MATERIALS world

Volume 15 Number 9
September 2007

The voice of the materials, minerals and mining communities. Incorporating International Mining and Minerals

Hard driving
Magnetic materials

PLUS: • UNITED WE STAND – UNION'S VIEW OF UK MANUFACTURING • TRUST FUNDS – CARBON TRUST FUNDING OF ENERGY EFFICIENT MANUFACTURING • AFTER THE WAR – MINING IN THE CONGO • EN POINTE – MATERIALS KTN SPARK AWARDS

Speed on silicon

Startup company AmberWave Systems, based in Salem, USA, has developed a novel technique to grow semiconductors, such as germanium, gallium arsenide and indium phosphide, on silicon. Researchers hope the method will lead to faster and smaller transistors, and cheaper lasers and photonic devices.

By etching trenches about 500nm deep through a silicon oxide insulation film on a silicon wafer, the team has epitaxially grown non-silicon semiconductor materials through chemical vapour deposition.

Dr Anthony Lochtefeld, Vice President of Research at AmberWave Systems, explains, 'Electrons can move much faster in various non-silicon semiconductor materials. However, only silicon substrates are suitable for mass manufacture [due to their] mechanical and electrical properties. This means that key materials like germanium, indium antimonide and gallium arsenide need to be integrated onto the silicon wafer.'

Faster and smaller transistors are the key to extending Moore's Law – this chip industry axiom predicts that doubling the number of transistors in an integrated electronic circuit every two years will improve performance.

Furthermore, by depositing materials such as indium phosphide and germanium, which emit or detect light, on silicon, manufacturers could combine the light handling and electronic functionalities of photonic devices in one chip. This would in turn reduce the costs of packaging multiple chips in a module and of module-level integration and chip interconnection.

'Growing epitaxially gallium nitride on silicon is reasonably well established,' comments Professor Christopher Snowden, Vice Chancellor of the University of Surrey, UK, and a specialist in semiconductor materials and devices. 'Other combinations have been explored – for example, gallium arsenide on silicon – but the economics of this combination do not stack up.

'[Overcoming] lattice mismatch and strain are key parameters. The use of trenches to negate the effect of dislocations would appear to be innovative and interesting. It would be good to compare the outcome and economics of the AmberWave approach with whole wafer epitaxy.'

In the AmberWave technique, defects in the crystal lattices are trapped at the vertical sidewalls of the trenches, allowing high quality non-silicon semiconductors to be grown above the defect-trapping region (see image above, right). But this is only achievable if the height of the trench is the same as or greater than its width – hence the method is called 'aspect ratio trapping' (ART).

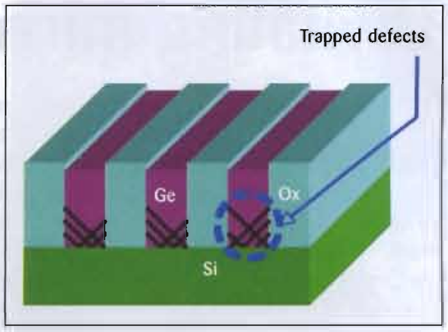
Lochtefeld explains, 'The atoms of the non-silicon semiconductors are typically much larger than silicon atoms. This leads to mismatch problems when you try to combine them [and] defects in the crystal lattices, which degrade device performance and reliability.

'Thermal expansion and contraction of silicon is [also] different compared to that of non-silicon materials. This leads to cracking of the [latter] during large temperature changes [during] device manufacture.'

According to AmberWave, silicon oxide film growth of just 0.5 microns thick can act as a buffer for lattice mismatch, while low epitaxial thickness can reduce the stresses and eliminate the cracking caused by thermal expansion coefficient differences.

The team has successfully grown germanium and gallium arsenide, and initial results for indium phosphide are promising. By collaborating with universities in the USA, the company aims to develop prototypes of germanium and III-V transistors by the end of this year.

But planarisation of the device needs to be



addressed. 'Aspect ratio trapping does not produce flat surfaces,' says Lochtefeld. 'We are exploring chemical mechanical polishing of epitaxial ART regions so that standard device fabrication techniques can be used. [Also] because the trench depth needs to be about the same as the width, a single region produced by ART is more than enough for transistors [but] not large enough for lasers. We are working on variations of the technique to overcome this limitation.'

Snowden adds, 'AmberWave's local growth in defined areas may allow a better combination of silicon and non-silicon technologies if it can develop the technique to achieve flexible manufacturing and design.'

For further information, visit www.amberwavesystems.com.

Rupal Mehta

Probing ionic liquids

Supercritical carbon dioxide and ionic liquids are the subject of a research agreement between BASF Corporation and CogniTek Management Systems, an advanced materials technology firm based in Northfield, USA. Scientists will examine whether combining the unique properties of these two substances could transform low quality heat from solar power, geothermal combustion waste and bottom cycling of existing power plants into high value power generation. The result would be a combined energy generating system with integral heating and cooling co-products capable of saving substantial amounts of energy.

BASF claims to be the first company to use high performance non-flammable ionic liquids in a commercial-scale operation. Websites: www.basf.com and www.cognitek.com.

News in brief

- An industrial consortium has been established to design methods for the manufacture of novel dispersed nanoparticulate products that meet rigorous quality standards. Headed by BHR Group an independent research and consultancy service in fluid engineering and process technology, that is based in Cranfield, UK, DOMINO will kick off in October. Its members will apply experimental and simulation work to allow rapid scale-up and consistent product quality.
- CERAM, a materials research organisation based in Stoke-on-Trent, UK, has secured funding from the European Community Framework 6 to investigate the surface chemistry of refractory crystalline silica. In conjunction with SME companies across Europe, CERAM aims to understand how ceramic processing affects the surface chemistry of the material and, in turn, its toxicity, to assist EU legislators in setting mg/m^3 exposure limits. Website: www.ceram.co.uk.