iBROW project newsletter #2

February 2016

Welcome to the second iBROW project newsletter!

iBROW is a research project supported by the European Commission through Horizon 2020 under Grant Agreement 645369.

iBROW is a collaborative research project supported by the European Commission through Horizon 2020 which has now completed its first year. The project will address the growing requirement for high bit rate short range wireless communication by exploiting the opportunities offered by resonant tunnelling diodes (RTDs). This newsletter contains:

- *Some considerations of heterogeneous integration in the context of iBROW from baseline studies led by Alcatel-Lucent Deutschland*
- *High speed laser characterisation at CST*
- *Simulation and measurement of lasers at INESC TEC.*

iBROW will run for three years and these bi-annual newsletters will report on the project progress, as well as news of other events and activities. More information is available on the project website (www.ibrow-project.eu) or by getting in touch by email (see below).

The iBROW team enjoying a break in the sunshine at the 6M meeting (Faro; Jun-2015).

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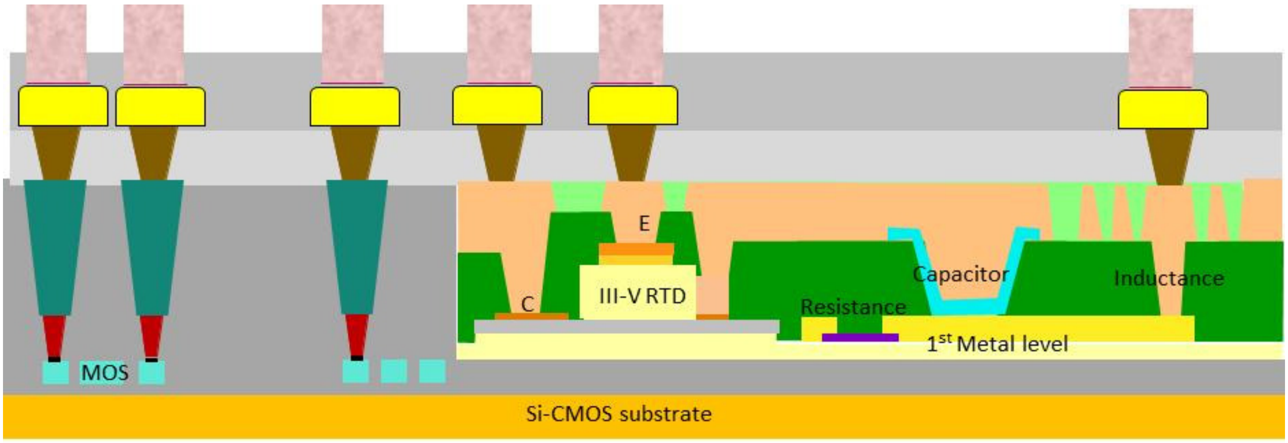
University of Glasgow · UAlg Universidade do Algarve · cea · INESCTEC Technology & Science Associate Laboratory Portugal · Alcatel·Lucent · optocap · Compound Semiconductor Technologies · IQE Silicon Compounds · Technische Universität Braunschweig · III-V lab · VIVID Components

Heterogeneous integration in the context of iBROW

Alcatel·Lucent

The footprint, power consumption and cost of future communications systems are of ever-increasing importance. This translates into the need for advanced integration of additional functions into smaller volumes by combining or integrating several high performance technologies. To this end, *heterogeneous integration* is considered today as a powerful technique as already demonstrated on 3D integration of complex CMOS technologies or even the emerging III-V on silicon CMOS substrate for both photonic and electronic applications.

III-V Labs in collaboration with CEA-LETI have developed an iBROW bonding process. The following figure shows a schematic view of the resulting III-V RTD on silicon CMOS substrate.

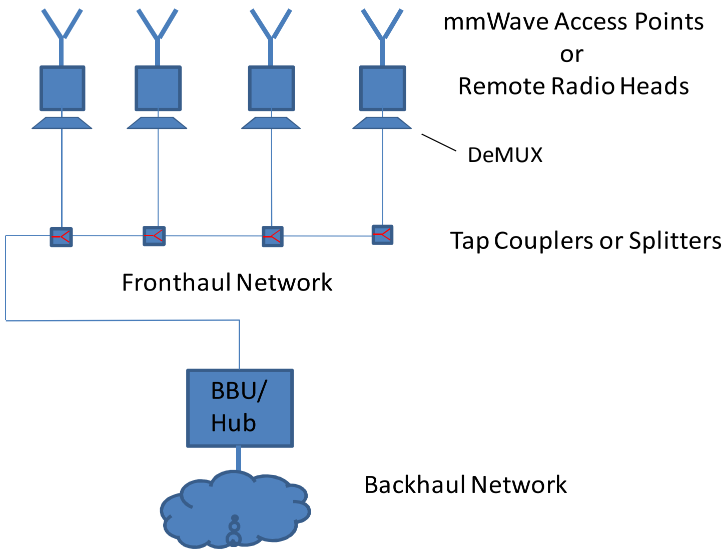


Schematic view of III-V resonant tunnelling diode (RTD) on silicon CMOS

Due to the RF-power performance limitations of RTD devices, all the application scenarios considered in iBROW deal with small cells in mainly indoor- or campus-environments. The targeted products will address consumer-type markets. This imposes a number of physical and cost constraints, i.e. to avoid ending up with an unaffordable system.

