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'Demonetisation'.... digitalisation ...

The demonetisation phenomena overshadowed nearly everything in India during the close of 2016. While the expected resultants of the demonetisation exercise seem positively aligned, it's implementation on ground met with enormously massive challenges. Some pain and discomfort notwithstanding, demonetisation may have actually initiated a shift in consumer mind-set that may even influence their normal spending habits. However, one of the outcomes triggered during the course of demonetisation has been increased adoption of electronic and other cashless transactions. While wholesale shift to various digital platforms seems desirable, any slip in the delivery mechanism, interoperability or breach in security protocols can create havoc and may bring in serious scepticism about such systems. Who wants to lose his shirt to a hack! Given the fast paced innovations happening all-around, we may be in for other disruptions by agile start-ups and hitherto unregulated players who may provide newer transaction models. The hassles of long queues for cash post demonetisation led some smart chaps to come up with interesting tactics to address a few such challenges. However, it's the 'Fintech' innovations that are likely to throw up interesting solutions to obviate consumer pain points even in normal situations. Aside of start-ups working on available opportunities, quite a few innovators ideate on devising disruptive business models. Blockchain technologies (eg Bitcoin) for digital transactions or other smart ideas may change the face of financial dealings. The use of payment cards may not encounter challenges over a period of time in case better, more secure and user-friendly systems come into play. Irrespective of the intent behind demonetisation exercise, one thing is clear that it has provided an opportunity landscape for start-ups to innovate newer models of economic transactions that may, in future, obviate the need for demonetisation-type policies. And, yes the bright start-ups including those from University campuses should aim at creative solutions. Tools of automation, artificial intelligence (AI) etc. may help innovators to devise robustly tamper-proof, smart and compliant platforms that may entirely alter the present face of monetary dealings not just in cities but, in the country's rural hinterland where the challenges are genuinely manifold.

Let's hope we see increased digitalization in future.

Best for the New Year!

Dr A Wali

What's in this issue?

21st AGM of FITT at the Senate Room, November 22

Delegation from the ministry of Israel headed by the Minister of Science, Technology & Space visited the TBIU, December 6

Rumour in the Post-truth Age

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The coinage "post-truth" gained worldwide attention in 2016, signalling a shift into a new information-led era. In this era the fast and irreversible dissemination of messages through semi-trustworthy channels is capable to creating wide-ranging impacts that could potentially change the course of human history. It's worth noting that the deleterious effects of the wide and quick spread of inflammatory messages is not a new problem. "Rumor, the swiftest of all evils," Virgil says in his Aeneid, written about two thousand years ago,"Speed lends her strength, and she finds vigor as she goes." What is new is the existence of platforms like Whatsapp, Facebook, Twitter etc. that allow for spread on a vast scale. The nature of these platforms and their widespread adoption by common people and institutional players alike has led to certain new kinds of problems and a few opportunities. In this article we will look at the notions of trust that people employ in their use of social networks and the way this trust is misuse to spread harmful messages. We will also discuss briefly a method for counteracting the spread of rumors by putting trust to good use. But first let us quickly review what is known about how things spread on a social network.

The term meme has often been used to describe objects that spread across a social network. A meme could be a particular object like an image or a video or a web URL, or it could be a concept, a piece of "reportage" that spreads quickly and extensively through the network. Researchers largely agree that there are two kinds of explosive phenomena on social networks. The first of these, less relevant to our discussion, relates to what are known as exogenous memes. These are memes that are propelled through the network due to circumstances outside the network. Examples of these might be a natural disaster, the death of a well-known figure, a terrorist attack and so forth, typically events that are experienced or reliably learned by a large number of people from multiple sources. The other kind of explosive phenomenon is called endogenous. This is the spread of a meme that is propelled by the network and typically emerges from a small number of sources. In the early days of the large online social networks these memes were largely in the nature of jokes, funny videos and other similar phenomena, some of which like Lolcats--images of cats with accompanying funny text--were unknown prior to the advent of these networks.

There is a vast body of research on characterising the spread of endogenous memes. This research can be loosely divided into two categories: content-based and network-based. The first category works on the assumption that there is something inherent in the meme that makes it viral. The second line of research is content-agnostic and seeks to determine the fate of a meme from the characteristics of its early spread. Since the first category is highly domain-specific, we ignore it here and focus on the latter category. Summarising the main insights that years of research have produced, we can say that it is widely believed that the early spread can often give clues to the eventual virality or non-virality of a meme. The key, according to several groups of researchers, including myself, is an understanding of the "community structure" of the network, i.e., understanding who are the groups of users who typically interact with each other more than they interact with others. This notion has been variously defined and we need not go into the merits and demerits of all those definitions, but what researchers have found is that if a meme spreads widely within a few communities then it is likely to go viral. A good indicator of the imminent virality of a meme is when individuals who lie at the intersection of more than one community start talking about it, i.e., if the musicians are talking about it and the wrestling fans are talking about it, it could go either way, but when the musicians who like wrestling start talking about it then it is time to start taking note of that meme.

As such it is not hard to imagine that there are individuals within the network, possibly those who can talk to and influence multiple communities, who are able to give a meme a good push on its way to virality. These need not always be celebrities with large followings. In fact our research showed that celebrities don't often initiate endogenous memes, although they often jump in at critical points. We found that there were several celebrity initiated memes that did not get any traction in the network. While celebrities are important, there are a number of community-level influencers within the network who are pushing viral memes. As an aside, those who follow Twitter in India will no doubt have noticed that since early 2014, in the run up to the last general election, a number of overtly political memes attacking or supporting a particular political party began to be seen. The situation today is that if we look at the list of topics trending on Twitter in India on any given day we realise that at most one or two trends are "organic." Most trends are today being manufactured and pushed by political parties, companies trying to sell new products or position brands, or

special interest groups with deep pockets. This gives rise to the feeling that the process by which trends are identified by Twitter has been completely reverse-engineered. In fact we now have particular groups openly claiming with pride that they managed to get this or that hashtag to trend.

So how do we address the problem of harmful messages propagating through the network? There are several issues here, starting with the detection of such false, misleading or harmful messages and then moving on to curtailing their spread and finally identifying and prosecuting mischievous elements who have actively worked to spread the message. In some work conducted collaboratively with IBM's India Research Lab we addressed the second of these three issues. We modelled the spread of rumour as a message spreading and replicating on a network. Our primary suggestion was that the best way of combatting rumour is by attacking it with a similar process, anti-rumour, which is also a message spreading and replicating through the network the contradicts the rumour and brings attention to the fact that a rumour is spreading. The idea is that on a social network we have some trust in our connections and this trust is used to debunk a rumour. Sometimes if a government says something people are suspicious, a classic example being rumours about vaccinations. However they do trust their friends and if, on a whatsapp group for example, someone forcefully debunks a rumour and encourages people to further debunk it, this might help contain the rumour better than authorised broadcasts through mass media channels.

We studied three modes of combatting rumours: the first was a centralised mechanism by which if an authority, say the government, learns that the rumour is spreading they approach individuals involved in spreading the rumour and instruct them to begin spreading the anti-rumour. The second method was semi-centralised but more proactive: we assumed that the authority had positioned individuals within the network, we call them beacons, who would immediately begin disseminating the anti-rumour once a rumour reached them. Note that this idea of having individuals seeded in the network is not different in principle from what is being done by "marketing" companies that pay influencers to spread a particular message, except that it is for a good cause! The third method we studied was a completely decentralised method that assumed an enlightened citizenry. In this method we assumed that any individual within the network may, on receiving the rumour may turn into a beacon and begin transmitting the anti-rumour. We found that the third model, that of an enlightened citizenry, was the most effective in the sense that it succeeded in curtailing the rumour in the shortest time given our modeling assumptions.

