The narrow optical band-gaps of antimonides play a key role in the development of next generation infrared (IR) detectors

EPSRC
Engineering and Physical Sciences Research Council

National Centre for III-V Technologies

Universities of Sheffield, Cambridge, Glasgow, Nottingham

Case Study - Antimony-based III-V Semiconductors

In the periodic table, antimony (Sb) lies in the nitrogen group (group V) below arsenic. III-V compound semiconductors containing Sb often have unique band structures and physical properties. Antimonide semiconductors play a key role in infrared imaging and light sources, and are also promising candidates for the fabrication of high speed and low power consumption electronic devices that may complement silicon transistors to extend *Moore's law.*

Challenge
The epitaxy of antimonides is less mature compared to material systems such as GaAs or InP. The following challenges have to be addressed in order to achieve a high quality functional structure: control of interfaces due to the high segregation length of Sb, control of strong elemental exchanges between Sb and other group V elements; accommodation of large lattice mismatch between antimonides and the other III-V semiconductors; miscibility gap in ternary / quaternary alloys.

Solution

The National Centre has been developing antimony-containing materials since the late 1990s and has attained extensive expertise in tackling the above mentioned crystal growth challenges. Key factors allowing the National Centre to have a leading position in this development are:

> Two MBE reactors equipped with the latest Sb cracker cells allowing a wide range of III-V-Sb combinations
> Established calibration procedures for key growth parameters ensuring reproducibility and continuous improvement
> The availability of in-house electrical, optical and structural characterisation facilities
> Close and collaborative working with customers to gain quick feedback and to develop the field

Notable achievements from the National Centre include:

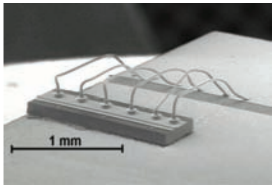
> World-class Near- and Mid-Infrared superlattice photodetectors with type II staggered band alignment (InGaAs/GaAsSb SLs on InP, InAs/GaSb SLs on GaSb)
> State-of-the-art Quantum Cascade Lasers based on antimonide alloy layers for improved carrier confinement
> InAs quantum dots with Sb surfactants and dilute nitrides. Improved optical quality was achieved at telecom bands (1.2-1.6μm)
> InSb/AlInSb two-dimensional electron gas (2DEG) structures on GaAs with high room temperature mobility

Conclusion

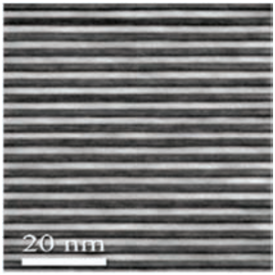
The National Centre has broad ranging expertise and capability in the epitaxy of III-V antimonide materials that is available to researchers and industrial customers in the UK.

The National Centre continues to work with academic partners developing the technology further for both fundamental studies and device applications. New directions include, but are not limited to, exploring new material systems (such as antimonide/phosphide, antimonide/bismide alloys) and low dimensional structures (for example nanowires) to address applications from IR detectors to transistors to topological insulators.

We welcome the opportunity to work with you in new areas of antimonide-based structures built on this expertise.



Sb-quantum cascade laser bar



Dark field 002 TEM image of InAs/GaSb SLs

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