High bitrate communication systems in the range of up to 100 Gbps as targeted by iBROW are costly and involve high power consumption. This problem can be addressed by RoF-based (radio-over fibre) concepts in centralised RAN-like (radio access network) architectures or distributed antenna systems. Both have in common that the bulk of signal processing tasks is shifted into a central node, which may run high performance signal processing and hence can be more expensive and power consuming than the remote RF-frontend nodes.

The figure opposite shows an optical bus-like chain topology structure. By featuring multiplexers and splitters or alternatively optical tap couplers this concept involves low cabling effort. Optionally this topology can be closed to a more resilient ring type topology by connecting the last node of the chain to the baseband unit or hub.



Fronthaul network in bus- (queue-) topography

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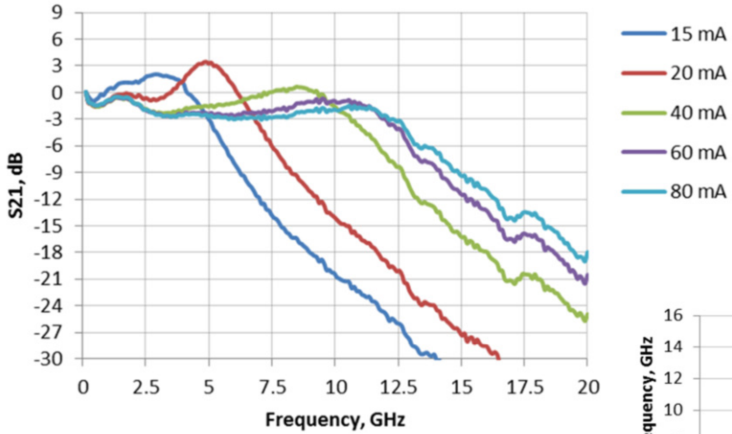
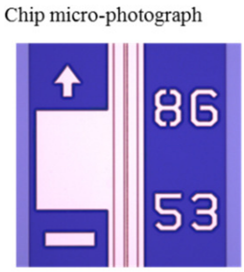
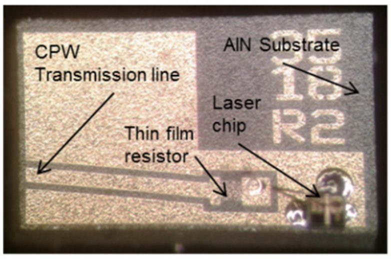
Laser characterisation and development work at CST

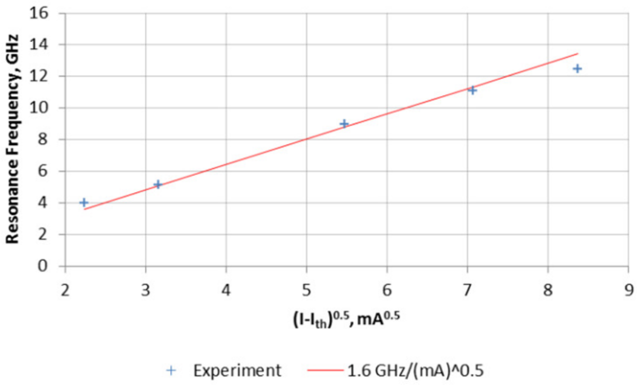
Compound Semiconductor Technologies

During the first period of iBROW, CST has been involved in a range of activities relating to the characterisation and measurement of high speed lasers to assess their suitability for the applications targeted by the project. This includes high speed characterisation of 1550 nm and 1310 nm Fabry-Perot (FP) lasers from CST for optical fibre communication applications which are to be used for the iBROW wireless to optical link. Measurement of the optoelectronic transmission properties of sub-mounted lasers (S21) up to 20 GHz was performed. Subsequently the laser resonance frequencies and bandwidth of the devices was determined for optical fibre communications applications up to 10 Gpbs.