Although our research was done in an idealised setting with several assumptions that made analysis and simulation tractable, there are certain broad ideas that emerge from it that could be seen as inputs to policy makers looking to combat the increasingly dangerous phenomenon of rumour spread on social networks. In brief, here are some ways of approaching this problem based on our research:

- The government can think of creating a "human infrastructure" of beacons within the network who can be tasked with detecting rumours. The beacons could be principals of government schools, district and block level functionaries and so forth. Such people are naturally embedded within their communities and, consequently, within social networks enabled through Whatsapp or other messaging platforms. When they realise a rumour is spreading they should alert the authorities.

- A clear and credible rumour debunking message, anti-rumour, should be created and immediately seeded into the network through the beacons who should be instructed to aggressively spread the anti-rumour

- Public awareness on how to combat rumours must be created. People should be encouraged to spread anti-rumour messages on a priority basis. Once clear methodologies for this are communicated to the public if even a small fraction of them decide to take this on as a civic duty, rumours can be contained at all levels (local, regional and national).

In conclusion, I want to note that the widespread adoption of communication platforms like Whatsapp, Twitter, Facebook etc has brought tremendous good with it, specifically for the free and fast movement of information in public settings. These platforms have increased governmental accountability and public participation in community activities. All these outcomes are laudable, but the tremendous danger to society, especially democratic society, that these platforms bring with them should not be ignored: it is in fact the other side of the same coin. I feel it is time for a greater discussion on the misuse of social media and other communication platforms, and for beginning to put safeguards in place.

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Technology Transfer During December 2016

"An improved process for the production of aleuritic acid from lac and its waste and product thereof" has been transferred to M/s. C K Lac Processing Industry

Block Copolymer Self-Assembly: From Ordered Nanostructures to Individual Nano-Objects

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Block copolymers are a special class of copolymers which consist of chemically distinct homopolymer chains covalently linked to form a single molecule. The number of distinct homopolymer blocks determines the molecular architecture of block copolymer; diblock, triblock, and higher multiblock copolymers as well as branched and star-like architectures are possible. Due to their mutual repulsion, dissimilar blocks tend to segregate into different domains, the spatial extent of the domains being limited by the constraint imposed by the chemical connectivity of the blocks. The nature of the domains in determined by two competing factors: area minimization of the interface to lower the interfacial energy and maximization of the entropy as the polymer chains stretch away from the interface to avoid unfavourable contacts. As a result of these competing effects, self-organized periodic nanostructures are formed depending on the interaction between components, relative volume ratio between the blocks and chain architecture as well as the degree of polymerisation and persistence length of the respective blocks.[1,2] Typical dimensions of these nanostructures range from 5 to 50 nm.

The simplest block copolymers are the amorphous coil-coil AB diblock copolymers which will be largely in the focus of this section. The phase behaviour of such diblock copolymers has been studied extensively from both experimental and theoretical perspectives. The morphology of the self-organized nanostructures is determined by the product χN, where χ is the temperature-dependent Flory-Huggins interaction parameter between the monomer units and N is the degree of polymerization, and the composition of the copolymer determined by the volume fraction of the respective blocks *f*. The typical morphologies observed in a coil-coil AB diblock copolymers range from body centered cubic (BCC) packed spheres to hexagonally packed cylinders to alternating lamellae. For other compositions and weaker segregation other morphologies, such as the bicontinuous gyroid or hexagonally perforated lamellae, can also be observed. The size and the domain spacing of the nanostructures depends on the molecular weight, segment size, and the degree of repulsion between the blocks, represented by χ. Figure 1 shows the well-studied phase diagram of a model diblock copolymer, polystyrene-*block*-polyisoprene (PS-b-PI) in bulk.[3] The figure shows the dependence of morphology on the volume fraction of the constituting blocks. A disorder-order transition (or microphase separation) occurs when χN reaches a critical value which can happen when the molecular weight of the polymer is high enough for given χ and / or at a particular critical temperature as a result of the temperature dependence of χ. Mean field theory predicts that the transition occurs at $\chi N = 10.5$ for diblock copolymers (neglecting fluctuations) which means that copolymers are much better compatible than corresponding homopolymers of same molecular weight, where phase segregation occurs at $\chi N = 2$. The phase behaviour of the block copolymer becomes much more complex with the incorporation of an additional building block into the system to form ABC type of triblock copolymers. Thus, a richer and more complex morphology of microdomains has been predicted and also has been experimentally observed for ABC triblock copolymers.

The microphase separation of block copolymers in thin films, however, significantly differs from that in the bulk since the domain structure, apart from other parameters, depends also on the surface energies and geometrical constraints. The interfacial energy (polymer-air and polymer-substrate interactions) and the film thickness relative to the domain periodicity play a crucial role in orientation and ordering of microdomains in thin block copolymer films. Even in the simplest compositionally symmetrical coil-coil block copolymer system, although both of the two building blocks have similar volume ratios and the system thus favors formation of a lamellar mesophase in the bulk, a very sophisticated picture is revealed in the thin-film state. The fundamental aspects of the thin film block copolymer structures have been presented in detail in several excellent reviews. [4,5]

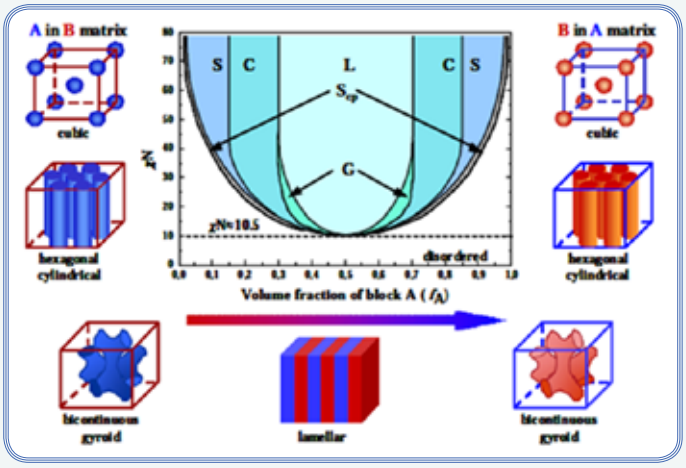

Figure 1: Phase diagram and equilibrium phase morphologies for bulk diblock copolymer: L – lamellae, C – cylinders, S – spheres, G – gyroid, S_{cp} – closely packed spheres. Modified from [3].

