COMPOUND SEMICONDUCTOR

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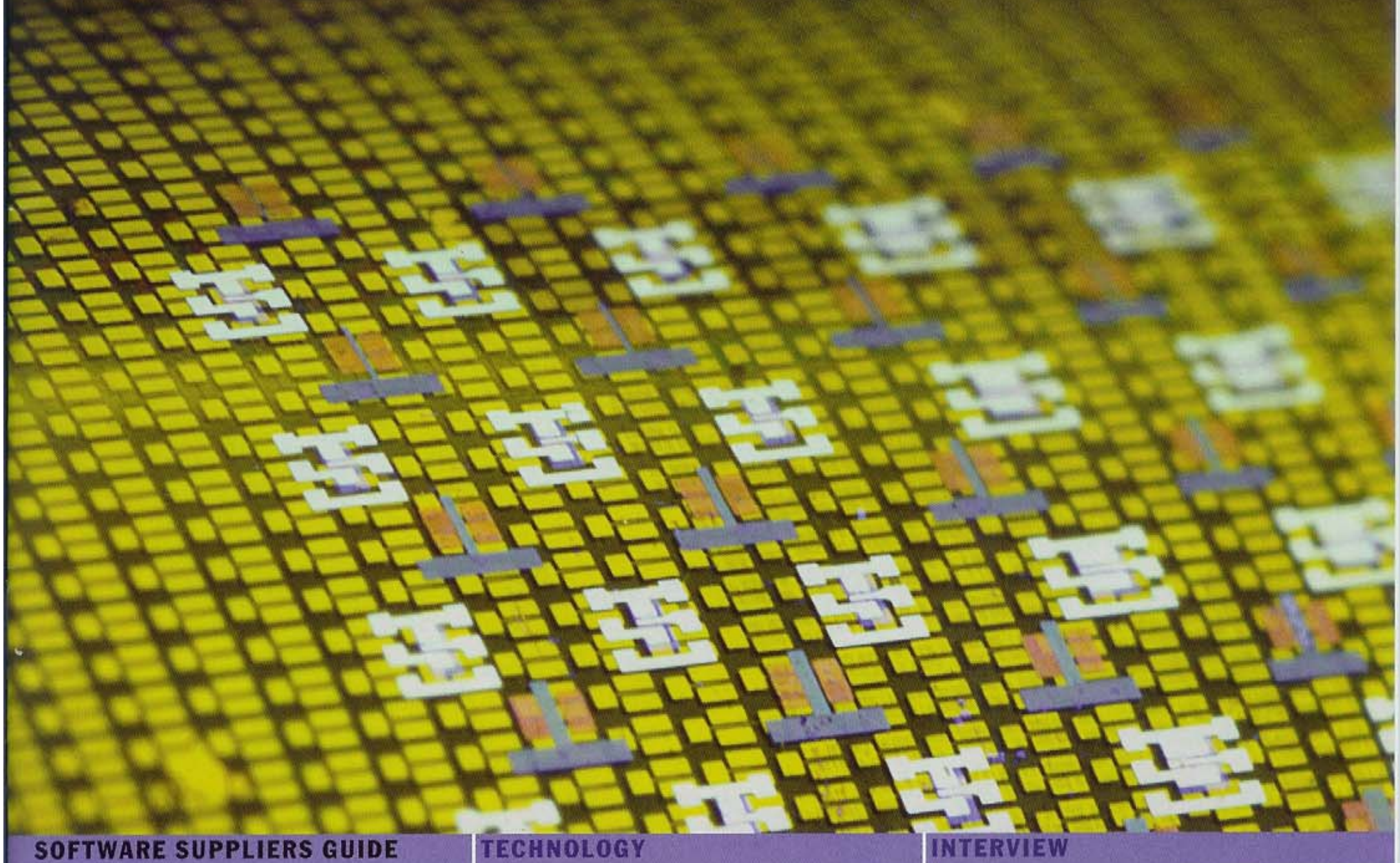
CONNECTING THE COMPOUND SEMICONDUCTOR COMMUNITY

NEW MATERIALS

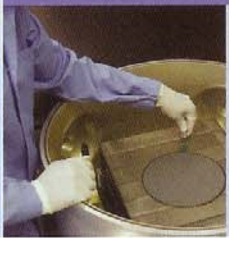
Printing nitride nanostructures



SOFTWARE SUPPLIERS GUIDE

Tools for image acquisition and crystal growth p24

TECHNOLOGY



Forever diamond?

Both LEDs and power transistors could benefit from silicon-on-diamond substrates. p29

INTERVIEW

Free radical

How do GaN light emitters really work? Cambridge University's Colin Humphreys has developed a theory. p14

DEVICE PROCESSING

Printing technique integrates materials

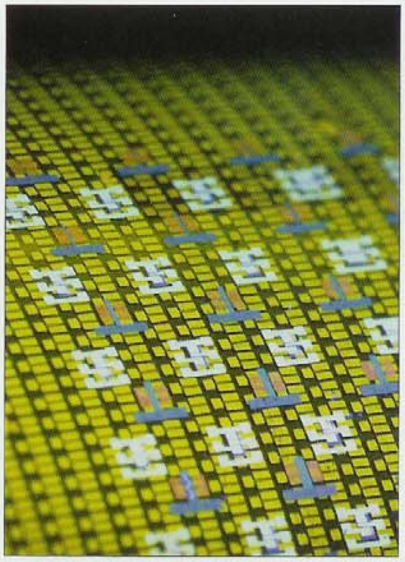
A printing technique that combines HEMTs, MOSFETs and thin film transistors made from nanowires and nanotubes has been developed by scientists from the University of Illinois, Urbana-Champaign.

