Medal/Jarus W. Quinn Prize in 2013. Other awards he has received include the CNRS Gold Medal (2005), the Wolf Prize in Physics (2010), the Niels Bohr Gold Medal and the UNESCO-Niels Bohr Gold Medal (2013), and the Balzan Prize in Quantum Information (2013). In 2014, he was named Officier de la Légion d'Honneur, the highest French order of merit.

Clauser is known for his contributions to the foundations of quantum mechanics, in particular for the Clauser-Horne-Shimony-Holt inequality, the first experimental proof that nonlocal quantum entanglement is real (Stuart Freedman and Clauser), and for the formulation of the theory of local realism (Clauser and Michael Horne).

Clauser also proposed and patented atom interferometers as useful ultrasensitive inertial and gravity sensors. In 1998, he invented and patented the use of the Talbot-Lau interferometry for ultrahigh-resolution interferometric x-ray imaging. This invention, in turn, enabled the x-ray phase-contrast medical imaging of soft tissue. Clauser was awarded the Reality Foundation Prize in 1982, the Wolf Prize in 2010, and the Thompson Reuters Citation Laureate in physics in 2011.

Zeilinger pioneered quantum mechanics through theoretical and experimental work on entanglement, most notably with his demonstration of quantum teleportation in 1997. In 1998, his group was also the first to experimentally demonstrate entanglement swapping — the teleportation of an entangled state between qubits, a critical mechanism for quantum computation networks.

Zeilinger was awarded the inaugural Isaac Newton Medal of the Institute of Physics in 2008. The award recognized his pioneering contributions to the foundations of quantum physics, which have become the cornerstone for the rapidly evolving field of quantum information. He received the Wolf Prize in 2010 and the Cozzarelli Prize from the National Academy of Sciences in 2019.

$23.4B — projected size of the global fiber optics market by 2027, according to IMARC Group

This month in history

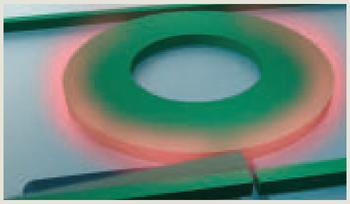
What were you working on five, 10, 20, or even 30 years ago? *Photonics Spectra* editors have perused past December issues and unearthed the following:

1992

Georgia Tech physicists created a feedback system that actively controlled the chaotic output of a complex laser system over the entire range of its operation.

2002

Researchers at Kansas State University developed a means of characterizing the optical quality of aluminum nitride (AlN) that enabled them to make semiconductor-quality AlN.



2012

University of Minnesota researchers developed a microscale optical device that used the force generated by light to flip a mechanical switch on and off at very high speeds.

2017

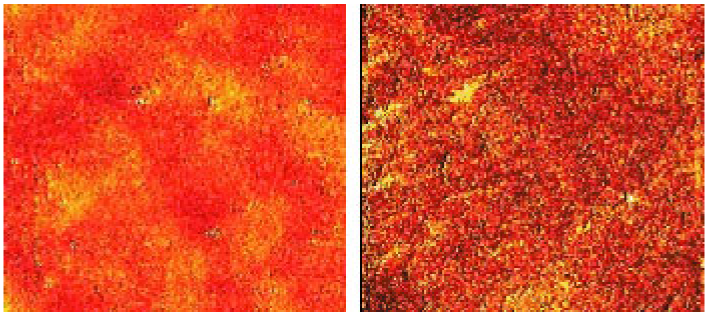
ETH Zürich researchers used nanomaterials and a room-temperature fabrication process to develop an ultrathin, flexible LED that emitted pure green light.

PHOTONICS MEDIA photonics.com

.: Photoluminescence Characterizes AlN

KEVIN ROBINSON

Researchers at Kansas State University in Manhattan have developed a means of characterizing the optical quality of AlN. The technique enables them to make semiconductor-quality AlN with the potential for fabricating deep-ultraviolet laser diodes.



A deep-UV laser spectroscopy system offers picosecond time-resolved photoluminescence measurements of AlN, enabling researchers to characterize and thereby improve the quality of the material. Atomic force ***microscopy*** *images of this AlN crystal reveal a smooth surface morphology. The rms surface roughness is 0.8 nm for a 10 x 10-µm scan area (left) and 0.7 nm for a 2 x 2-µm area (right), comparable to high-quality GaN. Courtesy of Hongxing Jiang and Jingyu Lin.*

AlN has a number of desirable characteristics for photonic applications, including a high direct bandgap of approximately 6.1 eV at room temperature, high thermal conductivity, hardness and chemical resistance. Unlike many other III-nitride compounds, however, measuring the optical and electrical properties of AlN has been a challenge because the material is a good insulator, which renders some standard characterization methods, such as Hall measurement, useless.

Hongxing Jiang, Jingyu Lin and colleagues have developed a deep-UV laser spectroscopy system that allows them to make picosecond time-resolved photoluminescence measurements of AlN and, thus, to characterize and thereby improve the material's quality. The system uses a 3-mW, 196-nm frequency-quadrupled Ti:sapphire laser that excites the sample. A streak camera captures the resulting exciton photoluminescence. Because only high-quality semiconductor materials emit exciton photoluminescence, Jiang explained, the spectra reveal the optical quality of the sample.

The group measured the photoluminescence spectra from 2.2 to 6.2 eV in AlN at 10 K. The ratio of the intensity of signals caused by impurities to the signal from the band-edge emission at 6.033 eV reveals the optical quality of the compound. If the emission from the defects and impurities in the compound does not overpower that of the compound itself, the optical quality is sufficient. The researchers found that this ratio is directly related to the growth conditions.

Determining the quality of the material is key to improving the manufacturing process. Because AlN and many of its III-nitride cousins are grown on foreign substrates, defects, dislocations and impurities are a significant problem. The new work indicates that it is possible to make AlN that displays less thermal quenching of the emission intensity and fewer problems resulting from impurities, dislocations and nonradiative recombination channels than GaN.

Much work remains to be done before manufacturers can incorporate AlN-based UV lasers in their products. Nevertheless, the group is taking the initial steps to developing N- and P-type AlN. Other studies already have suggested that N-type AlN can be created with dopants such as silicon.

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Dec 2002