In the thin film state, the block copolymer microdomain formation takes place relative to the surface of the film. Hence, the microdomains tend to form with a particular orientation to the substrate surface. Here, for shapes such as cylinders and lamellae, the orientation of the long axes with the surface is a major characteristic of the film. Parallel cylinders and perpendicular lamellae are of interest in the patterning of nanowires. Perpendicular cylinders and spheres may be of interest in the patterning of hexagonal arrays of nanodots or nanorods for data storage. Standing cylinders are also of interest for photovoltaic device fabrication. In the thin-film case, preferential interaction of one block with the substrate or the low surface energy of another block forces them to segregate onto the interfaces. As a result of the general incommensurability of film thickness relative to the natural period, these surface / interfacial effects drive the anisotropic lamellar and cylinder domains to preferably align parallel to the substrate. Hence, the orientation of the microdomains parallel to the substrate is more commonly observed in thin films of block copolymers. For orienting the microdomains normal to the surface, these preferential interactions had to be negated. In last few years, significant attention has been given to control the orientation of microdomains in thin films of blocks copolymer. Generally, the strategies applied for orienting block copolymer thin films have focused on following approaches: control of film thickness relative to the natural period(substrate topography); control of substrate polymer interactions (neutral surfaces, chemically patterned surfaces, and modified interfacial characteristics); and application of external fields (electric, solvent evaporation, etc.). Generally, it should be noted that many of the reported thin film morphologies are non-equilibrium structures which are determined by preparation conditions and solvent evaporation kinetics. The interesting self-assembly behaviour of block copolymers coated on a substrate as thin film and their further utilization as template for nanopatterning application is shown, from one of our work, in Figure 2.[6,7] The thin film of a cylinder forming polystyrene-*block*-poly(4-vinylpyridine) (PS-b-P4VP)coated on a silicon substrate was found to exhibit domain orientation dependent on solvent selected for casting it. Hence, casted from 1,4-dioxane, the block copolymer depicted vertically oriented cylinder morphology which were further packed in a hexagonal lattice. The cylinder were constituted of minority P4VP block. However, when the same block copolymer was casted from choloforom as solvent, the cylinders were oriented parallel to the substrate. Interestingly, the orientation was switchable such that exposing the vertically oriented cylinder to chloroform solvent vapors switched the orientation to parallel which on further exposing to 1,4-dioxane solvent vapour, switched the orientation back to perpendicular. The process could be repeated many times without affecting the stability of the thin film. Next, the P4VP block was selectively functionalized with palladium nanoparticles. This could be done either using pre-synthesized nanoparticles or could also be carried out directly doing the synthesis on the P4VP block. In either of the cases, the Pd nanoparticles are selectively incorporated in the P4VP cylinders. The polymer film then were removed by oxidative pyrolysis such that only metal nanoparticles were left on the silicon substrate where the assembly of the nanoparticles mirrored that of the original polymer template. Hence, the vertically oriented morphology led to the formation of hexagonally arranged assembly of Pd nanodots with an average diameter of 15 nm and an inter-dot spacing of 27 nm. The parallel cylinder led to the formation of Pd nanowires. The methodology reported here is general and versatile so that it could easily be extended for patterning a variety of metallic materials into dot and wire arrays.[8-10] Moreover, the size and spacing of the nanostructures could easily be tuned by controlling the molecular weight of the block copolymer.

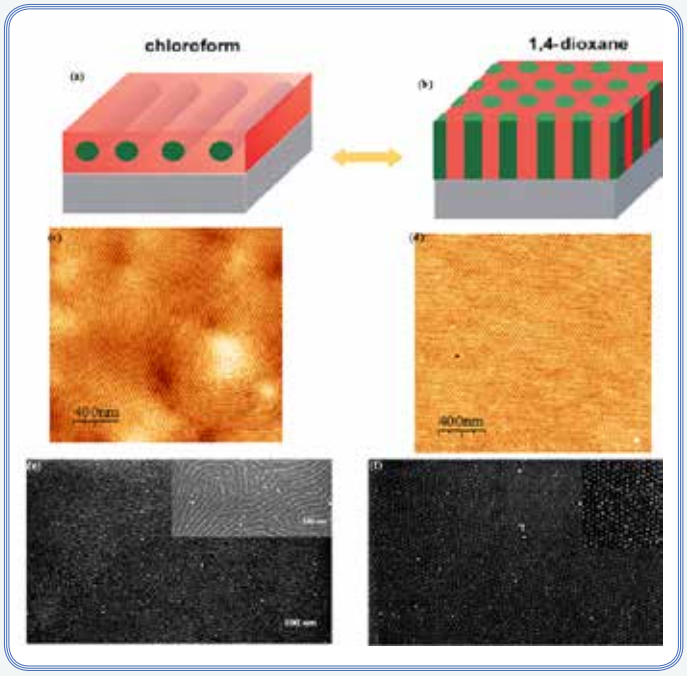

Figure 2: (a-b) Schematics of PS-b-P4VP block copolymer morphology casted on a silicon substrate from different solvents; (c-d) AFM topography image depicting paralle and perpedncilular orientation of P4VP cylinders (e-f) High resolution SEM images of Pd nanodots and nanowires obtained via selective adsorption of colloidal Pd nanoparticles into the P4VP pores and subsequent template removal by pyrolysis.[7]

The self-assembly behavior of block copolymers could also be used to fabricate individual polymer hairy core-shell nano-objects. There are two basic approaches for preparing hairy polymer nanoobjects from the block copolymers. The first approach involves the use of block copolymer solution in selective solvent such that the copolymer forms micellar structures in which non-soluble block forms the core and the soluble block forms the shell. Depending on the solvent concentration and the composition of the block copolymers, theoretically spherical, cylindrical or sheet-like nanoobjects can be prepared. Though, the principle is simple, the micellar approach to prepare cylindrical and sheet-like polymer nanoobjects is not that straightforward. This is attributed to the requirements that have to be matched to produce such nanoobjects i.e., the block copolymers should form micelles of required shape in solution, and also the core forming segments must be stabilized. Suitable block copolymers for such purpose are still very few due to a narrow window of block copolymer composition to form cylindrical or lamellar micelles. The second approach involves the bulk morphology of the

microphase separated block copolymers and is more robust. The reason is that the block copolymers form well-ordered lamellar, cylindrical and spherical morphologies in a relatively wide range of component windows, and, moreover, no solvent interaction needs to be considered. In this approach, the self-assembled structures achieved in the bulk state are dispersed in a solvent selective for the matrix block. Figure 3 schematically shows how the microphase separated morphologies of the block copolymers could be used to extract individual hairy polymer nanoobjects.[11,12]

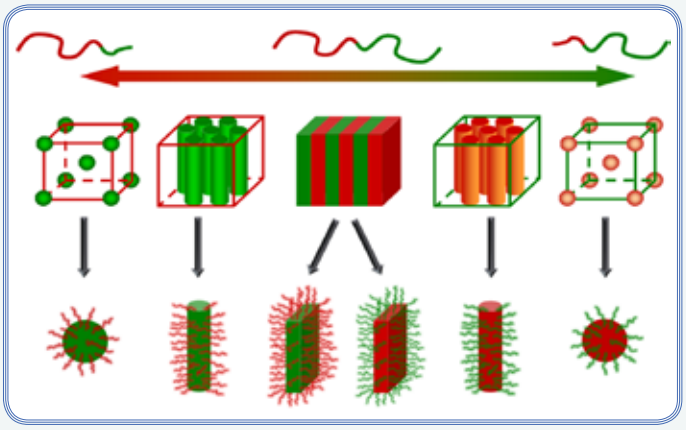

Figure 3: Schematics of isolation of hairy polymer nano-objects of different geometric shape from self-assembled morphologies of block copolymers.[11]

The approach involves a two-stage process in which first formation of the well-ordered microphase-separated structure of block copolymer is achieved and then, using a selective solvent, the self-assembled domain is isolated. The main requirement here is that during solvent treatment, the self-assembled domains should not undergo any distortion / deformation. Hence, the solvent used should be strongly selective for the matrix-forming block and have minimal affinity for the minority block which constitutes the nanodomains. Since, even in a selective solvent, the cylindrical and lamellar domains could readily undergo structural transformation to spherical micelles, these domains need to be stabilized before they are isolated. This has been done mostly using a chemical fixation approach where the minority block forming the self-assembled domains is stabilized by cross-linking. However, this requires the presence of a reactive minority block and, in some cases, may also induce undesired changes in the copolymer properties. However, more recently, we have demonstrated that for isolating the nanodomains the cross-linking step may not be required.[12] Furthermore, the hairy polymer nanoobjects so obtained have been used for hosting / directing inorganic and / or organic / inorganic hybrid nanoobjects of various geometries.[13-15] This involves either loading the functionality in the dense core of the polymer nanoobjects or functionalization of the hairy shell. Recently, we demonstrated the fabrication of polymer nanoobjects with densely packed silver nanoparticles (AgNP) in the PS core of PS-*b*-P4VP block copolymer.[14] The PS grafted AgNP selectively goes into the PS cylindrical domains of the PS-*b*-P4VP copolymer on self-assembly. More significantly, we found that under the experimental conditions used the AgNP pack in a helical morphology inside the PS cylinder. Hence, the isolated hairy nanofibers had the AgNP arranged in a helical packing inside the core(Figure 4). Whereas the ability of uniform particles to form well-ordered closely packed structures is well known, recent theoretical estimations have also shown that under cylindrical confinement uniform spherical particles can form a wide spectrum of densely packed morphologies whose geometry strongly depends on the particle-to-cylinder diameter ratio.

