Importance of chemistry in electronics engineering

Chemistry is important in many electronics fabrication and packaging methods and may one day help extend the trend toward faster and cheaper electronics by Molecular electronics," where individual molecules are used as electronic components. Chemists have always played a fundamental role in the dramatic advance of electronics EVERY YEAR, computers fall in price even as principle.

Consumers upgrade their systems and show appreciation by ranking the computer industry at the top of reputation indices. But when the subject of chemicals comes up, the smile disappears and a look of confusion takes its place. A consumer might recall stories about endocrine disrupter In baby bottles, explosives In drinking water or something else seen on the Internet. It would almost certainly never cross their mind that computers and the rest of today's electronics are inseparably tied to chemistry, or that their manufacture relies on some of the most demanding chemistry practiced at scale.

But Gordon Moore - the scientist who actually formulated Moor's Law - would know It quite well. Moore expounded electronics innovator Fairchild Semiconductor in 1 957, and made his career in the electronics industry, but he took his PhD in physical chemistry and physics, and he considers himself a chemist to this day. Moore and countless other chemists have played a central role In the advancement of electronics, beginning with their fundamental work on silicon and extending Into the present. ONLY THE BEGINNING Silicon lies at the heart of today's ubiquitous computing technologies, but that was to always so.

Vacuum tubes were once the cutting edge of electronics, essential components in early radios, televisions and even computers. Scientists had been Interested In the peculiar characteristics of silicon and other semiconductors since the late 19th century. These materials were neither highly conductive metals nor nonconductors insulators, but somewhere in between - hence the name. Unlike metals, their resistively did not increase with temperature. However, they did respond to exposure to light, even producing a current.

They also had the peculiar ability to strict an electric current to passing in one direction, transforming (or rectifying) AC current into DC current. Although semiconductor rectifiers were used early in the 20th century to detect radio signals, these " crystal detectors" were soon displaced by vacuum tubes. In the asses, however, interest revived when researchers at us-based Bell Labs found that vacuum tubes were unable to rectify very short radio waves. Early silicon rectifiers had been unreliable, but Russell OLL, a chemist at Bell, suspected that their erratic performance resulted partly from the presence of Impurities.

OLL and his colleagues applied themselves to the problem, and by 1940 they could produce high-purity polycrystalline silicon. With their highly pure material, the Bell researchers determined that the electrical behavior of silicon could 1 OFF other elements from the third column of the periodic table resulted in silicon with a deficit of electrons and " positive" electrical characteristics, which they called " p-type" silicon. Elements such as phosphorus from the fifth column, on the other hand, yielded material with an excess of electrons and " negative" electrical characteristics, r " n-type" silicon.

Pushing these revelations further, OLL found that the Junction between between p-type and n-type regions acted as a rectifier. These discoveries proved to be a major turning point in the development of semiconductor electronics, for it is this ability to manipulate the properties of semiconductor materials by adding impurities - or doping, as it is called - and distributing Junctions that enables the engineering of diodes, transistors and, ultimately, integrated circuits consisting of millions of these devices. Chemists made other important contributions to early nonconductor work.

Gordon Teal, another Bell Labs chemist, in collaboration with John Little, an engineer, developed techniques for producing single crystals of the semiconductor germanium, enabling creation of the first Junction transistors by Bell physicist William Shockley in 1951. Teal and his colleagues soon adapted these techniques to producing single crystals of silicon, which performed at higher temperatures than germanium. Bell scientists ran with this development, producing a host of new transistor types that included the diffused Junction transistor, whose eight Junction greatly improved performance.

Bell chemist Morris Attenuate advanced this technology in 1955 by making the first doubly diffused Junction transistor, a form that would dominate solid-state electronics for the next 10 years. MATERIAL FITNESS Every advance in electronics has been tied to the properties of materials, and many advances are possible only because new materials were created to incorporate specific properties. " As soon as you look at how advances are made on a materials basis, then you are involving the chemist," remarks Cathie Markham, global research ND development (R) director at DOD Electronic Materials. And in electronics, the materials change any time the customer device changes. " The steady improvement Moore predicted in the performance of integrated circuits has been achieved by shrinking features so that more and more devices can be packed into the same space, a task that has required continual materials innovation, says Markham. " It may be that you need to change the conducting characteristics of a metal, or the insulating characteristics of a polymer, and even the semiconductor layers themselves," she says.

And every one of those boils down to a chemistry problem and a materials selection. " Markham offers photocopies, a polymeric material that plays a key role in the photomicrograph process used to fabricate microchips, as an example. " Photocopiers create patterns at extremely small-length scales, which are getting so small that if one little polymer [molecule] has an arm sticking out in the wrong direction, you can mess up the whole thing," she says. " So we are trying to control these chemistries at tighter and tighter tolerances. " Chemists do not work in isolation, however.

Marshal's R&D group of over 600 scientists includes engineers, physicists and various technicians as well as chemists, all collaborating closely, not only among themselves, but also with customers. " A lot of innovation in materials is actually done Jointly with customers who are creating chips and circuit boards, very focused and very collaborative with the customer base. " Markham likes to view the relationships in terms of scale, with chemists working near the smallest scale. " It's about materials that can facilitate or enable miniaturization, speed, brightness ND lower power consumption.

The engineers putting these devices together hit a limit. Then they say, I want this piece smaller. They try to design it out of existing materials, but they hit a brick wall," Markham says. " That creates the problem for chemists. They are the molecular thinkers. " DEFINITIONS Moor's Law: The observation, made by Gordon Moore in 1965, that the density of transistors on a microchip doubles every two years. Actual performance would be expected to increase as, or more, quickly. Diode: A two-terminal semiconductor electronic device having a p-n Junction, used primarily as a rectifier.

Transistor: A three-terminal semiconductor electronic device that can be used for amplification, switching, voltage stabilization, signal modulation and other functions. In a three- terminal device, the voltage or current between two of the terminals can be controlled by the application of a voltage or current to the third terminal. Integrated circuit (or microchip): A miniaturized electronic circuit consisting mainly of semiconductor devices, manufactured in the surface of a thin substrate of semiconductor material.