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FITT

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MESSAGE

The Year that was ....

2019 was no ordinary year for us. It shall go down in the annals of India's history as an eventful period that witnessed some landmark decisions by the Government. These decisions reflect the strong political resolve that are likely to alter the popular narrative and enable a paradigm shift in decision making particularly, in strategic matters. The country's security environment is always a challenging piece and a few unprecedented steps have helped reset the ground rules of external engagement. The Chandrayaan 2 Mission was an exemplary attempt by our space scientists to explore the southern pole of the moon. On the other hand, the isolated incidents in a few Universities against decisions by the Parliament don't bode well for reasoned discourse in an academic environment. We hope these aberrations get corrected by the saner voices in the system. While all this was happening around us, we had our moments of pride on the campus. The Institute flagged off a bold initiative – the Global Alumni Endowment Fund targeting $ 1 Billion over seven years to catapult the Institute's growth and raise its global profile. Under catchy acronyms, we have formulated and initiated interesting innovation and entrepreneurship support programs like Faculty Innovation and Research-driven Entrepreneurship (FIRE), Platform for Harnessing Deep Technology (PHD) Incubator etc. Such steps are likely to help us strengthen the deep technology start-up ecosystem at IIT Delhi whose alumni have enabled several unicorns. Besides, FITT was instrumental in ensuring the highest ever IP filings from IIT Delhi. While the announcement of magical number of 150 IP filings attracted wide media attention, we simply consider these kinds of accomplishments as milestones in the Institute's journey to be a harbinger of regional development through advanced R&D, innovation and entrepreneurship.

Anil Wali

INSIDE

Underwater Communication: An Open Challenge

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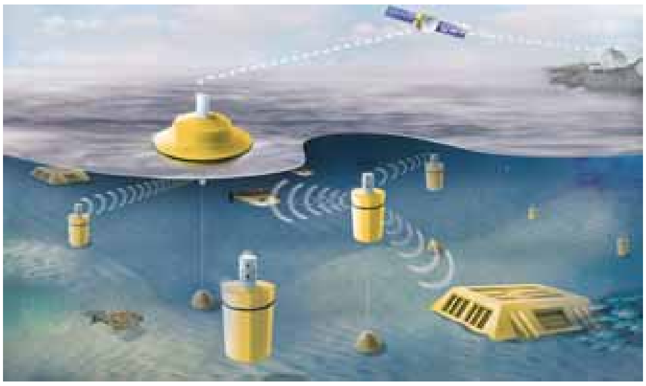
Little did Aristotle imagined when he discovered the propagation of acoustic waves through water, in around 400BC, that it would once lead to an era of undersea wireless communication and sensor network!

Underwater Wireless Sensor Network (UWSN) is network of unmanned, unwired, heterogeneously distributed sensors/ systems for complete surveillance, sea profiling and many other applications. This completely submerged system is becoming increasingly important not only for defense but also from other commercial and social activities.

In undersea domain, the deployment of sensor network is quite a challenge. Physical layer link along with the deployment and maintenance of these completely submerged underwater sensors, limits the range, capacity and various applications of these network.

The challenge of the physical layer starts from the selection of carrier waves. Electro-Magnetic waves get absorbed even at a very small distance of less than a meter. Light waves provide other possible carrier to carry signal in water though they can carry lots of data but the again the range is very minimal much lesser than a km. Acoustic waves are the only waves which can travel in water to a reasonable distance but there are many hurdles, which require special treatment to enable them to carry information to reasonable distance of few km.



Acoustic Medium

Information carrying acoustic waves are pressure waves, though they are capable of propagating over long distances but they get attenuated, absorbed very fast. Hence designing any reliable long-range communication systems using acoustic signals is quite challenging task.

Consider a very generic communication scenario of L transmitters and M receivers i.e. L × M UWA communication link. Sm(.) is an independent and identically distributed (IID) input symbol sequence from a memory-less M-ary constellation with zero mean and unity variance, x(.) are pulses carrying the information. Correspondingly signal received at mth sensor at time instant k is given by,

$$r_m(k) = \sum_{l=0}^{L-1} h_{m,l}(k) * \sum_{n} s_m(n) x(k - nZ) + n_m(k)$$

where $h_{m,l}$ (.) is the channel impulse response between l th transmitter and mth receiver, Z is the oversampling rate, i.e. the ratio between sampling and data rate. n_m(.) is the sample of the underwater noise i.e. underwater channel noises.

Underwater Channel

The propagation UWA channel cannot be modelled as Linear Time Invariant (LTI) system. Due to the continuous waves and agitation the reflection points on the sea surface are always in motion making the incident acoustic waves scatter in a random fashion. The multipath structure, thus formed, is not stationary and changes rapidly resulting in time-varying impulse response of the channel. The multipath structure in an UWA channel is very profound and depends on the transmission link configuration i.e. horizontal or vertical as well as the ocean depth (deep water and shallow water). Ray theory provides the skeleton for determining multipath structure, it is difficult to incorporate the random effects due to time- variance of the UWA channel. The experimental data can also manifest different stochastic distributions suitable to model the UWA multipath structure.

In horizontal UWA links, multipath spread gives rise to severe ISI that might extend upto a several tens or even hundreds of symbol intervals. It is very unlikely for a terrestrial RF link to experience such high degree of multipath spread.

The propagating acoustics waves in a UWA channel undergo spreading, refraction, reverberation, dispersion absorption scattering etc. these are frequency- dependent losses, also depends on the distance traveled by these waves. For short-range communication it provides much larger bandwidth than the corresponding long-range communication. Mathe-matically, the path loss corresponding to signal

of frequency 'f' at a distance 'l' is given by [1]

$$A(l,f) = A0lka(f)l \qquad (1)$$

In decidels (dB) it is given as,

$$10 \log A(l,f)/A_0 = k.\ 10 \log l + l.10 \log a(f) \qquad (2)$$

The first term on RHS of (2) symbolizes the spreading losses, 'k' represents the geometry of propagation, k=2 for spherical spreading and k=1 for cylindrical spreading and second term provides the absorption losses. 'a(f)' is the absorption coefficient, according to Thorp's formula it is given as [2],

$$10 \log a(f) = 0.11 \frac{f^2}{(f^2+1)} + 44 \frac{f^2}{4100+f^2} + 2.75 \cdot 10^{-4} f^2 + 0.003 \qquad (3)$$

The expression (3) is valid for all frequencies and for any propagation. As the medium is bounded, reflections at the boundaries will give rise to multipath and signal will reach to the receiver form the sources through P different paths, the overall channel transfer function of the channel is,

$$H(l,f) = \sum_{P=0}^{P-1} \Gamma_P / \sqrt{A(l_p, f) e^{-j2\pi f \tau_p}} \quad (4)$$

where Γ_p caters for all reflection losses and τ_p is the delay component corresponding to the pth path. The low speed of sound in water cause severe Doppler distortion that can either be viewed as a shift in frequency or a scaling in time of the signal under consideration. The effect of Doppler can spread over a few milliseconds (ms). On the other hand, time-varying multipath results in long delay spread that can also be few tens of ms. The former results in inter-carrier interference (ICI) also called frequency spreading, while the latter gives rise to inter-symbol interference (ISI) or time spreading of the transmitted wave. System involving moving platforms is adversely affected by Doppler shifts resulting from relative motion between the transmitter and receiver.

Channel noises

The studies related to UWA noise were initiated at the very time when underwater bell-and-hydrophone systems came into use in the early 1900's. Though deployed for picking up the bell's sound to ensure navigational safety, the ship-mounted hydrophones used to pick up background noise as well which made it difficult to detect the actual signal of interest.

