BIANCHO Publishable summary

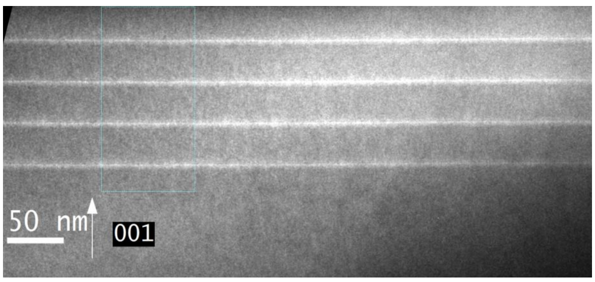
The BIANCHO project aims to develop photonic components designed to significantly reduce power consumption at the component and system level in advanced communication systems, thereby saving significant electricity, and enabling unlimited bandwidth through integration, more optical processing and very high spectral-density photonic transmission.

Current telecom components suffer severely from intrinsic losses. Around 80% of electrical power is wasted in a 1.55μm laser chip as heat. Most systems require thermo-electric coolers (TECs) and an air-conditioned environment, further increasing the energy budget by over an order of magnitude. The intrinsic losses in semiconductor lasers and optical amplifiers (SOAs) are due to Auger recombination, while control of the temperature dependence of the energy gap requires the use of TECs with electro-absorption modulators (EAMs). Incremental approaches to overcome these problems have reached their limits.

We are proposing a radical change, to manipulate the electronic band structure of novel dilute bismide and dilute nitride alloys of GaAs and InP to eliminate Auger recombination in lasers and SOAs and to dramatically reduce the temperature dependence of the energy gap in EAMs. We aim to research, develop, test and demonstrate uncooled EAMs, as well as highly efficient uncooled lasers and SOAs. The expected properties are also highly beneficial for high speed photodiodes as required in transceivers.

Considerable progress has been made during the first two years of the BIANCHO project. At the fundamental level, work at SURREY has confirmed experimentally that the spin-orbit splitting can exceed the energy gap in bismide alloys based on both GaAs and InP substrates. Theoretical models have been developed at TYNDALL to describe the band structure. The band structure models developed have been used to identify GaBi(N)As laser designs for Auger-free emission at 1.5 μm, and also to identify designs for mid-IR emission using GaInBiAs on InP or GaBiNAs on GaAs.

The team at FTMC have established growth of GaBiAs using both conventional and migration-enhanced molecular beam epitaxy, to achieve GaBiAs quantum well structures with over 10% Bi content. They have also developed a post-growth annealing technology that provides GaBiAs material with sub-picosecond carrier lifetimes for ultrafast photodetector applications. Picosecond photoconductivity spectra of ultrafast GaBiAs photoconducting antennas have been measured by employing a tuneable femtosecond laser source and their sensitivity up to a wavelength of 1.8 μm has been demonstrated. This has enabled the realization of the first THz Time-Domain-Spectroscopy system based on an Er-doped fiber laser and GaBiAs optoelectronic components. PIN and UTC photodiode devices with GaBiAs absorption layers have also been demonstrated, with their spectral sensitivity range reaching 1.4 μm and frequency bandwidths larger than 5 GHz.



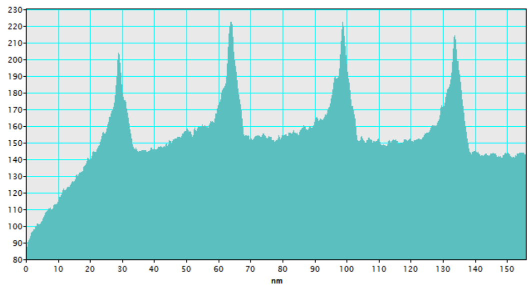


Figure 1 - TEM image of dilute bismide quantum well sample (left) and its quantitative analysis along the growth direction (right)

MARBURG have used their leading understanding of highly mismatched semiconductor alloys to set up MOVPE growth both of GaBiAs on GaAs and also of GaInNAs on InP. They established in year 2 MOVPE growth conditions for high quality Ga(BiAs)/GaAs structures (droplet free growth with room-temperature photoluminescence). Ga(BiAs)/(AlGa)As electrical injection laser structures have been grown and processed in partnership with CIP, which show electroluminescence at room temperature. They also established optimised conditions to grow GaInNAs/GaInAsP laser and EAM structures on InP, with these devices now being further investigated and analysed for improved temperature performance.

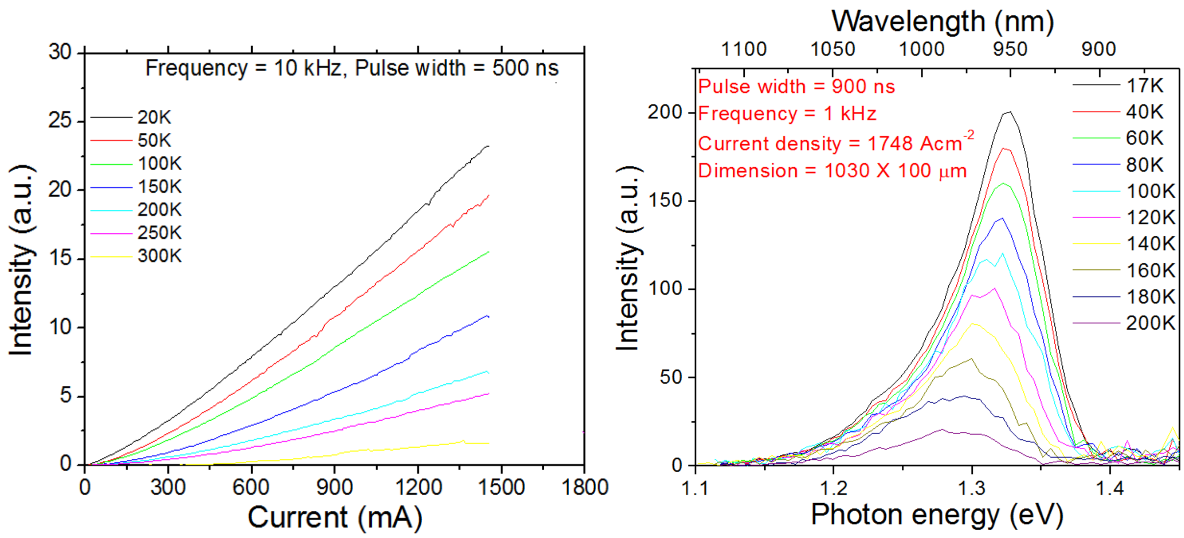


Figure 2: Light-current characteristics and spectral properties of GaBiAs/GaAs electrically pumped light-emitting diodes developed in the BIANCHO project.

Work in BIANCHO has focused to date both on material development and characterisation and also on device design and realisation. We have established a world-leading capability in bismide material growth, with critical experimental and theoretical expertise in materials and device design and analysis. We are now very well placed for the development and demonstration of efficient bismide- and nitride-based telecomm components.

Overall, the BIANCHO project includes leading European groups with complementary expertise in epitaxy, device physics, band structure modelling and advanced design and fabrication, in a well focused consortium. The exploitation activities of the project participants lay strong foundations for enhancing European competitiveness in the global telecommunications market and ultimately leading to new high technology jobs for Europeans, based on the development and application of uncooled telecom components with significantly reduced power consumption both at the component and system level.

Project website: www.biancho.org