learned surprisingly fast and were very grateful. It was during this experience that I discovered the immense satisfaction derived from giving back to society. Consequently, I continue to engage in teaching and mentoring whenever feasible, outside the confines of my regular work.

Your advice to students based on your experience?

Explore everything as a child or youth and discover what amuses you the most. Gather all the information you can on how to make a career in that direction. Then, approach the target with hard work, determination, patience, and discipline. Amidst your pursuits, make time for family, friends, and hobbies. Ultimately, spend some time with yourself, introspecting your motives and how you can contribute to the welfare of yourself and that of society.

Future Plans?

I aspire to continue working on energy- and biomaterials and play a role in making a direct impact on a healthier society for the future generations.

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