Traditionally, channel noise is assumed to be additive white Gaussian (AWGN) where the assumption of Gaussianity is motivated by the classical central limit theorem (CLT). Noise in an underwater acoustic (UWA) channel often carries impulsive components from various site-specific sporadic sources [3] such as, biological sources, shipping traffic, ice-cracking, earthquakes, underwater explosives, off shore oil exploration-production etc. Impulsive samples from such sources, punctuate the continuous background noise arising from waves, surface agitation, turbulence, thermal noise etc. This often leads to a noise density function which possesses heavy-tail and so, infinite variance that disobeys the classical CLT. The channel noise, thus, can no longer be appropriately approximated by traditional Gaussian statistics.

In brief the challenges in underwater communication are enormous in number and these are of various genre, therefore, a viable solution is only possible by fusing various signal processing, information theoretic, wave propagation based algorithms/concepts, to cater for impulsive noise, multipath spread Doppler shift etc.

Underwater acoustic communication System

The traditional approach for combating ISI (inter symbol interferences) is to use an adaptive equalizer whose tap length is defined by the degree of multipath compensation. In a profoundly dispersive UWA channel, obviously number of equalizer taps inflates. Alternately, time reversal (TR) is a much simpler technique, which provides spatio-temporal focusing of transmitted energy at the required receiver position. Spatial focusing improves signal-to-noise-ratio (SNR) and thus, abates fading. Temporal focusing reduces delay spread of the channel, which, in turn, minimizes ISI [4]. This is what motivates the use of TR technique in UWA communication.

TR can be implemented at the transmitter in much more effective way in the form of a pre-coder [5], which uses the time-reversed conjugated version of channel impulse response as the transfer function of precoder. It can also be implemented at receiver having the time reversed version of impulse response as matched filter to provide almost similar gain.

Another way to handle this frequency selective underwater channel is by converting it into large number of orthogonal flat fading channels. Orthogonal Frequency Division Multiplexing scheme (OFDM) partitions the given frequency band into constant magnitude sub-bands [6]. OFDM techniques uses sinusoids as carrier. Instead usage of frequency sweep signal which are resistant to detrimental effects of shallow water communication such as noise, Doppler effect and multi- paths fading, Chirp spread spectrum (CSS) modulation technique offers robust performance with very simple matched filtering based decoder. Therefore offers a preferred solution, which can particularly be adapted for the difficult UWA channel. Recently, OCDM, Orthogonal Chirp division multiplexing, based upon multiplexing chirp signals within the same time slot and bandwidth has been suggested and they provide several performance gains [7].

A system with OCDM having TR based matched filter at receiver filters along with the multitap non-linear equalizer serves as viable solution to handle this underwater environment.

Table summarizes these techniques and achievable performance

Handling noises

A robust and rugged underwater communication system should be able to overcome all the above mentioned hurdles. Underwater noise is a big hurdle.

The statistical understanding of these noises is very important for designing any solution to combat this. Based on the estimated density function (pdf) of the noise better receiver can be designed. This impairments of impulsive noise on signal detection can be mitigated either by designing algorithms that can suppress the impulsive behavior and/or alter the noise characteristics to a Gaussian-like behavior so that the standard optimal Gaussian receiver can be reused. One can also develop optimal receivers that can adapt to an impulsive noise environment [8] so as to recover the transmitted information from the noise corrupted signal without changing its statistical characteristics.

Billions and billions of data is available, we want to use these data for the betterment to design better system. All the open source data form NOAA and Venus site has been collected and noise properties of the collected data has been thoroughly studied. Location of data collection is far apart and moreover the features and parameters of the data is also different. NOAA data is sampled at 5kHz sampling frequency and Venus is at 128kHz. Table 1 gives the details of the data.

Table 1: Details of the underwater noise sample

Location	Data Source	Sampling Freq. (KHz)	Depth (m)
Gulf of Mexico	NOAA	5 KHz	50-100m
Gulf of Alaska	NOAA	5 KHz	50-100m
North Pacific Ocean	NOAA	5 KHz	50-100m
Indian Ocean	Experimentally	100 KHz	10-20m
Barkley Canyon	VENUS	128 KHz	50-100m
Clayoquot Slope	VENUS	128 KHz	50-100m
North Pacific Ocean	VENUS	30 KHz	50-100m

The histogram of data samples can give the crude estimate of pdf. But the discrete nature hides important details and produces incorrect peaks. PDF can be estimated from histogram using Kernel density, orthogonal polynomial etc. based approaches. Using the estimated pdf the Gaussianity of the noise samples can be tested. Various tests have been suggested by researchers to test for given pdf. Following test have been used to test the sample data for assumed pdf.

- Jarque – Bera Test
- Anderson –Darling Test
- Cramer-von Mises Criterion
- LillieFore Test
- Kolmogorov-Smirnov test
- Shapiro-Wilk Test
- Pearson Chi Squared Test

Table 2 summaries these finding. All these tests confirm that these noises are not Gaussian.

Table 2: Hypothesis testing; h = 1 means pdf is not assumed one, p-value tells us about how much observed data disagrees with null hypothesis.

Distribution	Anderson Darling		Lilliefors	
	h	p	h	p
Gaussian	1	6.30e-11	1	0
Exponential	1	4.58e-14	1	0
Extreme Value	1	6.30e-14	1	1.003e-03
Lognormal	1	7.52e-14	1	0
Weibull	1	4.33e-14	1	0

Several non-Gaussian statistics are proposed in literature to model UWA noise. Among them the Generalized Gaussian (GG) model offers a flexible parametric form that can describe a wide range of super-Gaussian to sub-Gaussian densities which makes it popular in modeling UWA noise. Another popular model is the symmetric \alpha stable (S\alpha S) which is characterized by an infinite second order moment. The Gaussian Mixture (GM) statistics offers "universal approximation" properties and is used in several UWA applications. The Cauchy Gaussian Mixture (CGM) or Bivariate Cauchy Gaussian mixture (BCGM) statistics, on the other hand, provides another approximation to heavy-tailed impulsive S\alpha S processes. Therefore to compare the estimated pdf of real noise with standard pdfs of the recommended models for UWA noises, various measures have used to compare the estimated pdf with these standard one. Many divergence measures the closeness are used to test the noises, Table 3-4 summarizes the results.

Table 3: K-L Divergence test for Comparison of Different Distributions

Noise sample taken from (sampling freq.)	Gaussian Distribution	Cauchy Distribution	Middleton Distribution	Generalized Gaussian Distribution	2 Gaussian Gaussian Mixture	3 Gaussian Gaussian Mixture
Gulf of Mexico (5 KHz)	0.01281	0.4223	0.035579	**0.00845**	0.009901	0.009366
Gulf of Alaska (5 KHz)	0.375886	0.40964	0.288839	**0.1095198**	0.170866	0.1545
North Pacific Ocean (64kHz)	0.002171	0.011262	0.00322	**0.000159**	0.006357	0.00642
Indian Ocean (100 KHz)	0.02289	0.040756	0.040756	**0.0175329**	0.0187568	0.0194914
Barkley Canyon (128 KHz)	0.02289	0.162036	0.040756	**0.0144488**	0.053514	0.054956
Clayoquot Slop (128 KHz)	0.006638	0.03679	0.006892	**0.0063132**	0.0082236	0.0093867