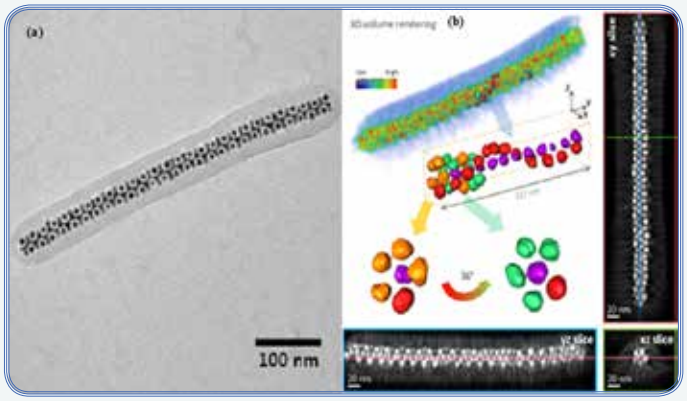

Figure 4: (a)TEM image of a single nanofibers isolated from the AgNP / PS-b-P4VP composite having AgNP closely packed inside core-forming PS domain. (b) 3D TEM tomography reconstruction of AgNP packed inside the isolated nanofiber formed by the PS-b-P4VP block copolymer. The 3D volume rendering shows the entire structure, in which the reconstructed density is color-coded according to the color bar, i.e., the AgNPs appear red (high density) and the BCP appears blue (low density).[14]

Synthetic approaches utilized for the functionalization of cores and shells of nano-objects can be also combined for the fabrication of multifunctional nano-objects having both the core and the shell functionalized with different types of inorganic additives.We successfully implemented such an approach for the fabrication of multifunctional nano-objects.[15] PS-b-P4VP nanofibers pre-loaded with Ag nanoparticles in the PS core were further functionalized with Au nanocrystals or CdS quantum dots located specifically in the shell. It should be noted that functionalization of the core and the shell can be achieved by using either *in-situ* methods or by loading with pre-synthesized nanoparticles (*ex-situ*).

Above approaches implemented for the functionalization of nano-objects can be further extended for various combinations of desired functionalities. They can be used for producing core-shell, yolk-shell or hollow structures. Those structures are of particular interest for potential application as materials for drug delivery (as nano-carriers), catalysts carriers, nano-sensors, or materials for environmental remediation and energy harvesting.

In summary, the self-assembly of block copolymers offers tremendous opportunity not only for a fundamental understanding of the self-organization principles at different levels but also it provides for a robust and scalable approach for the fabrication of functional nanostructured materials. The easy processibility and chemical distinct nature of different phases

in the resultant morphologies formed *via* block copolymer self-assembly makes them attractive material for directing the assembly of functional or multifunctional materials. This provides interesting possibility for the utilization of such materials in a number of advanced applications such as in storage devices and solar cells. However, the challenge in obtaining a perfectly ordered structures on a macroscopic scale remains, which so far has been a crucial hindrance in the actual realization of some of the potential applications of block copolymer based functional structures. The self-assembled morphologies of block copolymers could also be used to isolate nanoobjects with fascinating shape and structures, some of which are difficult to obtain through any other approach known so far. Moreover, the use of these nanoobjects as templates to grow functional nanoparticles also presents enormous possibilities. Moreover, by combining the nanoparticle deposition in shell and core, a range of multifunctional nanoobjects of different shape could be fabricated where two different functional properties could be combined in a single nanoobject.

Acknowledgement

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Floating Buildings For Earthquake Resilient Society

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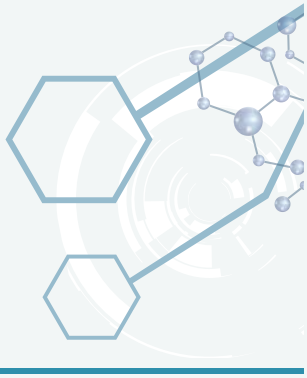
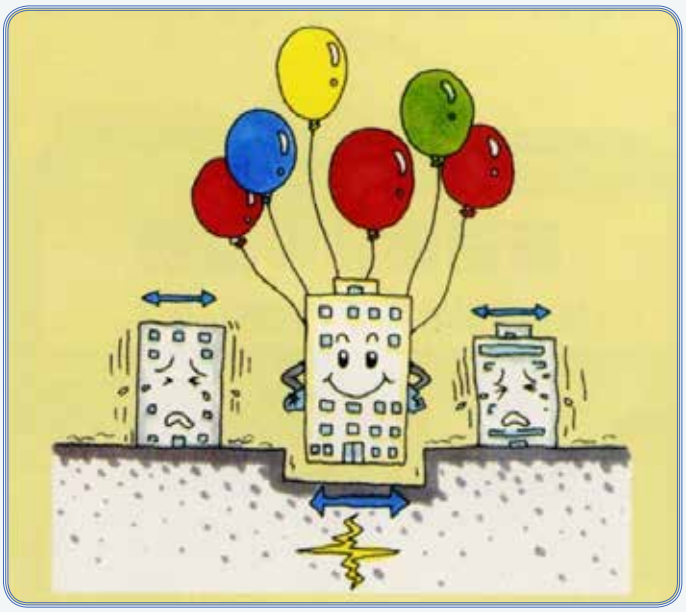


In India, about 60% of the land area is prone to severe shaking due to earthquakes. Especially, the area in the vicinity of the Himalayan subduction zone is seismically active. For the geopolitical reasons, the population density in the northern states is high, including the National Capital Region (NCR) of Delhi. Four seismic zones, II to V, are demarcated in India based on the anticipated increasing order of ground acceleration due to the earthquakes. Entire north-east region is included in the Zone V, whereas the states in the foothills of the Himalayas are included in the Zone IV or V. The built-infrastructure in the populous cities needs to meet the necessary functional requirements while exhibiting resilience against natural hazards such as earthquakes, flood, landslides, strong wind, etc.

Several past earthquakes have shown alarming vulnerability of the traditionally built structures, which led to catastrophic

collapse of buildings and bridges, causing loss of several lives. Unlike most other hazards, earthquakes directly do never cause loss of life; the structures which collapse under the action of earthquakes cause the death toll. The society consequently demanded from the researchers giving viable solutions to the construction industry in developing earthquake resilient infrastructure. One such possible advanced construction technology is seismic base isolation of structures.

As the name suggests, in the base isolation technology, the structures are isolated from the shaking ground, such that the adverse effects of the ground shaking on the structures are almost eliminated. Sketch-1 depicts from the cartoonist's perspective how a base-isolated building would be detached from the ground as compared the conventional fixed-base buildings, as shown besides. The conventional fixed-base buildings, which are resting on the ground, suffer vigorous shaking during earthquakes; whereas, the so-depicted floating buildings will suffer no earthquake-induced shaking, thereby the damages are prevented.

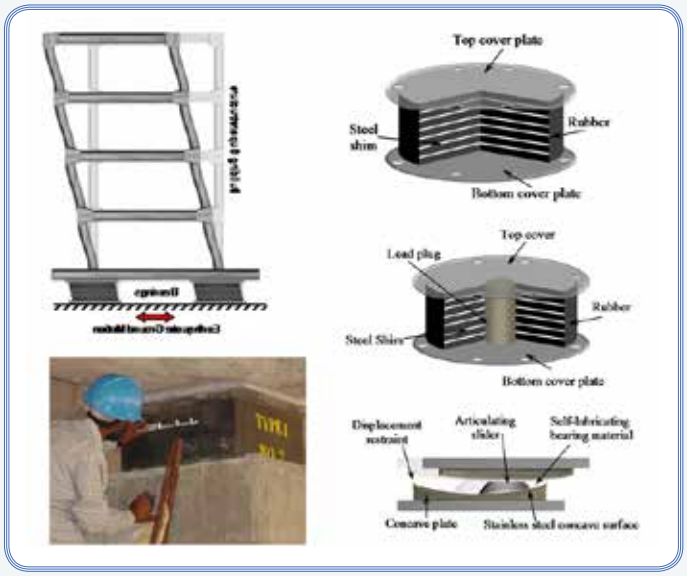


Sketch-1: Understanding how seismic base isolation of structures works.

