Department of Electrical Engineering
Indian Institute of Technology (Indian School of Mines) Dhanbad

VIBHAV

Vol.I, No.8 | April, 2025 | Monthly Newsletter

Message from HoD's Desk

By PROF. SUKANTA DAS

Dear All,
Hope you are doing well!
With a great pleasure, I hereby introduce a new edition of the Monthly Newsletter of the Department of Electrical Engineering: "VIBHAV".
I invite you to go through this edition of our Monthly Newsletter. I also ask our students to actively participate in the improvement of the Monthly Newsletter. You are requested to forward your constructive comments to ee@iitism.ac.in for the betterment of the forthcoming editions of "VIBHAV".
Thank you all.
Best wishes.

About the Department

The Electrical Engineering department was established in the year 2005. The four-year B.Tech. program in Electrical Engineering was started in the academic session 2006-07. Although the Department of Electrical Engineering is one of the latest of the existing departments of the Institute, the Electrical Engineering Section existed as a part of earlier Mining Machinery Engineering department from 1975. Apart from different B.Tech. programs, the department at present also offers M.Tech programs in Power System Engineering and Power Electronics & Electrical Drives. Through funded projects, consultancies, Doctoral, and postdoctoral programs, most of the research activities are being carried out in the department.

Publications

Journals

- V. Florinski, D. Balsara, D. Bhoriya, G.P. Zank, S. Biswas, S. Sharma, and **Sethupathy S**, "An Anisotropic Plasma Model of the Heliospheric Interface," *The Astrophysical Journal (ApJ)*, 2025. [Accepted]
- Soumyadip Banerjee, **Tanmoy Maity**, "Exploring conventional and recent algorithms for WECS: a comprehensive review of literature for MPPT," *IETE Technical Review*, 2025.
- S. B. Mitikiri, Y. Tiwari, **V. L. Srinivas** and M. Pal, "Regression Based Anomaly Detection in Electric Vehicle State of Charge Fluctuations Through Analysis of Electric Vehicle Charging Infrastructure Data," *Sustainable Energy, Grids and Networks*, vol. 101704, 2025.
- A. Alzhrani, P. K. Sahay, N. C. Sreeram, **V. L. Srinivas**, "A Multifunctional Wind Power System with Sensorless Operation and Power Quality Improvement Features," *IEEE Access*, vol. 13, pp. 51632-51644, 2025.

Conferences

- C. Verma and **A. Kumar**, "A Comprehensive Review of Dual Input Hybrid Converters for EV Battery Charging Applications," *IEEE 5th International Conference on Sustainable Energy and Future Electric Transportation (SEFET 2025)*, Jaipur, Rajasthan, India, 2025. [Selected for presentation]

Guest Lecture Organized

- **Prof. Tanmoy Maity** arranged a guest lecture in which Ms. Nandini Chakravarty, Managing Director of Mine Line Pvt Ltd, delivered a Guest Lecture on "Empowering Students Towards Innovation in Mining Safety" on 11th April, 2025 at the department of Electrical Engineering.

Outreach Activities

- **Prof. Sanjoy Mandal** visited Budapest as keynote speaker for international conference on "Semiconductor and Optoelectronics-2025" held in Budapest, Hungary from April 10-12, 2025.
- **Prof. Nitai Pal** evaluated Ph.D. Thesis of University of Calcutta as an External Examiner.

Prof. Sukanta Das, HoD, Department of EE is greeting Ms. Nandini Chakravarty, Managing Director of Mine Line Pvt Ltd.

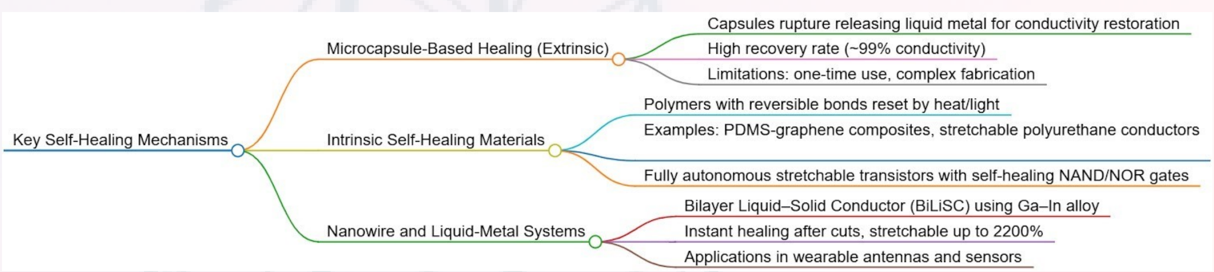
Students' Corner

What If Circuits Could Heal Themselves? Upasana Tharu – (22JE1028)