Table 4 J-S Divergence test for Comparison of Different Distributions

Noise sample taken from (sampling freq.)	Gaussian Distribution	Cauchy Distribution	Middleton Distribution	Generalized Gaussian Distribution	2 Gaussian Gaussian Mixture	3 Gaussian Gaussian Mixture
Gulf of Mexico (5 KHz)	4.44E-06	1.99E-04	6.20E-06	**1.75E-07**	3.38E-06	1.00E-06
Gulf of Alaska (5 KHz)	7.65E-05	1.E-0491	4.72E-05	**5.55E-06**	3.26E-05	8.09E-06
North Pacific Ocean (64kHz)	1.07E-06	2.04E-04	1.09E-06	**2.15E-07**	1.07E-07	3.17E-07
Indian Ocean (100 KHz)	1.08E-05	5.69E-04	1.04E-05	**5.02E-06**	7.51E-06	7.81E-06
Barkley Canyon (128 KHz)	6.38E-05	8.65E-04	3.62E-06	**1.20E-07**	3.73E-06	1.25E-06
Clayoquot Slop (128 KHz)	3.30E-06	5.80E-04	3.44E-06	**3.13E-06**	4.02E-06	4.53E-06

The results show that underwater noises can be modelled as GG noise with higher probability than others. These non-Gaussian noises change the received signal constellation. Pdf of GG noise is [9]-[10]

$$f_{N-GG}(n) = \frac{\beta}{2\alpha\Gamma(\frac{1}{\beta})} exp\left\{-\left(\frac{|n|}{\alpha}\right)^{\beta}\right\}$$

Where \alpha is scale parameter, \beta is shape parameter. Using this PDF it can be easily seen that the optimum receiver is given as,

$$\langle D\rangle_{GG} = Min_{m=1}^{M}\left\{\sum_{i=1}^{2}|r_i - s_{mi}|^{\beta}\right\}$$

Where ri is the received signal for ith dimension and smi is the received signal for ith dimension corresponding to mth symbol.

Unlike Gaussian receiver these receivers are very much noise dependent, and also depend upon the shape parameter in case of GG distribution [8]. Table 5 depicts various receiver designs for various parameters of the best fitted GG noise models. It can be easily seen that the receiver here is much depends upon noise parameters.

The effectiveness of these models are further studied. Using the correct noise model instead of Gaussian improves the performances of the communication system. Figure 1 depict the improved performance. But this performance improvement is very sensitive to correct modelling. As shown in Figure 2 even the performance is measure of kurtosis value i.e. a little mismatch in the beta value will results in huge reduction in the performance, therefore, there is a fundamental problem in using these receiver design in optimal way.

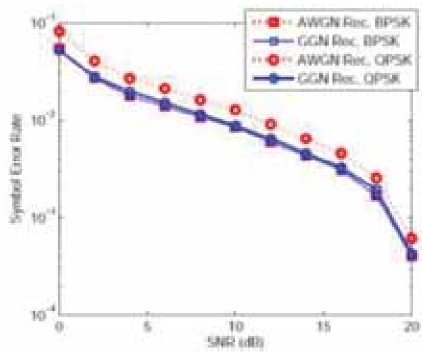


Fig 1 BER performance for GG noise

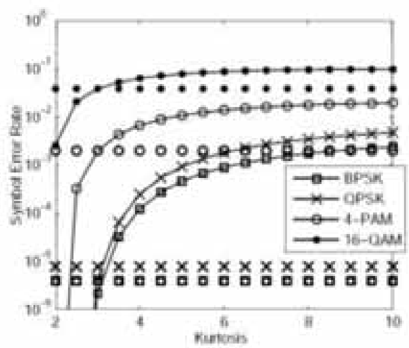


Fig 2 BER performance with different kurtosis values

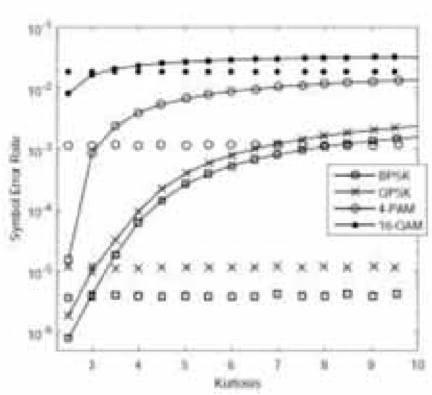
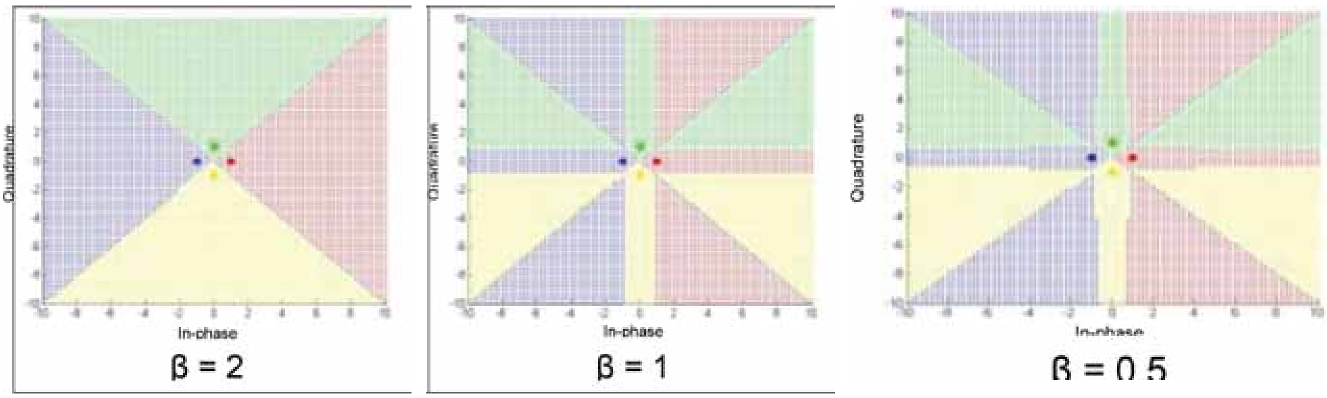


Fig 2 BER performance with different kurtosis values

A Neural network based receiver to do this job is suitable. A close observation of decision regions as shown in Table 5, clearly gave us the confidence to pose this as pattern matching problem. 3-layer neural network has been designed and trained by back propagation and validated to serve as decision device.

Fig 5: Receiver for different values of shpe parameter



Simulation Results

Using the above mentioned technologies a successful system has been designed which have achieved the maximum data rate is 5000 bits/second (with Constellation of BPSK/ QPSK) for a range if 5km. System was tested at a frequency of 8-12kHz band with the reson TC4014 Hydrophone . This test was conducted at Chennai, India in Jan 2018. The test was conducted in the first half of the day. Two moored fisher boats are used to house the TX and RX system. The transducer was lowered using cables. The summary of the results is given table 6.

Table 6: Real experiment results

Data rate	Distance (km)	Maximum (BER)	ModulationType
100	3/5	0	BPSK
1500	3/5	0	BPSK
2000	3/5	0	BPSK/QPSK
3000	3/5	0	8PSK
4000	3/5	0/.00025	QPSK

Conclusions

To deal with practical UWA channels the proposed techniques should combat the combined effect of impulsive noise, multipath spread, Doppler, etc. in real time. Further the dynamic nature of Oceans/ Sea makes underwater noises non- stationary, where designing ways to combat these non-Gaussian, non-stationary, underwater noises to aid the underwater communication becomes difficult and dynamic learning of environment is very much essential for a viable solution. Recent advances in Artificial Intelligence and big data have opened newopportunities here also, we can use AI based neural network system to design smart receiver for this purpose.