Such separation of the buildings using balloons is though infeasible practically, almost the similar effect is achieved by using "base isolation devices" or also simply called "bearings" as shown in Sketch-2. The bearings are of different innovative types and essentially serve the intended purpose of isolating/ separating the structures from the shaking or vibrating ground, nevertheless of course transferring all the gravity and service loads effectively to the ground.

Among various types of the base isolation devices, elastomeric rubber bearings are quite popularly used in Japan, USA, and European countries. The elastomeric rubber bearings are made of rubber to provide horizontal flexibility, and steel shims/ plates inserted in the rubber to provide vertical stiffness (Sketch-2). Therefore, the major design parameter for the elastomeric bearings is the horizontal stiffness of the rubber used therein.

For preventing excessive displacements of the structures even during small tremors or winds, lead-plug is commonly inserted in the rubber so that until it breaks the stiffness offered by the bearing is relatively high.



Sketch-2: Base isolation devices or bearings used in building construction practice.

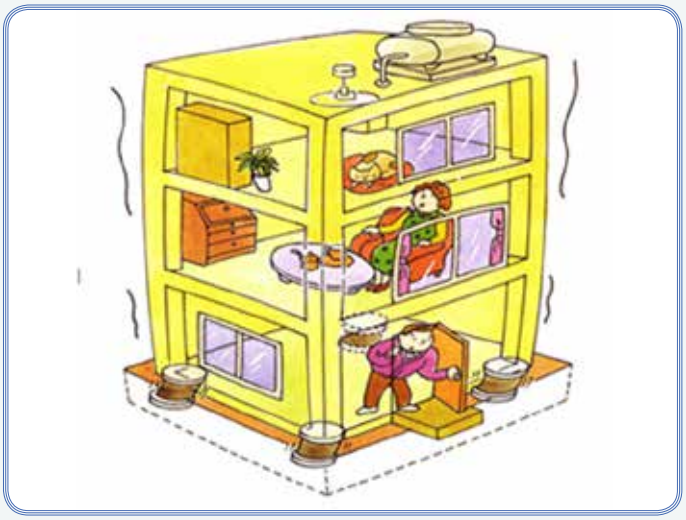
The increased horizontal flexibility, achieved due to insertion of rubber, ensures behavior of the buildings similar to the trees which sway with the ground during the earthquakes but doesn't collapse. Thus, distinguishing feature of the base isolation technology from the conventional earthquake-resistant design lies in the fact that, instead of resisting the earthquake forces by the structures, allow swaying of the structures under the action of the earthquake forces.

Alternatively, sliding type of base isolation devices are popularly used in protecting bridges from earthquakes. The bridge deck rests on the sliding type of bearings; thereby, the bridge piers experience minimal seismic forces. As seen in Sketch-2, a slider moves on a concave surface in the sliding systems, during which seismic energy is dissipated in the friction mechanism whereas the concave shape helps in ascertaining re-centering post-earthquake, i.e. the structure on top of the bearing returns to its original position. Hence, typical design parameters are the friction coefficient and the radius of curvature of the concave surface.

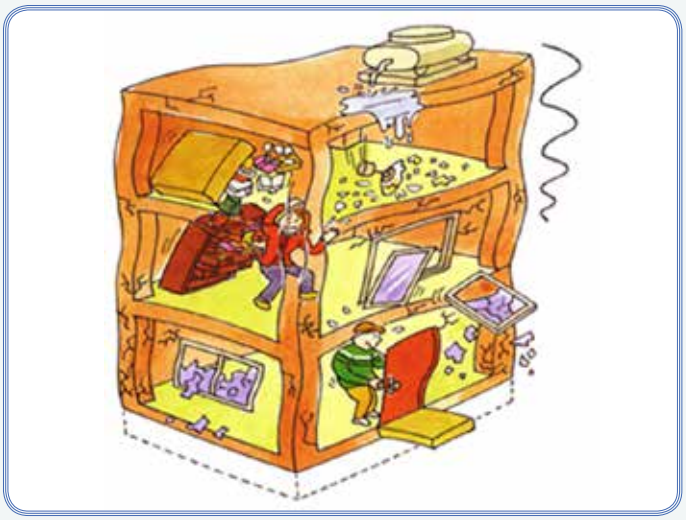
Newer type of seismic isolation devices include the roller systems, mostly based on the rolling friction. Among several novel roller systems, IIT Delhi has filed a patent on base isolation device for earthquake resistant structures based on innovative rollers, facilitating the purpose of earthquake energy dissipation and re-centering of the structure post-earthquake. The advantage of such base isolation system is that they can be easily replaced, if so required.

The effectiveness of using the base isolation technology in buildings is evident from Sketch-3 as compared to the conventional fixed-base buildings shown in Sketch-4. During

the strong ground shaking due to an earthquake, the fixed-base building as well as the contents within it are vigorously shaken; whereas, the base-isolated building and the contents within experience no such vigorous shaking. Falling of household objects during major earthquakes causes injuries or leads to secondary hazards such as fire. However, the use of base isolation devices ensures reduced vibrations in the buildings so that such objects are prevented from falling and avoiding occurrences of consequent secondary hazards.



Sketch-3: Earthquake behavior of the base-isolated building and contents protected.



Sketch-4: Earthquake behavior of the fixed-base building and contents unprotected.

Albeit realizing effectiveness of the base isolation technology for protection of the structures from earthquakes its use in India is rare. This is mainly attributed to the unavailability of robust and reliable base isolation devices manufactured indigenously. However, from experiences gained through some real-life projects currently undertaken in India, it has been inferred that, even with the use of imported bearings, the total cost of construction does not exceed 10% of the cost of the conventional construction. With the significant advantages mentioned erstwhile, such investment is justified towards making India an earthquake resilient society. In that, the two construction projects of base-isolated buildings in India, where IIT Delhi is contributing in the technology implementation, will prove to be remarkable examples for the construction industry. Architect's perspectives of the two upcoming base-isolated building projects are shown in Sketches 5 and 6.

Sketch-5: Base-Isolated Indira Gandhi Hospital at Dwarka in Delhi.

Sketch-6: Base-Isolated Indira Gandhi Hospital at Dwarka in Delhi.

A 700-bed capacity Indira Gandhi Hospital amidst earmarked area of about 60,000 m2 at Dwarka in Delhi is under construction using the seismic base isolation technology. The base-isolated structures remain functional even after the earthquakes; hence, the technology is highly desirable to be used for lifeline structures and essential services, which respectively includes bridges, liquid storage tanks etc. and hospitals, relief operation facilities etc. In view of this, police headquarters in the state capital, Patna in Bihar base-isolated building is being constructed. Furthermore, currently a few communication / data centres and educational institute buildings are planned to be seismically base-isolated in some cities of India.

In the National Capital Region (NCR) of Delhi, several buildings have been confirmed vulnerable to earthquakes by the National Disaster Management Authority (NDMA). A major future earthquake may impose severe catastrophe on the Nation's capital. Enhancing the earthquake resistance of such otherwise vulnerable existing buildings is possible by using the base isolation technology, especially without closing them down for the earthquake retrofitting. Therefore, it is recommended that important structures, especially in the Zone IV or V, are constructed with the advanced base isolation technology.

Disclaimer: Some of the illustrations are adopted from Google Images.

Reference:

1. Matsagar, Vasant; Ummer, Naseef; and Rawat, Aruna (2016) "Base Isolation Device for Earthquake Resistant Structures", The Patent Office Journal, E04H9/02, 21038.