Circuit damage? These materials fix themselves. That's not sci-fi anymore. From smartphones to satellites, self-healing electronics are emerging as a breakthrough in fault-tolerant design. Imagine a spacecraft millions of miles from Earth repairing its own severed wire—or a flexible ECG patch restoring function after a bend-induced fracture. It's more than convenience: NASA estimates nearly 40% of satellite failures stem from electrical faults. In wearables, IoT, and aerospace, every second of uptime counts. So what's making this once-futuristic vision real?

How Self-Healing Electronics Work?

At the heart of these systems are two main approaches: extrinsic fixes (healing agents embedded in the material) and intrinsic materials (where the material itself re-bonds). Both have their own flavor of cleverness—and challenges.

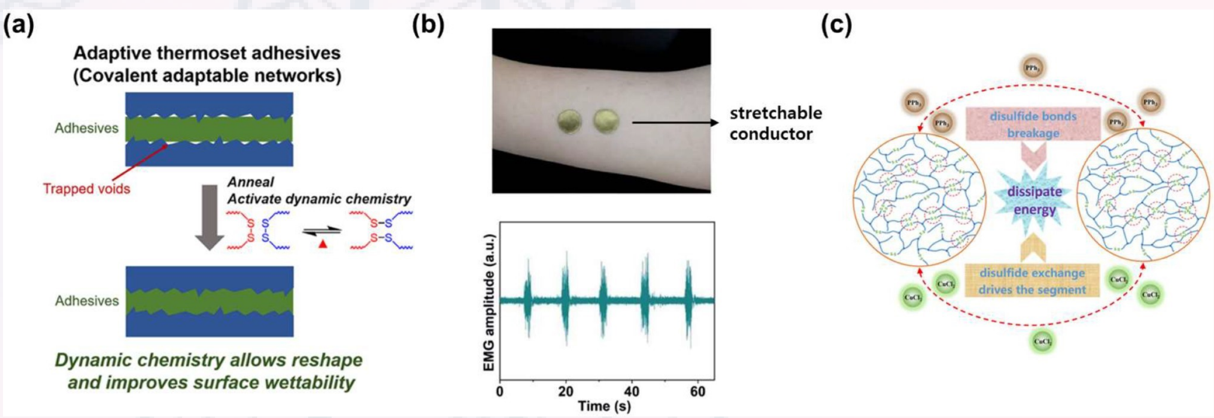


Microcapsules: Tiny Pods That Patch the Damage

Think of microcapsules as the circuit's built-in paramedics. These are microscopic polymer spheres filled with a conductive fluid—often gallium-based liquid metal or a polymer precursor. When a conductive trace cracks, nearby capsules rupture. The liquid seeps into the fracture, restoring connectivity on the spot. It's autonomous—no software, no sensors—just smart chemistry. In one landmark example, researchers embedded 50 µm gallium–indium capsules into flexible circuits. After breaking the trace, the alloy flowed out and restored up to 99% of original conductivity—within seconds. Engineers have tweaked these microcapsules to survive embedding in tough epoxies, trigger only under stress, and even deliver repeat healing using vascular networks—tiny capillaries that refill damaged zones like blood vessels. But here's the trade-off: capsules are often one-shot. Once they leak out, they're spent. That's where intrinsic materials take the stage.

Schematic of microcapsule-based self-healing. A conductive trace (grey) has cracked. Embedded microcapsules (blue) near the break have ruptured, releasing a conductive liquid (green) that flows into the gap and re-connects the trace, restoring electrical continuity.