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Seeking out elusive Majorana on an Island in a Sea of Gold

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An International team of Physicist at the Indian Institute of Technology (IIT) Delhi, Massachusetts Institute of Technology (MIT) and University of California, Riverside, USA is getting closer to confirming the existence of an exotic quantum particle called Majorana fermion, crucial for fault-tolerant quantum computing- the kind of quantum computing that addresses errors during its operation. In recently published article in Physical Review Letter and in Arxiv Manna et al.(1-2) reported considerable progress toward creating the Majorana state in the laboratory and probe them under microscope with high spatial and energy resolution.

Paul Dirac, the Quantum pioneer had predicted in 1928 the existence of antimatter-mirror particles that annihilate with their matter counterparts. Most known fermions-particles with half-integer spin, like electrons obey Dirac's equation, but in 1938, the young Italian Physicist Ettore Majorana discovered a contrary solution to the Dirac equation that implied the existence of particles, or states of matter that are their own antiparticles. Till today anything in nature that fits Majorana's prediction has remained unclear. There has long been suspected that neutrinos are Majorana particles but not proven yet [3]. Majorana fermions may or may not exist in nature as elementary building blocks, but condensed matter physics community believed that they can be constructed out of electron and hole excitations in the laboratory [4]. The hunt for the Majorana zero mode (MZM) has emerged as a topic of great reward and great challenge in condensed matter physics in the past several years. What is needed is a special type of superconductor to hide the charge difference and a special non-trivial topological phase to eliminate the energy difference from zero-point motion. In condensed matter physics, the definition for Majorana fermions is that they are fermionic quasiparticles which are their own antiparticles [5]. Under certain conditions, an electron in a superconductor can separate in space into two parts, each of which an exotic object is called Majorana zero mode. Two MZM's can be viewed as a single Fermionic mode that has splintered into two partners that are far apart in space. This nonlocality implies that MZM's are immune to local perturbations, and they have been proposed as key ingredients of qubits that are protected from de-coherence due to local noise sources [6]. The MZMs obey non-Abelian statistics, meaning that exchanging their positions lead to a new quantum state and not just a change of the phase angle as is the case for abelian Anyons. All these exotic properties make the MZM an exciting topic of study in its own right and also as building blocks for topological quantum computing. In the past several years, the Majorana state has attracted the attention of the condensed matter physics community, but a definitive sighting has remained elusive. MZMs are predicted to exist at the ends of one dimensional topological superconductors (SC) such as a triplet p-wave SC [7]. Since these SC have not been found in Nature, various proposals have been made to engineer them by combining more conventional materials. The key ingredients are strong spin-orbit coupling of the Rashba type, proximity coupling to a superconductor and a magnetic field parallel to the wire. The most detailed study to date has been done in semiconductor nanowires such as InSb and InAs that are proximity coupled to a superconductor such as NbTiN or Al [8-11] and the sought after signature is a zero bias peak (ZBP) in the tunneling spectra. Despite great progress since the original paper, there remains an on-going debate in the community as to whether the signal is due to MZMs that are located at the same or opposite ends of the wire. Importantly, ZBPs have not been reported to appear simultaneously at both ends of a semiconducting wire, so that direct evidence of the key property of non-locality is still lacking.

A second system that has received a lot of attention is the atomic chain of Fe atoms formed on a Pb substrate [12-13]. While ZBP is reported by scanning tunneling spectroscopy (STS) at one end of the chain, the other end is often attached to an island and not easily accessible. A common limitation with both systems is that they are not scalable, i.e., it is hard to imagine creating a network of more than a few wires, making the ultimate goal of creating an ensemble of qubits very difficult. As a way to overcome this, there has been recent progress using lithography to create wires on 2D substrates using slits in planar Josephson junctions, leading to topological SC [14]. Here we introduce a new platform utilizing the surface state of gold coupled to a superconductor. Several key steps have been developed to make this a reality, one of which is to cover the gold surface with two mono-layers of EuS, a magnetic insulator. In addition to providing the needed spin polarization, the EuS greatly reduces the Fermi energy of

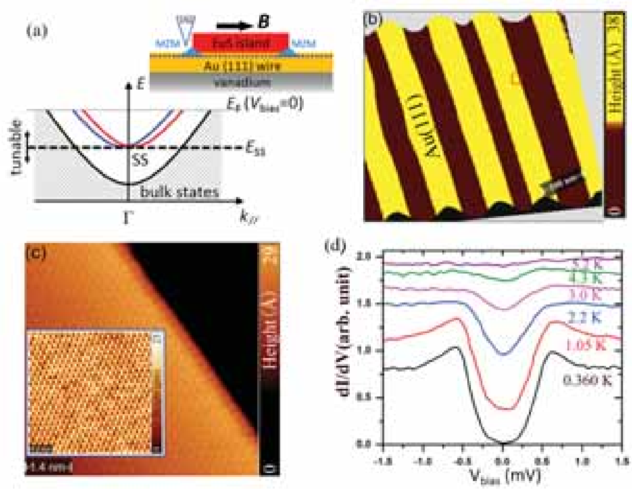

Figure 1: (a) Schematic of the experimental setup: Au(111) nanowire proximity couple on top of a conventional superconductor vanadium and EuS grown epitaxially on top of the Au nanowires. Dotted line represents the location of the surface state (SS). An external field is applied parallel to the wire in order to drive the system into a topological SC state. A scanning tunneling microscopy (STM) tip is used to probe the part of the MZM that is leaked out of the EuS island. Also shown is the schematic surface state Rashba split band structure which is isolated from the projected bulk bands. The position of the bottom of the surface band (ESS) can be tuned by varying the thickness of the EuS coverage. (b) Large scale (650 × 650 nm2) STM constant current topography of the nanowires network that is prepared using nanofabrication techniques. (c) A zoomed-in (7nm × 7nm) (shown by square box in (b)) topography of Au nanowire which showed sharp interface with the underlining vanadium film. Inset shows the atomic resolved STM image of the Au nanowire top surface, which shows the hexagonal atomic lattice of Au(111) surface (d) Temperature dependent dI/dV spectra measured on atomic resolved Au nanowire surface.

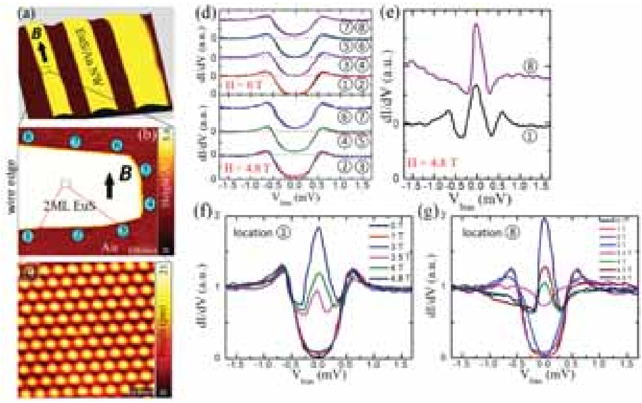

Figure 2: (a) The topography STM image of another Au(111) nanowire array with two monolayers of EuS deposited on top. The applied magnetic field is aligned with the nanowire to the best accuracy of our STM system. (b) The zoomed-in STM topography of a relatively large EuS island sitting at the edge of the Au nanowire in (a). The island is approximately 40nm long along the wire and 60nm wide. (c) The atomically resolved EuS surface in the marked region as noted in (b). (d) The comparison of the dI/dV tunneling spectra under both H = 0 T and H = 4.8 T. Dashed lines mark the zero conductance of each shifted spectrum. The spectra at all positions are gapped when H = 0 T. A slight filling in of the gap is seen at positions 2-7 in 4.8T field. (e) Sharp ZBP emerges for H = 4.8 T at positions 1 and 8. (f) and (g) show the evolution of the dI/dV spectra at position 1 and 8 as a function of the strength of the applied field. At 3.5T the gap is largely filled in at positions 1 and 8 simultaneously. The ZBP is visible at 3.5T at position 1 and at 4T at position 8. At 4T field and above, the ZBP's at positions 1 and 8 show comparable peak heights.

the gold surface state, making the observation of Majorana zero modes possible. We report the observation of a pair of zero bias tunneling peaks appearing at the opposite sides(Fig.2) of a EuS island on top of gold nanowire with the application of a magnetic field. This new platform opens the door to more complicated layouts using nano-fabrication and a path towards the creation of Majorana based qubits.