Faculty Profiles

Prof M Joshi
Department of Textile Technology
Indian Institute of Technology Delhi

Dr Mangala Joshi is an alumnus of IIT Delhi having received her MSc (Chemistry), MTech and PhD (Polymer Science and Engineering) (1992) from IIT Delhi. She graduated from Isabella Thoburn College, Lucknow University in 1981.

In the year 2000, Dr Joshi joined as Assistant Professor at department of Textile Technology at IIT Delhi and specializes in the area of polymer/fiber science & technology. After joining IIT, she was the first one in the department to initiate research in the emerging area of nanoscience and nanotechnology application in textiles. Her research interests include – polymer nanocomposite fibers, coating and nanofibers, nanomaterials for biomedical applications like antimicrobial textiles and transdermal drug delivery and coated and laminated textiles for defense applications. She has been instrumental in pioneering the R&D activities in the field of polymer nanocomposites as an advanced material for high performance textiles and also set up state of art laboratory facilities for polymer nanocomposite processing and characterization over the last sixteen years.

The recognition for her research work has come in the form of the prestigious National Award for Innovation in Polymer Science & Technology awarded by Ministry of Chemicals & Fertilizers, Government of India for the year 2012-13. The award was given for her work on development of modified nanographite based polyurethane nanocomposites for stealth application. This work was part of doctoral thesis of her PhD student and carried out under a sponsored project from Nano Mission- Department of Science & Technology (DST), and Government of India for which she was the principal investigator. Several other awards have been won by her research group such as in Open House organized by IIT Delhi every year to showcase the technologies developed in the institute through student research projects to the outside world. Her research work with students was awarded three times for being best industry and socially relevant projects by the Alumni Association of IIT Delhi. The first one was on extraction silk sericin from degumming waste liquor using membrane separation process and its application on textiles, Best Industry Relevant Project Award at I2 Tech, Open House, IIT Delhi, April 2008; Responsive Camouflage Textiles, I2 Tech, April 2012 and Antimicrobial HDPE/Clay Nanocomposites: A potential replacement for Conventional Plastics, I2 Tech, Open House 2016. Several other student poster awards have been bagged by her students in seminars and conference both at international and national level.

Her special R&D focus has been in the area of envelope material development for aerostats/airships with superior weather resistance and gas barrier properties, under a series of projects sponsored by Aerial Delivery and Development Establishment (ADRDE) Agra, DRDO. Dr Joshi has been pursuing active research in developing polyurethane nanocomposite based coated and laminated textiles for aerostats and airships used in defense applications.

The envelope and hull material development for such an application is a very challenging task as the material used for such inflatable has to be strong, lightweight, and resistant to harsh atmospheric conditions and be able to retain lighter than air gas such as Helium for a long duration. She is coordinating the sub group activity on coated and laminated textiles for inflatable under the smart and intelligent textiles vertical, as a part of setting up of Joint Advanced Technology Centre (JATC) at IIT Delhi, under a MOU with DRDO, Govt of India, which has been signed very recently between IIT Delhi and DRDO.

She is the principal investigator of several R&D projects at IIT Delhi. Some of the projects which have been successfully completed are High Performance Fibers Based on Polymer; Clay Nanocompositeby MHRD, Govt of India; Development Of Bioactive Nanocomposite Fibers from US multinational Locked Martin Corporation; Development of Nanomaterial Enhanced Coated Textiles from Nano Mission, DST, Govt of India; Standardization and Extraction of Sericin from Silk Degumming Liquor sponsored by Department of Biotechnology, Govt of India. She was entrusted the very important task of preparing a detailed project report on Hull Materials for High Altitude Airships by National Aerospace Laboratory, Bangalore which was submitted in 2010. Currently a sponsored project from Gas Authority of India, Ltd (GAIL) titled- Development of Multifunctional Hybrid Polyolefin Nanocomposites is under progress. Under this project three specialty grades of polyolefin i.e. with functionality such as antimicrobial, flame retardant and gas barrier are being developed.

In 1993, Dr Joshi joined Northern India Textile Research Association (NITRA) Ghaziabad as a Senior Scientific Officer. In NITRA she got an opportunity to work on an important area related to environmental issues in textile industry.

At IITD she has developed three new electives courses – 'Environmental management in textile industry', 'Functional and smart textiles' and 'Science and applications of nanotechnology in textiles'. She has also developed a laboratory manual on 'Experiments in fiber physics and course material on "Composites materials and technology'. Dr Joshi has published 75 papers in refereed international journals of repute and presented 120 plenary / invited / contributory papers in international and national conferences. She has co-edited one book and written several book chapters in books published by well- known publishers such as Wood head Publishers, UK. Dr Joshi is an inventor in the field having few patents to her credit. She has guided eight PhD students successfully and five more students are working under supervision for their doctoral thesis work. She has guided many masters and under graduate students for their major research project.

She serves as core member for expert committee on Materials, Mining and Metallurgy and co-opted member for expert committee on Engineering Sciences of Science and Engineering Research Board (SERB), DST, Govt of India for the year 2015-18.

She is member of Research Advisory Council of ADRDE, DRDO, Agra; Northern India Textile Research Association, NITRA, Ghaziabad and PSG Institute of Advanced Research, Coimbatore. She is life member of several professional societies.

Dr Managala Joshi belongs to a family of Vedic scholars from Varanasi (UP). Dr Joshi wishes to write a book in the future and also wishes to successfully take her research based on developed technologies to a scale which will make them relevant socially and have an academic as well as social impact.

Prof N Garg
Department of Computer Science
Indian Institute of Technology Delhi

Naveen Garg is a Professor of Computer Science at the Indian Institute of Technology Delhi. His research interests are in Theoretical Computer Science, specifically in the design and analysis of algorithms.

Naveen started his undergraduate studies in Computer Science at IIT Delhi in 1987. Very soon he was fascinated by theoretical computer science and decided to continue graduate studies in this area. He found an excellent advisor in Vijay Vazirani and after turning down a Regents fellowship from UC Berkeley started his PhD at IITD in 1991. The early 90's were the heydays of approximation algorithms and Naveen's thesis extending the celebrated Max-flow min-cut theorem of Ford and Fulkerson to an approximate max-flow min-multicut theorem for multicommodity flows was a significant contribution to this effort.

After completing his PhD in 1994, Naveen joined the Algorithms and Complexity group of Kurt Mehlhorn at the Max-Planck-Institut fur Informatik, Saarbruecken, Germany as a postdoctoral fellow. Prof Mehlhorn's group has been one of the most active centers of research in different aspects of algorithms and complexity and sees a steady stream of visitors. This was the time to expand ones horizon and Naveen made the most of this opportunity by collaborating with researchers from around the world. An important contribution he made during this period was to develop the primal dual framework to obtain fast approximate solutions for packing and covering linear programs.

Naveen returned to his alma-mater as an Assistant Professor in December, 1997. Soon he found an excellent set of students to work with and together they gave the first tight analysis of a 40 year old algorithm for a facility location problem. Together with Amit Kumar, a colleague, Naveen began investigating how mathematical programming techniques could be applied to problems in scheduling. This effort led to simple and improved algorithms with tighter analysis and to interesting new models of resource augmentation.

Naveen continued to maintain close ties with the MPI- Informatik and spent his sabbatical year in 2006-07 and about 7 months in 2002 visiting the algorithms and complexity group there. In 2004 he was chosen by the Max-Planck-Society to form and head a partner group on "Approximation Algorithms" at IIT Delhi. This then led to the formation of the "Indo-German Center for excellence in Computer Science (IMPECS)" which is a virtual center for collaborative research between Indian and German scientists and was funded by DST, Max-Planck-Gesselschaft and the German Federal Ministry for Science and Research. The research is carried out by a dozen groups at institutions around the country in collaboration with researchers at MPI-Informatik and MPI-Software systems.