The process, which can also be used to integrate other dissimilar materials, is claimed to be capable of producing a variety of unusual electronic systems that would be impossible to make with other methods like MOCVD and MBE.

The researchers' multi-device structures are formed by first producing semiconductor nanomaterials, such as single wall nanotubes (SWNTs), GaN nanobars and silicon wires, on separate substrates.

Material from these substrates is then transferred using stamp-based printing onto a device substrate, such as a sheet of polyimide. This sheet has a thin, spin-cast layer of a liquid prepolymer, such as polyamic acid, which adheres to the polyimide and embeds the printed material once it is cured.

Further processing steps include deposition and patterning of gate dielectrics, electrodes and interconnects. Once this is carried out another spin-coated polymer interlayer is added and a second circuit featuring a different material.



Printing combines silicon MOSFETs, single-wall carbon nanotube thin film transistors and GaN HEMTs on a flexible polyimide substrate. The gold contact pads on the silicon devices are spaced 100 µm apart.

With this approach, the researchers produced a circuit on polyimide with a bottom layer of GaN HEMTs, followed by layers of SWNT thin-film transistors (TFTs) and silicon MOSFETs. These devices have similar characteristics to those fabricated on the source wafers and repeated bending of the substrate produces no major change in their properties.

The flexible substrates make these devices suitable for applications such as wearable electronics and flexible displays. "The plastics that we make are lightweight and mechanically tough", said the team leader, John Rogers. "A disadvantage is poor thermal properties, but that doesn't matter for many applications."

Rogers says that the team is now working on printed photodiodes, solar cells and LEDs, and that it will report results later this year. Commercial applications are also being explored through the recent launch of a start-up company, Semprius, which is looking at flexible displays, large-area solar cells, curved focal plane arrays and structural health monitors for aerospace applications.

Journal reference

J Rogers *et al.* 2006 *Science* **314** 1754.

INP OPTOELECTRONICS

Dashes beat dots for high-power laser

Boon Ooi and his team from Lehigh University claim to have built the first high-power broadband semiconductor laser operating at 1.6 µm.

The InP-based laser, which was produced in collaboration with IQE, Pennsylvania, and the Army Research Laboratory, Maryland, features InAs quantum dashes, which are elongated quantum dots. The device has a center wavelength of 1.64 µm, a 76 nm wavelength range and delivers 0.4 W at room temperature.

"Compared with conventional InGaAsP quantum-well lasers emitting at 1.55 µm, Lehigh's quantum-dash laser displays significantly broader linewidth at comparable output power," explained Ooi.

The US Army is interested in using these eye-safe sources for range-finding and burst illumination imaging – a technique that involves probing objects with short laser pulses and detecting the reflection using time-gated electronics.

The quantum dot lasers, which potentially cover 1.3 to 2.0 µm, could also be used in spectrometers to identify common gases by their absorption spectra. Dentistry could also benefit, as these emitters could allow deeper images of gum tissue and enamel produced by optical coherence tomography.

IQE engineers grew the devices by MBE on (100) InP substrates. They formed InAs dashes using a Stranski-Krastanow growth mode and embedded in them InAlGaAs quantum wells.

Ooi says that quantum dashes are used in the active region, rather than dots, because it is easier to produce high gain active material in the required size distribution that is needed for broadband emission. Devices based on chirped quantum-dot layers can also suffer from photon re-absorption, which significantly reduces efficiency.

The team's goal is to develop a broadband semiconductor laser that covers both C-band (1525–1565 nm) and L-band (1565–1625 nm) for optical telecommunication, sensing and tomography applications.

PHOTODETECTORS

AlN stretches out photodetection range

Researchers at the Kansas State University and its spin-off firm III-N Technology claim to have extended the operating range of AlGaN-based photodetectors. The partnership's AlN device has a cut-off wavelength of 207 nm, which is 22 nm shorter than the previous best result that was produced by Bilkent University, Turkey.

The result is of interest to NASA, which is supporting the team's research, because it is keen to develop compact solid-state detectors that can operate in the extreme ultraviolet spectral range for applications in astrophysics.

The Defense Advanced Research Projects Agency is also funding the university's research efforts to develop ultraviolet avalanche photodiodes (APDs) for bio-agent detection and non-line-of-sight optical communications.

MOCVD-grown AlN detectors had a peak response at 200 nm, a dark current of 100 fA at a 200 V bias voltage and a responsivity that typically increases from 0.1 to 0.4 A/W as the bias voltage is increased from 0 to 100 V.

The team will continue to improve the quality of its AlN epilayers, and try to fabricate Schottky diode photodetectors and APDs based upon AlN epilayers and AlGaN alloys.

Journal reference

J Li *et al.* 2006 *Appl. Phys. Lett.* **89** 213510.