New materials provide for LED lighting advances

By R. Colin Johnson

PORTLAND, ORE.—Researchers at Samsung Electro-Mechanics and Rensselaer Polytechnic Institute (RPI, Troy, N.Y.) claim LED vendors will have to consider licensing their patent-pending material to remain competitive. The green energy switch to solid-state lighting is predicted to save trillions of dollars over the next 10 years.

So far, however, promoters of light-emitting diodes (LEDs) technology say it has largely been limited to applications like parking lot lighting, while residential use have been restricted to work areas in homes that have been rewired for LED lighting.

More LEDs are increasingly being used for solid-state lighting, and researchers say technology advances could expand their use.

U.S. researchers claim they have "started a revolution in solid-state lighting technology" using new materials. Fred Schubert, project leader for RPI's Smart Lighting Engineering Research Center, said LEDs have used the same materials for the last 10 years.

"Our new approach changes the core element of the LED in its active region, a change which we believe will revolutionize the world of solid-state lighting," he said. "Our technique will work for about 75 percent of the LEDs sold today, out of a total worldwide market of about $10 billion."

LEDs now use gallium indium nitride for the active-region quantum wells, sandwiched between thicker barrier layers of gallium nitride. The relative fraction between the two materials allows light color to be varied from violet to amber. A polarization mismatch between the two materials, resulting in electron leakage, reduces LED efficiency at high output levels.

"Gallium nitride barriers are a simpler material, but [they are] not polarization-matched to the gallium indium nitride wells," said Schubert. "That mismatch is the physical origin of the 'efficiency droop' at high output levels."

Efficiency droop in high-output LEDs causes them to burn more energy per lumen as their output is increased. "This is the most important problem in solid-state lighting today, because this is the greatest loss mechanism," said Schubert.

The RPI group, which includes Samsung engineers, claims that by using polarity-matched layers of gallium indium nitride, instead of gallium nitride alone, efficiency droop can be mitigated by 25 percent at high power levels.

"Matching polarization materials makes a big difference; it's not perfect yet, but we are increasing the output power of LEDs at high current levels, which is where it matters because for solid-state lighting we want to use LEDs for high-power illumination."

The large polarization mismatch between the materials means electrons initially flow with the current, then against it, as they travel to where they can recombine and emit light. "By matching these polarization fields, we have improved efficiency and reduced forward voltage," Schubert said.

The ideal LED efficiency is about 300 lumens per watt, but even the most efficient prototypes can only achieve about 170 lumens per watt. With the new Samsung/RPI process, and several related improvements, Schubert predicts that LEDs with 200 lumen-per-watt efficiency will be feasible in several years. ■