Research can be quite frustrating at times. This is, perhaps, even more true for research in the theoretical sciences and it is not uncommon to remain "stuck" for months on end while trying to solve a challenging problem. Teaching and mentoring smart students is a life-saver at such times. Naveen thoroughly enjoys teaching and works very closely with his students. His video lectures on "Data Structures and Algorithms" recorded as part of NPTEL are very popular and the 36 lectures together have over 4 million views on YouTube with the first lecture alone having over a million views. In 2012 he was awarded the "Teaching Excellence Award" by IIT Delhi.

Naveen's research contributions have been recognized by a few award committees. In 2002, he was awarded the Friedrich Wilhelm Bessel award by the Humboldt foundation, Germany. He received the AICTE Career Award for Young Teachers in 2004, the INAE Young Engineer Award in 2005, the INSA Young Scientist Medal and the IBM Research Faculty Award in 2006. In 2014 he was elected a Fellow of Indian Academy of Sciences, Bangalore and in 2016 he has been selected for the SS Bhatnagar award for Mathematical Sciences.

Innovations

Opportunities for IP Licensing

S No	Title	PI/Dept/Centres
1	Flexible composites for ballistic applications	Prof BS Butola/TT
2	Process for preparation of hydric alcohols	Dr MA Haider/CHEM
3	Process for production and isolation of recombinant human serum albumin in E. Coli	Prof TK Chaudhuri/KSBS
4	A novel device for measuring pressure pulse based on arterial tonometry	Dr S Roy/AM
5	Smart power management in DC home	Prof S Mishra/EE
6	Method of enhancing protein activity	Dr B Kundu/KSBS
7	A grid interactive solar photovoltaic based water pumping system and method thereof	Prof B Singh/EE
8	Fluid film journal bearing	Prof RK Pandey/ME
9	Green fluorescent carbon dots for pH sensing	Dr N Singh/CBME
10	Polymer tubes for manufacturing stents	Prof N Bhatnagar/ME
11	A lobular dental implant	Prof N Bhatnagar/ME
12	Development of a new process for c-n coupling	Prof AN Bhaskarwar/CHEME
13	Composite fibers having aligned inorganic nano structures of high aspect ratio and preparation method	Prof A Agrawal/TT
14	Multilobe adaptive fluid film journal bearing	Prof RK Pandey/ME
15	An assay and kit for detection of endotoxin	Dr S Gupta/CHEME
16	Image sensor	Dr M Suri/EE
17	Training a neural network	Prof Jayadeva/EE
18	A single phase dual mode reconfigurable microgrid system	Prof B Singh/EE
19	A PV power generating system for improving power extraction of solar PV module array	Prof S Mishra/EE
20	Alcohol-diesel-water microemulsion fuels	Prof AN Bhaskarwar/CHEME
21	A formulation for stabilizing bio-therapeutics	Prof AS Rathore/CHEME
22	A microelectromechanical (MEMS) switch	Dr S Dhanekar/CARE
23	Photovoltaic array fed water pumping system with switched reluctance motor and a method thereof	Prof B Singh/EE
24	Textile structures for controlled in vitro bone cell differentiation	Dr S Ghosh/TT
25	A grid interfaced SPV array fed water pumping system	Prof B Singh/EE
26	A device for automated diagnosis of epilepsy	Dr TK Gandhi/EE

Cell microenvironment pH sensing in 3D using fluorescent carbon dots

Dr N Singh
Centre for Biomedical Engineering
Indian Institute of Technology Delhi

The pH of cellular microenvironment plays an important role in deciding the fate of cell to a large extent. The changes in pH can tightly control different biological processes. For instance, the function of proteins depends on their structure, which is governed by its peptide sequence and solvent properties that includes pH as a major component. The charge on cell surface receptors, which act as a communication link between intracellular and extra-cellular environment is controlled by pH outside the cell. Therefore, even a small change in cell microenvironment pH can affect the cell fate. In a tumor mass, cancer cells are always in condition of stress due to poor supply of oxygen and nutrient because of poor vascular perfusion, which initiates fermentative glycolysis leading to extracellular acidosis. This causes the extracellular pH to decrease to upto 5.8 due to lactate production by the cancer cells. Thus, accurately sensing changes in pH of the microenvironment can become an indispensable tool for early diagnostics and enable better understanding of the growth of cancer cells.

At the Centre for Biomedical Engineering IIT Delhi, we have developed a fluorescence based nanosensor, which can sense the pH changes in the biologically relevant range (7.6 to 5.8). We have further developed a process for incorporating the nanosensors in a 3D microgel platform, which supports 3D cell culture and provides *in situ* information about the pH changes in the cellular microenvironment. The developed pH nanosensor is a biocompatible fluorescent carbon dot that can be encapsulated with live cells in transparent spherical PEG microgels; with easily controllable composition, diameter, and architecture; using droplet based microfluidics and UV photo-polymerization. The pH nanosensor with size ~5nm are fluorescent carbon dots that display change in intensity of emission with corresponding change in pH. The range of pH detection is pH 10 to pH 4. These pH sensors are a "turned on" type sensors where the intensity fluorescence intensity increases as the pH is lowered and the environment becomes more acidic. Using this platform of microgel 3D cell culture we can monitor the growth of cells or tumoroids inside microgel with subsequent pH change as they grow. This platform can not only be used for monitoring growth of cells or microbes but can also be used to develop diagnostic tools where lowering of pH can be of clinical relevance.

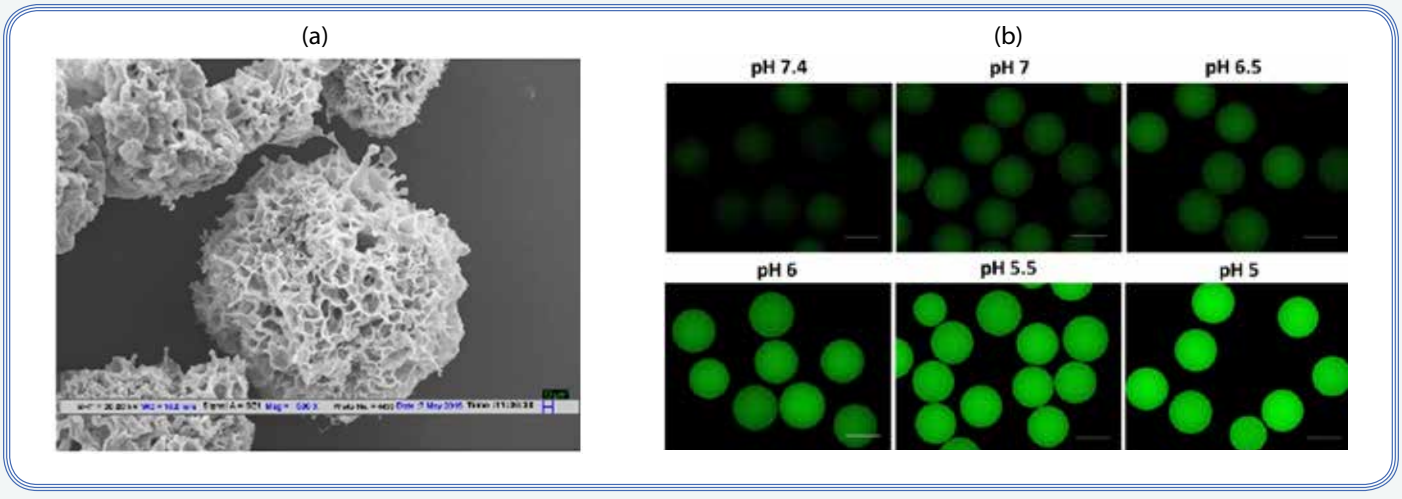


Figure 1: (a) Scanning electron micrograph of microgels showing porous structure that allows cells to grow in 3D environment. (b) Microgels loaded with carbon dots showing increase in intensity with decreasing pH. (scale bar = 200 µm)