In 2012, MIT theorists, led by Patrick Lee, predicted [15-16] that heterostructures of gold can become a topological superconductor under strict conditions. Experiments done by the IITD-MIT- UCR team have achieved all the needed conditions for heterostructures of gold combined with Magnetic insulating island of EuS. Achieving such heterostructure is highly demanding because several material physics challenges needed to be addressed first. Our work shows first time that in the combination of EuS island in sea of gold surface state, the superconductivity, magnetism, and electrons spin-orbit coupling can co-exist in gold. This is important for future manipulation of Majorana fermions, required for better quantum computing. Nevertheless the surface state of gold is a two-dimensional system that is naturally scalable, meaning it allows the building of Majorana fermion circuits.

The research team includes Sujit Manna (IIT, Delhi), Peng Wei (UCR, USA), Y. Xie, Kam Tuen Law (HKUST, HongKong), Patrick Lee and J. Moodera of MIT.

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FACULTYPROFILE

Professor S Bhalla
Department of Civil Engineering
IIT Delhi

Prof Suresh Bhalla is Professor at the Department of Civil Engineering, IIT Delhi. His main areas of interest are smart structures, structural health monitoring, electro-mechanical impedance (EMI) technique, bio-mechanics/ bio-medical applications of smart materials, piezoelectric energy harvesting and engineered bamboo structures. He has special interest in integrating internet-of-things and artificial intelligence paradigms to structural health monitoring applications. Prof Bhalla has published over 60 papers in SCI indexed international journals and over 70 in international/ national refereed conferences/ workshops. He has co-authored two books "Piezoelectric Materials: Applications in SHM, Energy Harvesting and Bio-mechanics (Wiley)" and "Smart Materials in Structural Health Monitoring, Control and Bio-mechanics (Springer)". He has also contributed chapters for three other books. His publications are highly cited in the Web of Science and Scopus by peers, represented by an h-index of 18 in the Web of Science and 22 in SCOPUS. A finalist of the SCOPUS Young Scientist Award 2014, Prof Bhalla has been the recipient of several other laurels, such as Three International Best Paper Awards (2018, 2016, 2012), Award For Teaching Excellence (2011), Outstanding Young Faculty Fellow (2008), NSTB gold medal for best Master's thesis (2001) and the Institute Silver Medal (1995).

Prof Bhalla has completed R&D projects amounting to over Rs 900 lacs and has five invention disclosures to his credit, three of which have been applied for patent, with one product, namely concrete vibration sensor (CVS) already commercialized. Prof Bhalla has been the founder of the "Smart Structures and Dynamics Lab" at IIT Delhi.

Prof Bhalla is a pioneer in the field of piezo-sensor based structural health monitoring, both theoretical and experimental, internationally. He has founded the Smart Structures and Dynamics Laboratory (SSDL), at IIT Delhi, a first of its kind multi-disciplinary lab in India dealing with advanced sensing/ monitoring technologies and piezoelectric energy harvesting. The SSDL also has an online virtual component, where interested students can learn and practice concepts related to structural health monitoring at their own pace online. The On theoretical front, his contributions include new impedance model, modelling piezo-bond-structure interaction and impedance-based identification for improved damage severity assessment. On experimental front, new contributions include adaptation of the electro-mechanical impedance (EMI) technique to RC structures, devising a new experimental modal analysis paradigm based on piezo-sensor response, devising a low-cost version of EMI technique, metal-foil based variant of EMI technique, non-bonded/ reusable variants of piezo-transducers for industrial applications, fabricating customized vibration/ damage for concrete and new applications of the technique on rebar corrosion assessment and fatigue damage prognosis in steel and RC structures. He has also pioneered the extension of piezo-based structural health monitoring technologies to bio-medical engineering. Prof Bhalla has developed two new courses- Structural Health Monitoring (CVL 864) and Analysis and Design of Machine Foundations (CVL 861). Both these courses have significant experimental content. He is a pioneer in the field of engineered bamboo structures and also filed invention disclosure for Fiber Reinforced Bamboo Composite (FRBC). Prof Bhalla has provided training to over 700 industry professionals on application of advanced technologies in the field of structural engineering and thousands of engineering students have been benefited by the Virtual Smart Structures and Dynamics Lab http://ssdl.iitd.ac.in/vssdl

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Professor DS Mehta
Department of Physics
IIT Delhi

Dr Dalip Singh Mehta is currently a Professor in the Department of Physics at Indian Institute of Technology Delhi since 2012. Previously, he worked as Associate Professor and Assistant Professor at the Instrument Design Development Centre, Indian Institute of Technology Delhi. He joined Indian Institute of Technology Delhi in the year 2002. He was born in Pithoragarh, Uttarakhand and did his BSc. and MSc from Kumaun University, Nainital, Uttarakhand and Ph.D. in Physics from National Physical Laboratory, New Delhi and CCS University Meerut, UP. His research interest is primarily in the area of Bio-photonics; Optical coherence tomography, quantitative phase microscopy, micro-endoscopy and optical tweezers, and Green photonics: Sunlight harvesting, laser based solid state lighting and optics of LEDs and OLEDs. He has also been working on optical metrology, laser Doppler velocimetry, optical 3D-surface profilometry and optical interferometry.

Before Joining the IIT Delhi he was JSPS Post-Doctoral Fellow (2000-2002) at the University of Electro-communications, Tokyo, Japan. During his stay at Tokyo he developed advanced spectral interference microscope for 3D-surface profilometry and high-resolution tomography of industrial objects. He was also Post-Doctoral Fellow at National Dong-Hwa University, Taiwan where he worked on the development of optical tweezers for trapping biological cells and micro-particles and fluorescence microscopy. He was STA Post-Doctoral Fellow (1997 – 1998) at National Institute of Resources and Environment (NIRE), Tsukuba, Japan and UNESCO Research Fellow (Jan. 1996 – Sept.1996), Tokyo Institute of Technology Tokyo, Japan where he worked on the development of Laser Doppler Velocimetry for shock wave velocity measurement. He was JRF, SRF and RA in National Physical Laboratory, New Delhi where he worked on the effect of spatial coherence on the spectra of radiated fields and demonstrated its applications in measurement of spatial coherence of light source, source size, angular size of twin sources, and optical metrology. Some of his research work has been cited in the renouned books; Optical Shop Testing by D. Malacara, Introduction to the Theory of Coherence and Polarization of Light by E.Wolf, Optical Interferometry by Hariharan, Optical Coherence and Quantum Optics by L. Mandel and E. Wolf and Principles of Optics by M. Born and E. Wolf.

