ELECTRONS INTO ORDER

PROF. V RAMGOPAL RAO

Prof. V. Ramgopal Rao is a globally recognized nanoelectronics researcher with over 500 publications and 50 patents, including 20 US patents and technologies used in hundreds of millions of chips. He previously served as Director of IIT Delhi from 2016 to 2021 and as a Chair Professor at both IIT Bombay and IIT Delhi. He co-founded two deep tech startups, Nanosniff and Soilsens, and played a key role in establishing India's major nanoelectronics programs. A Fellow of all major science and engineering academies in India and abroad, he has supervised 52 Ph.D. students and received over 40 national and international honors including the Shanti Swarup Bhatnagar Prize, Infosys Prize and IEEE EDS Education Award. He currently chairs national bodies such as JNCASR and NIFTEM and serves on editorial boards of leading international journals. He is currently the Group Vice Chancellor of BITS Pilani, overseeing its campuses in Pilani, Hyderabad, Goa, Dubai and Mumbai.

NOTES OF FUTURE

- **Witness to the Moore's Law Era:** I had the privilege of contributing during the peak years of Moore's Law, when device scaling and increased component density drove innovation in nanoelectronics. It was a time of tremendous clarity and excitement, where every advancement had a clear goalpost. That era helped shape not only my technical perspective but also my appreciation for structured innovation.

- **Embracing a Future of Integration:** As Moore's Law reaches its limits, I find myself energized by the transition to heterogeneous integration—combining different technologies on a single chip through systems-on-chip and systems-in-package. The future lies not in further miniaturization, but in smarter Integration. This transition opens up a rich landscape of possibilities, redefining how we design, scale and innovate.

- **Exploring Alternatives to the Transistor:** The need for alternatives to the traditional MOSFET which could be Nobel Prize-worthy work is both urgent and inspiring. I'm especially intrigued by molecular electronics—envisioning molecules that act like switches or transistors, with their states changing under electrical stimulus. Success in this area would be revolutionary, and pursuing it represents the kind of high-risk, high-reward science I deeply value.

- **A Passion for Molecular Logic Systems:** Beyond making a single molecule switch, the challenge and opportunity lie in scaling—connecting hundreds of such molecules to perform logic operations. To me, this represents as one of the most exciting frontiers in technology, where foundational science converges with transformative future applications.

- **A Believer in India's Semiconductor Promise:** India holds vast untapped potential in semiconductor manufacturing, backed by a strong talent pool and emerging industrial activity. The entry of leading companies like Micron and Tata into the sector marks an encouraging beginning. With the right combination of infrastructure, policy support, and strategic intent, I think India can become a major global player in this domain.

- **Championing Policy, Technology, and Execution:** Throughout my journey, I've learned that success depends on three pillars: sound technology, effective policy, and flawless execution. India often has the technology, but the gap lies in execution and alignment of intent with policy. I strongly advocate for reforms that bring specialists into governance and reduce bureaucratic hurdles to innovation.

- **Deep Tech and the Call for Patient Capital:** I'm inspired by India's vibrant startup ecosystem, but I believe our next leap must come from deep tech. This requires long-term investment and an ecosystem that supports intellectual property-driven innovation. I remain optimistic that with evolving investor mindsets and government collaboration, India will soon foster world-class deep tech ventures.

- **The Joy of Scientific Curiosity:** What has always driven me is curiosity—the thrill of not just understanding how things work, but how they could work. From my early work on semiconductor devices to current exploration of molecular logic and quantum alternatives, that sense of wonder has never faded. I believe that the future belongs to those who pursue difficult questions with a sense of scientific adventure.

- **Recognizing Energy as the Next Guiding Principle:** As we move beyond Moore's Law, energy efficiency is emerging as the next unifying constraint. The era of brute force computing, with high-performance chips consuming massive power, is not sustainable. I see great opportunity in innovating at the intersection of computing and energy—designing systems that do more with less, in a way that aligns with both environmental and technological advancements.

- **Pushing for India's Deep Tech Ecosystem:** While India has become a global leader in IT services and digital innovation, our deep tech sector still lags due to a lack of ecosystem support and long-term capital. I believe this can change. With policy incentives, venture capital willing to be patient, and academic-industry partnerships, India can cultivate world-class startups in fields like semiconductors, advanced materials, and quantum computing.

- **Encouraging Foundational Infrastructure:** One key learning from my years in the field is that breakthrough technologies require an equally strong foundation. For India to thrive in semiconductor manufacturing, we must build not just fabs, but the entire ecosystem—gases, chemicals, water, power, and logistics. These are not glamorous elements, but they are absolutely critical, and I remain hopeful that national initiatives will recognize and invest in these enablers.

- **Valuing Leadership and Ground Execution:** In my view, leadership isn't just about vision—it's about on-the-ground execution. Whether it's fixing Delhi's air or deploying chip plants, the alignment of vision, policy, and hands-on action is vital. I believe India is increasingly aware of this need, and I look forward to a time when execution excellence matches our ambition.

- **Mentoring as a Legacy:** One of the most fulfilling parts of my journey has been mentoring young engineers and researchers. As India moves into an era of innovation-led growth, nurturing talent becomes more important than ever. I'm committed to sharing knowledge, encouraging original thinking, and helping the next generation take bold and informed risks.

- **Remaining an Optimist for India's Technological Future:** Despite the challenges, I remain an optimist. I see an India that is young, eager, and capable. With the right intent and the courage to break old molds, I believe we can not only catch up with the world but lead in areas that define the future—be it AI, semiconductors, or clean energy.

"No dream is too big if you are willing to start small, stay grounded, and work relentlessly."

- V. Ramgopal Rao