Abbreviations

AM:	Department of Applied Mechanics
BSTTM:	Bharti School of Telecommunication Technology and Management
CARE:	Centre for Applied Research in Electronics
CAS:	Centre for Atmospheric Sciences
CBME:	Centre for Biomedical Engineering
CES:	Centre for Energy Studies
CRDT:	Centre for Rural Development and Technology
CPSE:	Centre for Polymer Science and Engineering
CE:	Department of Civil Engineering,
CHEME:	Department of Chemical Engineering,
CHY:	Department of Chemistry,
CSE:	Department of Computer Science and Engineering,
DBEB:	Department of Biochemical Engineering and Biotechnology,
DMS:	Department of Management Studies,
EE:	Department of Electrical Engineering,
HUSS:	Department of Humanities and Social Sciences,
IDDC:	Instrument Design Development Centre,
ITMMEC:	Industrial Tribology,
KSBS:	Kusuma School of Biological Sciences,
ME:	Department of Mechanical Engineering,
PHY:	Department of Physics,
TT:	Department of Textile Technology

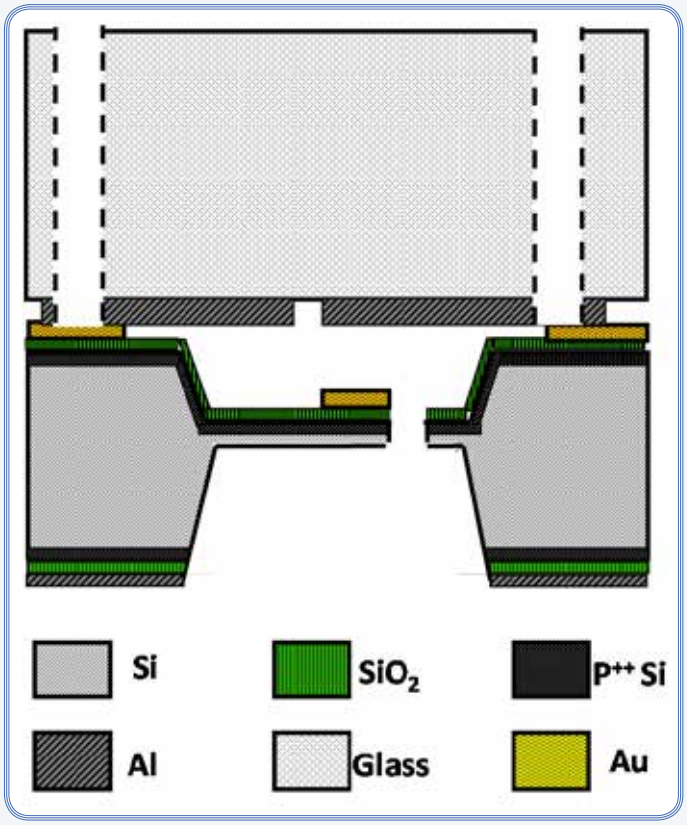
A self-encapsulated silicon cantilever based DC MEMS switch – Batch fabrication and packaging at wafer level

Dr S Dhanekar
Centre for Applied Research in Electronics
Indian Institute of Technology Delhi

Micro-sized switches using Micro-Electro-Mechanical System (MEMS) concepts and technologies have been subject of intense R&D for a long time now. These are used in communications systems, phased array radar and host of other systems. Broadly, switches can be classified into two categories namely RF switch and DC switch. In an RF switch, the signal is transmitted or stopped by capacitive coupling between movable micro-bridge and a fixed electrode. On the other hand, in a DC switch, a metal-to-metal contact is required to be established by movement of metal-coated beam with the fixed electrode for routing the signal. The design and technology of RF switches is now sufficiently known and these are being manufactured globally.

The current technologies/processes being used in switch manufacturing are: (1) Use of surface micromachining, wherein a sacrificial layer is used under the beam which is finally etched out to release the beam. Use of such layers adds a lot of complexity to the fabrication process as selectivity of the etchant to etch the sacrificial layer becomes a prime concern. Thus the choice of beam material is restricted. Moreover, single crystalline silicon material cannot be used in this technology, (2) Packaging of single devices: Single switches can also be packaged however, this will not allow batch fabrication processing and encapsulation of beam within silicon and glass. Thus, this kind of packaging will be time consuming and the probability of cantilever/beam (which is an integral part of the switch) breakage and damage will be high.

In IIT Delhi, a process for fabrication of DC MEMS switch including self encapsulatedrecessed silicon cantilever beam/bridge has been developed. The micro-beam made in silicon substrate is secured using anodic bonding with glass. To provide the space for the movement of the beam and; the critical gap between the fixed electrode and the movable beam for electrostatic actuation is achieved using a recessed structure created in the silicon substrate, formed in a pit of precise depth. For establishing the metal-to-metal contact required for DC operation, the beam is partly coated with a metal layer and the fixed electrode is formed on the glass plate.The pull-up electrode for electrostatic actuation of the beam is formed on the glass plate. Press-on contacts are established between the electrodes formed on silicon substrate and the glass plate used for anodic bonding. For this purpose, holes are made in the glass plate at appropriate locations. Once the wafer level fabrication steps are completed, the individual chips (switches) are separated by conventional dicing machine. The advantages provided by adopting this process are: (a) use of single crystalline silicon as material for beam/bridge, (b) wafer level packaging, (c) beam encapsulationusing recessed structure and anodic bonding, (4) batch fabrication of switches, (5) visibility of beam during actuation, (6) isolation of switch from actuation voltage. The following is the schematic of the fabricated DC MEMS switch:



Sketch-4: Schematic of DC MEMS switch

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Some examples of Development Project @ FITT

S No	Title	PI	Dept/Centre
1	Assessment of bank stability and bank protection measures in respect of river Kaushalya downstream of Kaushalya dam, Panchkula, Haryana	Prof BR Chahar	CE
2	Weather at home for attribution over South Asia	Dr KA Rao	CAS
3	3D modeling of clothes	Dr S Kumar	CSE
4	Phase change polymers using nanotechnology to extend surface property performance	Prof AK Ghosh	CPSE
5	Development and deployment of integrated visual and acoustic system towards conservation efforts of Ganga river dolphin - Phase-II	Prof R Bahl	CARE
6	Compositional and microstructural analysis of mild steel pipes	Dr NN Gosvami	AM
7	Design improvement and performance testing of BLDC hut motor and controller for electric	Dr AK Jain	EE
8	Thermal design of a heat sink for an LED bulb	Dr P Talukdar	ME
9	Establishing caused undermining the foundation of Chamravattom regulator cum bridge	Prof AK Gosain	CE
10	Evaluation of slaughter house ETP (at HMA Factory, Kuberpur, Agra, UP)	Dr SZ Ahammad	DBEB
11	Axial thrust calculations and balancing piston sizing for higher rating supercritical sets	Dr SS Sinha	AM
12	Development of modular solar trackers	Prof S Mukherjee	ME
13	Functionalized silica from rice husk ash	Dr L Nebhani	CPSE
14	Evaluation of technical feasibility of Dr JK Bharthkur's invention to generate electricity through electrolysis	Prof R Khanna	CHEME
15	LED receptor for foot scanner	Dr B Lall	EE
16	Generation of NaOH from sodium sulphate	Dr S Sapra	CHY
17	Installation of community based biogas plant (2x25m cubic) with gas distribution network at village Madiya Khedi, Sconi Malwa, Madhya Pradesh	Prof PMV Subbarao	ME
18	Finalization and design of a swap based interchange at Bailey road, Patna	Prof A Chawla	ME
19	Algorithmic framework for MEMS sensor fusion applications-Phase-III	Prof A Kumar	CARE
20	Modeling, analysis and experimental validation of dynamic response of liquid propulsion turbo pump	Dr AK Darpe	ME

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