He has contributed more than 145 research papers in International Refereed Journals, and more than 180 in International and National Conferences. He has delivered more than 50 Invited Talks/Lectures in various International and National Conferences and Universities. He has supervised 15 PhD students and currently supervising 10 PhD students. He has also supervised more than 50 MTech/BTech students major projects. He was honored with the Teaching Excellence Awards in the year 2017 and in 2013 from the Indian Institute of Technology Delhi, India for his passionate and dedicated teaching skills. Many of his PhD students and master students has received Best Paper Awards, Best Poster Presentation Awards, National Science Day presentation award and Alumni Association Awards in International and National conferences. He has filed 9 patents and one technology transferred to Industry. Many of his research papers has been reported in various International Magazines, such as, Laser Focus World, Bio-optics World, Nature Photonics and New Scientist. During his course at IIT DELHI, he has also been part of many administrative assignments and performed his duties to the fullest. Currently, he is serving as Coordinator of MTech Applied Optics course since July 2015. He has served as the convener DRC (Department of Physics) from September,2013 to August,2014 and for CRC IDDDC from September, 2003 to August, 2012. He was member of many technical conference committees ICOP 2009, ICON-TOP 2009, CLEO 2009 and many more.

One of the major contributions of his research work is the development of swept-source full-field optical coherence tomography and topography. Optical coherence tomography (OCT) is an important biomedical imaging technique for the visualization of cross-sectional, 3D-tomographic imaging of tissue structure non-invasively below skin. The OCT system developed in Prof Mehta's group is low cost and high-resolution and using this set-up he has demonstrated many new applications, detection of latent finger prints, tomography and topography of Si-IC circuits, topography of micro-lens structures, tomography and topography of whole fisheye, and tomography of composite materials. The research work has been published in many International Journals of high repute and many of the research articles has been covered in the International Magazines, such as, Laser Focus World, OCT News and New Scientist.

Most of the conventional OCT systems world-wide use low coherence light source, i.e., broad band light source and exploit the temporal coherence properties of light source to achieve high axial resolution. Recently, Prof DS Mehta made significant contribution in the field of optical coherence tomography and made a paradigm shift in the fundamental concept of OCT. Prof Mehta's group instead of using low temporal coherence light (broad band) source used low spatial coherence light in OCT system and demonstrated high-axial resolution OCT images of biological samples using longitudinal spatial coherence rather than temporal coherence of light source. The proposed new concept has many advantages over the conventional OCT systems, such as, speckle free imaging, requires no dispersion compensation and low cost. Currently, the system is being utilized optical sectioning of various multilayer structures and biological samples.

Prof DS Mehta has also designed and developed speckle-free quantitative phase microscopy (QPM) system. This microscope is utilized for the measurement of various bio-physical parameters, such as, 3D-phase map, 3D-height map, refractive index, hemoglobin concentration, dry mass and nano-metric membrane fluctuations of various biological cells and tissue without using any fluorescent dye. The developed holographic microscope can be used for early stage disease detection, quantification of sperm cells, oxidative stress condition macrophages, and health monitoring of red blood cells. Prof DS Mehta could establish a strong collaborative research in this area with the University of Tromso, Norway, where the same system was developed and being utilized by Norway group for various biological studies. Prof DS Mehta and the Prof B Ahluwalia filed a joint patent on the development of highly stable quantitative phase microscope. The developed system is being tested for various label free quantitative phase imaging and soon will be commercialized. The QPM system has been combined with simultaneous waveguide trapping biological cells and total internal reflection fluorescence (TIRF) nano-scopy.

Another important work of Prof DS Mehta is the development of smart phone based field-portable multi-modal auto-fluorescence, fluorescence imaging, spectroscopy and microscopic device; a point of care digital pathology kit with artificial intelligence (AI) software for cost-effective screening and diagnosis of oral, skin, breast and cervical cancer. Presently cancer screening and diagnostic devices are invasive, requires slide preparation, staining and time-consuming. Further, it requires costly equipment, procedures, highly skilled personnel and expert doctors to interpret results. These facilities are available only in big hospitals in metro-cities. Dr Mehta's dream is to develop multi-modal devices, which are low cost, user friendly, do-not require sample preparation, staining and long procedure which can be utilized in operation theaters and in clinics in vivo., so that fast screening and diagnosis is done. In low resource setting developing world, moving cancer treatments out of specialized centers and into local clinics or small hospitals could significantly lower healthcare costs, travel time and leading to early diagnosis and treatment of cancer. Presently, Prof Mehta and his research group are working in the development of smart phone based point of care devices which can be easily be deployed in the hospitals, small health clinics, pathological laboratories for fast and accurate screening of diseases such as oral and breast cancer. His devices are based on multi-modalities such as auto-fluorescence, fluorescence imaging, spectroscopy measurement and high resolution phase measurement combined with artificial intelligence to provide automated and accurate screening of diseases. In this area he has established a strong collaboration with AIIMS hospital, New Delhi with Department of Breast Cancer and Oral Cancer.

Prof DS Mehta has very strong interest energy efficient green technology which is sustainable and pollution free. The Country like India has abundant sunlight throughout the area. But at present solar energy harvesting is done only through solar photovoltaic which has very low efficiency. In the area of Green Photonics, Prof Mehta is working on efficient sunlight harvesting for daylight saving and energy efficient solid state lighting (Optics of LEDs and OLEDs), laser based solid state lighting. Prof Mehta has designed and developed a non-mechanical tracking multiple

Fresnel lens based solar concentrator system to concentrate sunlight in a small area throughout the day and for all seasons. This has been accomplished by means of innovative mounting of Fresnel lenses and six segmented mirrors for concentrating sun light using ray optics approach throughout the day and for all seasons. The system is utilized for multipurpose Sun light harvesting system: fast water heating, solar chulha for cooking, fast snow melting, steam generation and battery charging. The system can also be utilized for day light saving; direct sun light inside the room for best quality light and health benefits and thermoelectric conversion/photovoltaic conversion for battery charging and storage. The system has been applied for patent. Prof Mehta has also done significant amount of work on light extraction of OLEDs and laser based solid state lighting. He has given the concept of blue laser pumped Ce:YAG phosphor coated tube light and laser lined pumped light sheet. By means of exploiting the remarkable properties of laser, i.e., directionality and high brightness a tube light is designed and developed which requires a single high power laser instead of multiple blue LEDs. Because of drop in power conversion efficiency in LEDs under high injection current, laser is an alternative source for efficient phosphor converted white light applications. Prof Mehta's group is working on development of various applications of blue diode laser based solid state lighting, such as, general illumination, automobile headlight, etc. This is an energy efficient green energy.

TECHNOLOGYPROFILE

Polymeric Resins for Removal of Heavy Metal Ions from Aqueous Waste

Prof J Jacob
Department of Materials Science and Engineering, IIT Delhi

Heavy metal ion pollution has become a major environmental issue facing most of the developing countries today. Recent reports suggest that in many states in India, heavy metal ion contamination in leafy vegetables and cereals exceed permissible levels set by the US Environment Protection Agency. Removal of heavy metal ions such as Cu^{2+}, Pb^{2+}, Ni^{2+}, Cd^{2+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Hg^{2+}, Fe^{2+}, Fe^{3+}, Cr^{3+}, and Co^{3+} etc. from water is essential because of their persistence, non-biodegradability, and toxicity for living organisms and the environment[1]. These contaminants, if left untreated, can enter the food chain and get accumulated in the human body leading to serious health disorders[2]. The removal of heavy metal ions from industrial waste is difficult due to their low concentration and presence in complex forms. Iminodiacetate (IDA) is a tridentate ligand, comprising half of a unit of ethylenediaminetetraacetic acid (EDTA) and has the potential to complex various metal ions from aqueous solution. IDA unit, if incorporated on a polymeric backbone, has the potential to complex and remove heavy metal ions and depending on the choice of material, can be potentially regenerated and reused[3].