Intrinsic Materials: Polymers That Reconnect Like Skin:
Intrinsic self-healers don't need capsules. Instead, they use dynamic chemical bonds—like reversible covalent links or strong hydrogen bonding—to rejoin after damage. One 2024 study blended graphene into a PDMS matrix with hindered-urea bonds. When sliced, the composite reconnected under mild pressure, and—amazingly—the circuit lit up an LED after healing. Other systems use reversible disulfide bonds in stretchable conductors to achieve repeated healing at room temperature. The biggest win here? Reusability. Intrinsic systems can mend multiple times in the same spot. That's a game-changer for wearables or soft robotics, where cracks aren't a one-time thing. Still, they aren't perfect. Healing usually needs a small trigger—heat, light, or even time—and getting high conductivity without sacrificing healability is tricky. But researchers are pushing the envelope. A team in Tokyo recently built fully autonomous stretchable transistors, using a supramolecular polymer that allowed even NAND/NOR logic gates to self-recover. It's not just wires anymore—it's whole devices.



Liquid Metals: Conductors That Flow and Heal

Enter gallium alloys: room-temperature liquid metals that ooze like mercury but conduct like copper. In some designs, these metals are embedded in soft silicone matrices or porous scaffolds. When the circuit is damaged, the metal flows back into the breach. One standout material—dubbed BiLiSC (Bilayer Liquid–Solid Conductor)—can stretch over 2,000% and still recover function almost instantly. These systems don't need microcapsules or tricky chemistries—they rely on fluid dynamics. And they shine in extreme use-cases: flexible displays, stretchable batteries, or soft robotic skins. But the cost and handling complexity of gallium alloys (they oxidize easily and can damage other metals) still present barriers to mass production.

Breakthrough Study: Nanowire Networks That Fix 10,000+ Breaks
In 2023, University of Tokyo researchers showed a self-healing nanowire network that could autonomously repair over 10,000 microscopic fractures. The trick? A blend of silver nanowires in a dynamic polymer matrix that rerouted current and bridged gaps on its own. They applied it to stretchable circuits, withstanding over 100% strain and healing performance on par with intact circuits. No user intervention. No reboot. Just plug-and-play resilience. It marked a shift—from proof-of-concept patches to integrated, functional devices capable of real-world operation.

What's Holding Back the Revolution?
Self-healing circuits are smart—but scaling them is no walk in the lab.

- **Manufacturing complexity:** Embedding microcapsules or tuning polymer chemistry adds cost and processing steps.
- **Performance trade-offs:** Conductivity vs. flexibility vs. healability—optimizing one often degrades the others.
- **Durability:** Some systems heal once, some need specific stimuli, others can't handle repeated abuse.

But there's hope. AI-driven diagnostics are starting to pair with these materials, enabling real-time fault detection and targeted healing—think circuits that sense, decide, and act. Kind of like a nervous system. Also, hybrid approaches—mixing microcapsules with dynamic bonds—are emerging to get the best of both worlds.

Final Thought: From Mars Rovers to Smart Shirts
The holy grail? Devices that fix themselves faster than we notice they're broken. From deep-space probes to wearable heart monitors, self-healing electronics are reshaping how we think about failure. Silicon Valley's all in—but is industry ready for the leap to large-scale production? Because soon, throwing away a broken gadget may feel… downright primitive.

Dr. Anurag Singh Yadav and **Dr. Deependra Kumarf Mishra** who had been working for doctoral research under the supervision of **Prof. Vivekananda Mukherjee** are awarded with their respective Ph.D. degrees in Electrical Engineering in the month of April 2025.
Hearty Congratulations to all !

UPCOMING EVENTS

A Two days Centenary Webinar on Embracing Control Theory in Modern Real World will be conducted from 28^{th} May to 29^{th} May 2025 by **Prof. Bhawana Singh** and **Prof. Shyam A B**
This webinar aims to enhance the researchers' understanding of Control theory and their practical applications in modern real-world systems like autonomous vehicles enabling precise control, safety and efficiency. Control systems facilitate tasks that were previously reliant on human intervention, allowing for greater adaptability, consistent performance and optimized operation. The theme of this webinar is dedicated to the practical applications of control theory in real world such as robotic systems, unmanned aerial vehicles, multi-agent systems.

For Brochure & Other Details: https://www.iitism.ac.in/storage/NewsAttachment/News$_6 80b57fd02638.pdf$

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