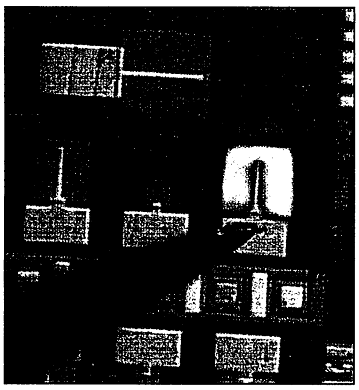
OPTOELECTRONICS

Blue Semiconductors Settle on Silicon

Researchers trying to coax light from semiconductors have a case of the blues, but they couldn't be happier. For the past several years they've managed to cajole semiconductor devices containing gallium nitride to emit blue light when pumped with electricity. That has opened a world of possible applications, including converting some of that blue light to other colors and combining them to make a chip-sized replacement for the light bulb. But blue semiconductor lights are still too expensive for such uses, in part because they're grown on expensive substrates such as sapphire. Now a team of U.S. researchers reports progress on a cheaper alternative.

In the 17 January issue of *Applied Physics Letters*, Asif Khan and colleagues at the University of South Carolina, Columbia, along with co-workers at Wright Patterson Air Force Base in Ohio and Sensor Electronic Technology Inc. in Troy, New York, describe a scheme for producing blue and green light-emitting diodes (LEDs) on a base of silicon, the cheap and ubiquitous substrate for microelectronics. They've also managed to make small LEDs just where they want them on the chip, an important step toward complex displays made up of thousands of separately controlled lighting elements. The new LEDs atop silicon aren't yet as bright as those grown on sapphire. Still, "it's a good development," says Fred Schubert, an electrical engineer at Boston University in Massachusetts. "Silicon substrates are cheap and big. So if a silicon LED technology succeeds, it would mean the technology could be very cheap."



Cheaper blue. Semiconductor light may one day replace the light bulb.

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The garden-variety light bulb, little changed over the last century, costs just pennies to produce but is expensive to run. It pushes electricity through a tungsten filament, turning it white hot and producing 15 lumens/watt of soft white light and a lot of waste heat. Newer compact fluorescents, which excite gases to emit light, do better, turning out 60 lumens/watt. But LEDs, which inject energetic electrons into a solid semiconductor, have the potential to put them all in the shade. As these charges move through, they shed some of their excess energy as photons of light, the color of which depends on the exact combination of materials used in the device. And because this process generates far less heat, it can theoretically produce 250 lumens/watt, says Schubert.

But so far reality has fallen far short of theory. Billions of tiny cracks and other defects form in the gallium nitride as it is grown, and they resist the flow of electrical charges through the device, generating heat instead of light. To minimize the number of cracks, researchers grow their gallium nitride devices atop sapphire in part because it has a roughly similar crystal structure, making it easier for the gallium nitride to form an orderly lattice. Silicon's lattice is slightly different, and it suffers from other drawbacks as well. Most notably, at the temperatures usually used to vaporize gallium nitride and deposit it on the substrate—around 1000°C—silicon atoms evaporate off and get mixed up in the gallium nitride lattice, causing more defects that mar its optical properties.

Still, the lure of silicon's low cost has kept researchers searching for a way to make blue LEDs work. In 1998, an IBM team made some initial progress using a growth technique known as molecular beam epitaxy that works at a relatively cool 750°C. This produced LEDs that turned out ultraviolet and violet light, albeit about 1/15th the brightness achieved by devices grown on sapphire. Researchers from the New Jersey–based Emcore Corp. improved matters last September by using a technique known as metal-organic chemical vapor deposition to lay down a 20-nanometer-thick layer of buffering material on the silicon substrate and then grow the gallium nitride on top.

Khan and his colleagues combined the two approaches. First, they used a 700°C epitaxy technique to lay down a buffer layer of aluminum nitride. They then raised the temperature to 900°C and used vapor deposition to create gallium nitride. They also went beyond the other teams and used the masks and etching of conventional photolithography to place the gallium nitride only where they wanted it. The result was an array of tiny blue LEDs.

The new LEDs still only put out about one-fifth the light of those grown on sapphire. But Khan and others say they have other ideas up their sleeve to improve efficiency. The patterning technique also opens up the possibility of making full-color gallium nitride LED displays. Khan says that his team

ScienceScope

No Holds Barred Researchers are planning to debate a controversial theory on the origin of AIDS. The United Kingdom's Royal Society will host a meeting in London in May to explore the contentious idea that HIV entered humans through a contaminated polio vaccine tested in Africa in the 1950s. The thesis, which received a flurry of attention in 1992 following an article in *Rolling Stone*, last year became a hot topic again when British journalist Edward Hooper published *The River*, a weighty tome on the subject.

The meeting, proposed by Simon Wain-Hobson, an AIDS researcher at the Pasteur Institute in Paris, will examine the notion that HIV or one of its simian cousins infected the primate cells used to manufacture an oral polio vaccine developed by Hilary Koprowski, then head of the Philadelphia-based Wistar Institute. An independent scientific panel convened by Wistar concluded in 1992 that there was an "extremely low" probability that the theory was correct, but Hooper and other critics say the panel failed to make a convincing case.

Wain-Hobson hopes that if Hooper, Koprowski, and other key players agree to attend the meeting, they can clarify the scientific issues. "Discussion is better than a year's worth of invective delivered at arm's length," Wain-Hobson says.

Can't Stand the Heat? Eager to avoid another failure, a suddenly timid NASA has delayed the launch of a science satellite pending further tests. The High Energy Transient Explorer 2 (HETE-2), the first spacecraft dedicated to the study of powerful gamma ray bursts, was ready for a 28 January lift-off from Kwajalein Atoll in the Marshall Islands. But last week NASA brass halted the countdown so that technicians could make sure the $8.5 million satellite is ready to withstand launch vibrations and the frigid cold of space.

The delay "came as a complete surprise," says HETE-2 investigator Kevin Hurley of the University of California, Berkeley, who worries that engineers might inadvertently create new problems when taking apart the craft for tests. But NASA's Don Savage says it was only prudent "to look over everything" given the agency's recent string of losses, including two high-profile Mars probes. If all goes well, HETE-2 should be bound for space by mid-May.

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