Towards the above objective, we have recently developed water soluble homopolymers and highly efficient macroporous chelating resins capable of sequestering trace amounts of various heavy metal ions from aqueous waste (patent filed)[4]. These materials were synthesized by direct polymerization of a suitably designed chelating monomer, which generates iminodiacetate-styrene resins (IDASR) in high yield and purity in simple steps which are scalable. Also, all the monomeric units in the resin have the iminodiacetate chelating group which make them highly efficient chelating materials for waste-water treatment. The process to remove the metal ions are simple and can be easily implemented at larger scale, a schematic of the column method used to demonstrate the removal of heavy metal ions from aqueous waste by the resin is shown in Figure 1.

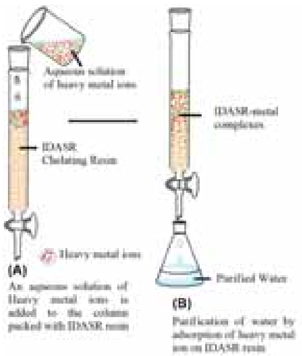

Figure 1. Schematic of the column method for metal ions adsorption studies of IDASR Chelating Resin

The chelating capacity of IDASR resin is shown in Figure 2. It is found that the efficiency of this resin varies in the range of 0.5-0.9 metal ion per monomer repeat unit for all the metal ions shown here which is highly remarkable and holds significant potential for commercial use. In addition to water purification, these materials hold promise for applications in the recovery of trace metal ions, nuclear chemistry, as fire retardants, molecular ion imprinting polymers etc. some of which are currently being explored.

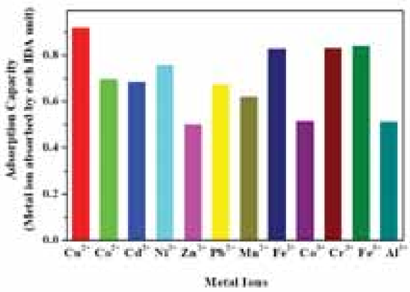

Figure 2. Chelating capacity of IDASR chelating resin for various heavy metal ions in aqueous solution.

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4. J. Jacob and R. Tyagi, "A process for synthesis of an iminodiacetate styrene resin", Patent application filed by IIT Delhi (Ref. Number: 201911038339).

Converting Waste Biomass to Medicine

Prof M Ali Haider
Department of Chemical Engineering
IIT Delhi

In what could help mitigate the pollution arising out of burning the biomass waste, scientists at IITD have developed a biorenewable platform that can convert the waste to a high value chemicals and medicine.

Utilization of waste lignocellulosic biomass to produce high value fuels and chemicals is opening up avenues for the design of novel processes to provide a range of products in the portfolio of a futuristic bio-refinery.

The Renewable Energy and Chemicals (REC) Research group at the Department of Chemical Engineering, IIT Delhi led by Prof M. Ali Haider has devised ways to provide solutions through an integrated bio- and chemo-catalytic process in which waste biomass is fermented to produce a platform chemical, which is further upgraded via a simple catalytic transformation to produce a desired high value chemical. For this purpose, Prof. Haider's group has developed 2-pyrone molecules obtained from the fermentation of waste biomass (e.g. sugarcane bagasse) as a potential biorenewable platform, from which a range of pharmaceutical, polymer, food-additive, insect repellent and other high value chemicals are derived.

In this approach, recent experiments by co-researchers Dr. Md. Imteyaz Alam and Mohammad Wasi Akhtar have demonstrated a green, sustainable and robust route to produce Warfarin and similar drugs with high yield (>90%) from 4-hydroxycoumarin (4HC), which is a 2-pyrone platform chemical synthesized from the fermentation of waste lignocellulosic biomass. At present, Warfarin and such drugs are commonly prescribed for thromboembolic and cardiovascular disorders. These drugs are synthesized via a chemical synthesis route using 4HC as a precursor and pyridine (a possible carcinogenic chemical) as a solvent.

"The biorenewable process to produce Warfarin developed in his lab is based on using water as a solvent with a solid acid catalyst, which can be easily recovered. This route to produce medicine and other high value chemicals from waste biomass can solve local issues related to air pollution experienced in National Capital Region (NCR) of India," Prof Haider said.

With an economic incentive, the farmers who burn waste agricultural residues will now have a choice to ferment it and produce platform chemicals such as 2-pyrone molecules, which can be processed in a bio-refinery to produce the desired medicine and other high value chemicals. WowChemE (https://www.wowcheme.com), an IIT Delhi start-up will be working further on this technology.

Reference:
1) http://web.iitd.ac.in/~haider/

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
CE	: Department of Civil Engineering
CES	: Centre for Energy Studies
CHEME	: Department of Chemical Engineering
CHY	: Department of Chemistry
CRDT	: Centre for Rural Development and Technology
CSE	: Department of Computer Science and Engineering
DBEB	: Department of Biochemical Engineering and Biotechnology
DMS	: Department of Management Studies
DMSE	: Department of Material Science & Engineering
EE	: Department of Electrical Engineering
HUSS	: Department of Humanities and Social Sciences
KSBS	: Kusuma School of Biological Sciences
MATHS	: Department of Mathematics
ME	: Department of Mechanical Engineering
PHY	: Department of Physics
TFE	: Department of Textile and Fiber Engineering
	and many more...

Innovations

Some of our Latest IP applications filed are as follows:

Sl No	Title	PI	Dept/ Centre
1	System and method for identifying passive optical identifier	Prof A Dixit	EE
2	Efficient liquid phase exfoliation route to few layer transition metal dichalcogenides using non-tox	Prof AK Ganguli	CHY
3	Chitosan-onion shell composite and preparation thereof	Prof BS Butola	TFE
4	A time and resource effective process to produce warfarin using heterogeneous catalysts	Prof M A Haider	CHEME
5	Cup-Shaped Tool Component	Prof S Jha	ME
6	"Path loss compensated MM wave 5G antenna module with 3D printed radome"	Prof SK Koul	CARE
7	An antenna model	Prof SK Koul	CARE
8	Person identification and imposter detection using footfall generated seismic signals	Prof S Kar	EE
9	Ultra-battery energy storage system for load frequency control in a multi-area power network	Prof B Singh	EE
10	A novel process for preparation of pegylated recombinant human granulocyte colony stimulating factor (PEG-GCSF)	Prof AS Rathore	CHEME
11	Polymer nano composite formulation loaded with metal nanoclay complex	Prof M Joshi	TFE
12	Electric field induced annealing of inorganic thin films for densification	Prof M Singh	EE
13	Method of preserving raw milk	Prof AS Rathore	CHEME
14	Organic and organometallic water soluble redox-active polymers for neutral PH aqueous redox flow batteries	Prof BP Tripathi	DMSE
15	A short and medium wave infrared nano-antenna array for sensing particles in an air column	Prof M Singh	EE
16	Nano hetero-structures of transition metal dichalcogenide sensing film based extended gate field-effect transistor for the sensing of heavy metals	Prof M Singh	EE
17	A chair with self-assisting mechanism for elderly and users with inadequate muscular strength	Prof PVM Rao	DESIGN
18	A magnetic nano-photocatalyst and a method of preparation thereof	Prof SW Ali	TFE
19	Power efficient photonic network-on-chip for a scalable GPU	Prof SR Sarangi	CSE
20	A medicament for the treatment of diseases by biofilm forming microorganisms	Prof S E Hasnain	KSBS
21	Solar-powered water pumping system	Prof B Singh	EE
22	Measuring effectiveness of informative content (video & or any form) on public health engagement	Prof A Mehendiratta	CBME
23	Orthopedic screw	Prof D Kalyansundaran	CBME
24	Wound dressing hydrogel and process for preparation thereof	Prof N Singh	CBME
25	A wireless system for improving performance and prolonging battery lifetime of node by energy harvesting	Prof S Prakriya	EE
26	Direct printing of vascular stent by solvent casting 3d printing technique	Prof PM Pandey	ME
27	A medicament for the treatment of diseases by biofilm forming microorganisms	Prof S E Hasnain	KSBS
28	A recombinant construct, and implementations thereof	Prof AS Rathore	CHEME

