**Challenges in Nanotechnology Manufacturing and Emerging Semiconductor Materials an Essay about the of Future Methods and Materials of Nanotechnology**

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## INTRODUCTION

I am a professional in the semiconductor industry and have a passion and admiration for the intense intelligence, work, and creativity that has been put into the arrangement of atoms to build microscopic electrical structures. My experience is more technical and less theoretical and with that I am writing an essay on design considerations and project summary on the current trends in semiconductor manufacturing that could lead to breakthroughs in nanotechnology.

Creating nanostructures and nanomaterials presents a huge problem on a very tiny scale. Building nanotechnology is not like building a house. In the case of building a house a solid foundation is laid upon which solid and sturdy building materials such as wood, concrete, and metal are all layered. The result is a very sturdy solid structure that remains in the same configuration for tens if not hundreds of years.

Nanotechnology includes materials and theoretically machines that are built at an atomic level. Once we get into the realm of sub atomic particles, quantum physics comes in to play because of the extremely odd behavior of these particles. For example, wave particle duality is a characteristic of the electron where it behaves both like a solid object and a wavelength of light (which is not solid) at the same time. Quantum physics is based in terms of probability not certainty. This is due to the fact that all these particles are moving all of the time and it is impossible to fully predict their path. This inability to fully predict the behavior of materials presents a problem in manufacturing which relies very heavily on repeatability and uniformity. It also presents a problem in designing nanotechnology that can be used meaningfully and repeatably.

The first part of my discussion will be based on my opinions of what I see as the new design paradigm for nanotechnology. Since I am not a scientist, I will use my imagination to outline some paths I would like to see taken in developing nanotechnology. Finally, I will summarize an actual scholarly nanomaterial break through currently happening and conclude with my hopes for the future.

## NANOTECHNOLOGY DESIGNS

Because of the random behavior of materials at the subatomic, I think that it will become increasingly important for the mechanical engineers and other designers to start looking at the random processes and behaviors in nature and biological organisms. Watching the behavior of single celled organisms while thinking about what kind of meaningful work they might be able to do will require throwing out the traditional ideas of repeatability and absolutes. What kind of things could a herd of amoebas accomplish? How could the group locomotion of single cell organisms be harnessed? What meaningful tasks could be performed that would be acceptably accomplished at a high level of probability rather than 100% certainty?

It might be too much too soon, but looking at viruses as a means of manufacturing things at the molecular level could also yield some significant breakthroughs.  Typical virus behavior to infect a host cell starts with binding to a receptor of some sort on the outside of the cell. Chemicals are then released allowing the virus to pass through the cell membrane where it erupts and deposits DNA or RNA that inserts itself into the DNA of the host cell.  This inserted genetic material causes the cell to start creating copies of the virus.  Viruses are essentially the product idea seeking factory space for production.

Looking at processes that can happen recursively rather than correct  the first time every time will be critical to the effective development of nanotechnology and materials. Repeating a statistically high process quickly and efficiently can deliver accurate and quality results.

The purpose of nanotechnology design and required materials for manufacture are critical areas of focus in moving forward.  I would also argue that embracing the random and letting go of things like total quality management, strict levels of uniformity and repeatability will be the biggest pieces of moving nanotechnology forward.  Chaos and unpredictability are not friends of the scientist or engineer.  Being able to model the world and understand how things behave with absolute certainty no longer becomes a viable option with matters at the atomic and molecular level.  I believe the patterns of the micro and macro universe and the results they produce from perceived randomness hold more answers than we can imagine.

## RUBBERY AND ELASTIC ELECTRONICS

Hae-Jin Kim and colleagues have written a paper discussing the recent advances in material science that have led to the creation of stretchy, rubbery, elastic semiconducting and conducting materials.  This has led to the design of some very interesting nanosensing applications for strain, stress, pressure, and temperature (Kim et al. 2017).

Stretching and elasticity of material has presented problems in the past creating mobility for the electron or the hole in semiconductors.  Through a highly scientific process and development of novel, fully liquid based fabrication process transistors and junctions can be created with excellent electrical properties.  The team goes on to discuss how such materials and designs could lead to applications such as robotic skins and other highly tuned sensing applications (Kim et al, 2017).

Below is a link to the paper for further information.  I wanted to mention this project because I feel as though it embraces some randomness and less precision but obviously can deliver astonishing results.  The novel material is much more forgiving of process deviation than today’s transistor node size on silicon.  This is a project that I think is an excellent move towards processes that resemble processes in nature more than processes in a vacuum.  We can only do science so long, neglecting friction, assuming it is in a vacuum until we hit the wall of understanding due to not knowing what is not known about a material or process.

## CONCLUSION

The future of technology has plenty of obstacles to overcome with rewards that are proportionally as great once they are figured out.  I work in the semiconductor industry.

How can things be made smaller?  How can things be measured less?  How can such small things be measured at all?  There is no technology for "that" so we will just have to invent it.

These are the attitudes that prevail in my industry and certainly will prevail in nanotechnology.  Those attitude examples are certainly not a fully inclusive list of the stresses and hopes that turbulently move the tech industry forward, but they are an excellent example of rising to the occasion.

## REFERENCES

Kim, H.-J., Sim, K., Thukral, A., & Yu, C. (2017). Rubbery electronics and sensors from intrinsically stretchable elastomeric composites of semiconductors and conductors. *Science Advances*, *3*(9). https://doi.org/10.1126/sciadv.1701114    (Kim et al., 2017)