

Our work provides a novel approach to casting off the limitations of a [down-converting] phosphor," said Chen. According to him, phosphor-free devices promise to deliver longer lifetimes and higher output efficiencies than conventional LED designs.

The researchers fabricated their 300 $\mu\text{m} \times 300 \mu\text{m}$ LED chips by low-pressure MOCVD growth on sapphire substrates. A 3 μm thick buffer was grown, followed by 220 nm of InGaN, a four-period active region comprising 3 nm InGaN quantum wells and 14 nm GaN barriers, and a p-type region.

Transmission electron microscopy revealed spinodal decomposition of InGaN

yellow emission from the dots dominates the device's output. However, blue emission kicks in at higher currents and the ratio of blue-to-yellow emission intensity is almost constant between 20 and 60 mA.

This leads to a stable white light output over this current range, which makes the chip suitable for LED lighting applications. In fact, Chen says that the device can overcome the unwanted color change that plagues many phosphor-converted white LEDs when the drive current is changed.

If quantum-dot LEDs were to replace the light bulb, then their ratio of blue-to-yellow

power chip operating at 700 mA.

One downside of the phosphor-free device is its efficacy, which is lower than 10 lm/W. The researchers are planning to develop new technology to increase quantum efficiency.

"We also need to investigate how to control the ratio of blue and yellow light intensities, and see whether yellow emission can be shifted to longer wavelengths," explained Chen. If this is possible, it would improve the device's color-rendering index.

Journal reference
XH Wang 2007 *Appl. Phys. Lett.* **91** 161912.

GAN OPTOELECTRONICS UCSB ramps non-polar blue LED output power

Non-polar LEDs can now deliver far higher output powers and efficiencies in the blue thanks to the efforts of Kenji Iso and co-workers at the University of California, Santa Barbara.

The team's encapsulated LEDs are not as efficient as today's best conventional devices (which have the handicap of strong internal polarization fields), but their brightest 468 nm emitter delivers output powers and external quantum efficiencies of 8.9 mW and 16.8% at 20 mA, and 27.6 mW and 10.4% at 100 mA.

Iso and colleagues fabricated the 300 $\mu\text{m} \times 300 \mu\text{m}$ devices using MOCVD on *m*-plane Mitsubishi Chemical GaN. The

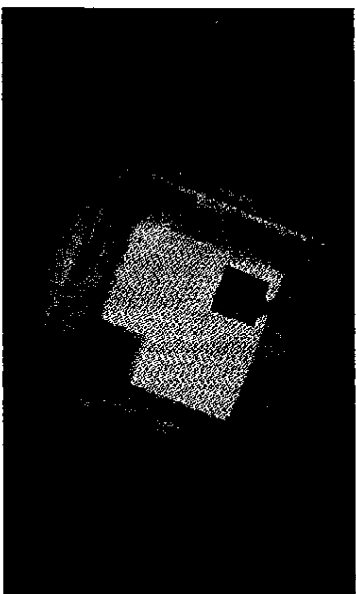
reduces the open circuit voltage and the photogenerated current.

Inefficiencies also result from the semi-transparent current spreading layer that

The best device had a six-period multiple quantum well that featured 8 nm thick wells and 37.5 nm thick barriers. Surprisingly, variations in the barrier's thickness produced a 43 nm shift in peak emission wavelength. "We don't know the reason for this," admitted Iso.

Increasing drive current from 1 to 100 mA led to an emission blue-shift of 3.7 nm. This variation is not due to polarization-related electric fields but to the band-filling effect of deep localized energy states.

Iso believes that non-polar LEDs could provide efficient emission in the so-called "green-gap". The team is working towards this goal by optimizing the growth conditions for 500 nm emitters.



The non-polar LED features a six-period InGaN/GaN multiple quantum well, an undoped AlGaN electron blocking layer and an indium tin oxide contact.

substrates were polished with chemical and mechanical treatments and had a threading dislocation density of less than $5 \times 10^6 \text{ cm}^{-2}$.

Various LED epitaxial structures were produced. These had similar designs to conventional devices but with different active regions.

Research in brief...

..GaN shows multijunction potential

A US partnership led by Georgia Institute of Technology has built GaN/InGaN solar cells on sapphire substrates with internal quantum

reduces the open circuit voltage and the photogenerated current.

Inefficiencies also result from the semi-transparent current spreading layer that

980 nm laser capable of delivering 35 Gbit/s.

The design is claimed to be suitable for mass-production and does not require any ion-implantation or regrowth steps.

Journal reference
K Iso et al. 2007 *Jap. J. Appl. Phys.* **40** L960.