29	A method for gain and aperture efficiency enhancement of a linearly polarized antenna and system thereof	Prof SK Koul	CARE
30	A water-in-diesel microemulsions obtained from bi-liquid foams and method of making the same	Prof AN Bhaskarwar	CHEME
31	A non-invasive technique for accurately determining harmonics in radio frequency discharges	Prof A Ganguli	CES
32	Multivariate data compression system and method thereof	Prof S De	EE
33	Transition metal oxide nanowires and preparation thereof	Prof AN Bhaskarwar	CHEME
34	Development of Zinc-Hydroxyapatite-Fe degradable composite material and processing route for biomedical applications	Prof PM Pandey	ME
35	Electrodialytic purification and recovery of fermentation derived cyclic esters for catalytic upgrading	Prof MA Haider	CHEME
36	A system and method for providng co-channel transmission in digital television (DTV) bands	Prof S De	EE
37	Interleaved switching high voltage gain boost converter	Prof M Veerachary	EE
38	Python for glass genomics (PyGGi)	Prof A Krishnan, Prof H Kodamana	CHEME
39	A photocatalytic reactor and method for producing visible light active nanocomposites	Prof N Khare	PHY
40	3D printed construct for correcting bone defects and stem cell delivery	Prof S Ghosh	TFE
41	An ocular drug delivery device	Prof D Kalyansundaran	CBME
42	Development of novel material for microwave absorption using magnetic field assisted solvent based extrusion 3D printing	Prof PM Pandey	ME
43	A microemulsion fuel composition and method for preparation thereof	Prof AN Bhaskarwar	CHEME
44	A flexibly operated virtual synchronous machine for synchronizing three phase inverters with a grid	Prof B Singh	EE
45	In-plane active steering of radiation patterns by steerable plasmonic nanoantenna structures	Prof A Dhawan	EE
46	Method for diffraction based pre-processing of cryo-electron microscopy image data for superior 3D structure determination	Prof K B Khare	PHY
47	Biological pretreatment process of lignocellulosic residues		
48	Thermally stable bio-based polybenzoxazine and their process for preparation thereof	Prof MK SAIF	EE
49	Agrobacterium derived cell penetrating peptides as nanocarriers	Prof A Chugh	KSBS
50	Development of MG-based biomaterial	Prof PM Pandey	ME
51	Tunable shock absorbing passive control device for vibration and shock response control of structures	Prof V Matsagar	CE
52	Transmission microscopy	Prof J Joseph	PHY
53	Method and apparatus for uplink timing synchronization in wireless communication system	Prof S Kaif	EE
54	Green manufacturing process of nanolignin	Prof AK Ghosh	DMSE
55	A bioresorbable radiopaque stent and a method for preparation thereof	Prof N Bhatnagar	ME
56	A cellular artificial skin substitute & method of preparation thereof	Prof V Koul	CBME
57	Highly efficient macroporous chelating resins for heavy metal ION removal from aqueous waste	Prof J Josemon	DMSE
58	A process of decolourizing textile dye effluent by microbial consortium	Prof A Mallik	CRDT
59	Current sensing device based on rogowski coil for measuring current of a current carrying conductor	Prof R Maheshwari	EE
60	Wearable gait analysis system	Prof D Joshi	CBME

61	EdgeEGG - a system and method for hand-held electrode free electroglottograph using neural networks on programmable controllers	Prof AP Pratosh	EE
62	Aprocess for preparing grafted nano-cellulosic fibre and implementations thereof	Prof AK Ghosh	DMSE
63	improving efficiency and power quality of a 36-pulse ac-dc converter fed 9-level CHB- inverter based induction motor drive for medium voltage application	Prof B Singh	EE
64	DC synchronized optimal regulator for hybrid PV-battery-diesel-generator	Prof S Mishra	EE
65	Damped fifth-order generalized integrator based pcc voltage sensorless topology for 1-phase 1-stage grid integrated solar PV array	Prof B Singh	EE
66	Integrated process for conversion of e-waste plastic into fueland metal recovery using the low-temperature roasting technique	Prof KK Pant	CHEME
67	BI-stable microelectromechanical system (MEMS) based non-volatile memory cell with piezoelectric reset	Prof P Singh	CARE
68	An intra-vitreal injection delivery device	Prof TK Gandhi	EE
69	A process and two-step catalytic reactor system for the production of liquid hydrocarbons from plastic waste	Prof KK Pant	CHEME
70	Insole-based foot pressure measurement system	Prof D Joshi	CBME

Major Happenings.....

Dr Anil Wali, MD FITT announced the filing of 150 patent applications by IITD during their 25th AGM on December 18, 2019

FITT in association with Samsung organised a workshop on 5G technologies on October 17, 2019

Bio-tech Innovators meet on October 25, 2019 at IIT Delhi

Outreach Program conducted by iDEX for Defence India Startup Challange (DISC)- III on December 4, 2019 at IRD Conference Room

Some examples of Investigative/ Development Projects undertaken during July-December 2019

Sl No	Title	Faculty	Dept/Centre
1	Management and analysis of effectiveness of acoustic barrier at the IGI Airport	Prof AK Darpe	ME
2	Optimal allocation of drivers for the food delivery problem	Prof S Ranu	CSE
3	Learned index structures	Prof A Bagchi	CSE
4	Network efficient VM scheduling	Prof A Kumar	CSE
5	Automated Intra-day solar power generation forecasting system for NTPC:Development, implementation and capacity building	Prof SB Roy	CAS
6	Neuromorphic PoC application	Prof M Suri	EE
7	Algorithms and architectures for Machine Learning and computing on the edge	Prof B Lall	EE
8	Chemical analysis and coating characterization of small scale components	Prof J Jain	DMSE
9	Endurance/Fatique testing & analysis in track pin material	Prof P Mahajan	AM
10	Computer simulation of fire in Mandideep factory Daawat Foods Ltd	Prof R Khanna	CHEME
11	Development of technology and processes for marketing automation	Prof B Lall	EE
12	Process Design for AN MBR system for wastewater treatment	Prof TR Sreekrishnan	DBEB
13	Consultancy for specification and scope definition of –(E55735-HUAWE1, MF90-ZTE, WD670-HU AWEI, B3105-927-ZTE)	Prof B Lall	EE
14	Development in traffic management through vehicle speed estimation and other techniques	Prof R Sen	CSE
15	Digital Gandhi Darshan	Prof SB Roy	EE
16	Opinion on telecommunication goods	Prof RK Varshney	PHY
17	2D to 3D Audio	Prathosh A P	EE
18	Simulation and experimental validation of the closed Loop I-S process	Prof S Upadhyayula	CHEME
19	Storage and stability characteristics of Hydrogen Colloidal Gas Aphrons (CGAs) loaded with treated metal hydrides	Prof AN Bhaskarwar	CHEME
20	Effect of oxygen functionality and partial exfoliation on activity of carbon electrode for electrooxidation of sulfur dioxide in sulfuric acid	Prof S Upadhyayula	CHEME

Glimpses of our Activities

FITT signed MOU with Power Finance Corporation on October 3, 2019

A delegation from Danish Patent and Trademark office visited FITT on November 25, 2019

LEADERSHIP AT FITT

1) Prof V Ramgopal Rao, Director IIT Delhi & Chairman FITT
2) Dr Anil Wali, MD FITT

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