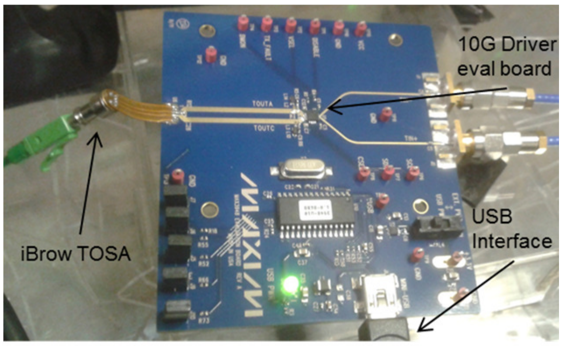


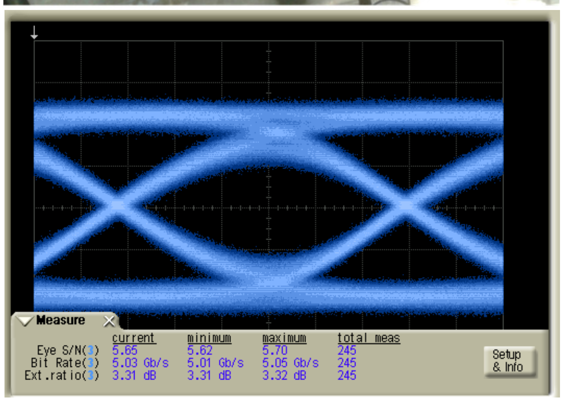


Characterisation of sub-mounted lasers up to 20 GHz and resonant frequency measurement.

CST has performed a range of investigations of the FP laser package characteristics. These have been designed to conform to industrial standards and ensure that the laser is suitable for system integration within the iBROW wireless to optical link.

Further measurement and characterisation of the laser driver over a range of driving conditions was carried out in order to find the optimal eye-diagram performance at various operating speeds up to 10 Gbps. This testing included an investigation of realistic deployment conditions (i.e. maximum stress conditions and ageing tests). This work has confirmed the applicability of 1550 nm and 1310 nm 10G CST lasers for the iBROW wireless link for T<70°C. Open eye diagrams have been obtained up to 10 Gbps, and work on noise reduction continues.





Measurement of the packaged iBROW laser and preliminary eye diagram results at 5 Gbps.

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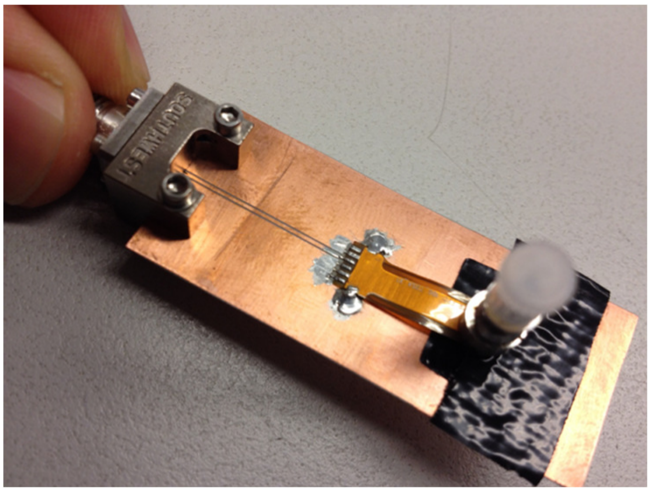
Laser measurement and simulation at INESC TEC

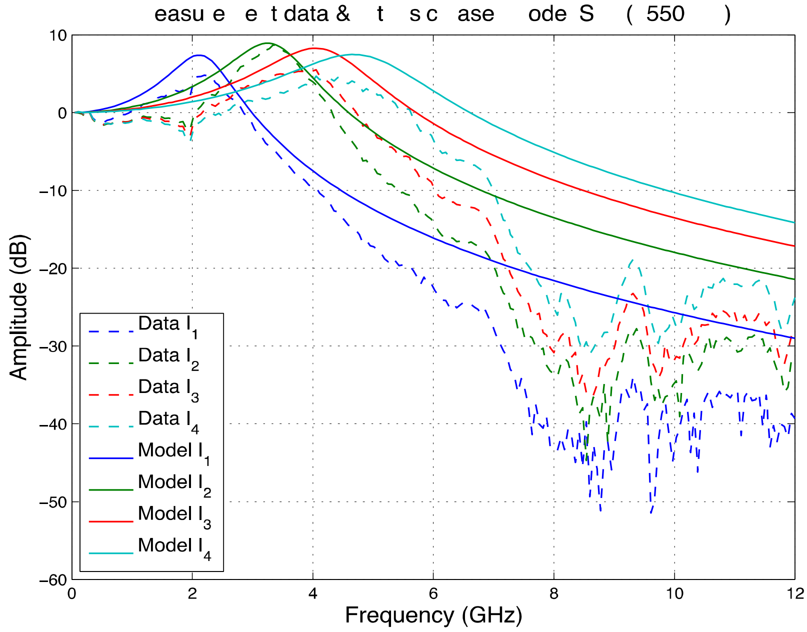
The multi-gigabit capable transceiver being developed within iBROW features a resonant tunnelling diode (RTD) coupled together with a semiconductor laser in order to enable a seamless interface between wireless and fibre-optic networks. As discussed on the previous page, CST is conducting the laser development and characterisation in accordance with the project specifications. INESC TEC is conducting further characterisation and modelling of the laser devices. This aspect of the characterisation involves evaluation of the the power vs. current curve, threshold current, and frequency dependent input impedance and transfer function.



Measurement of the laser devices at INESC TEC

Before reaching the intrinsic laser, the modulating microwave signal passes through a bias-T, a microwave transmission line, and electrical impedance discontinuities from the laser packaging parasitics. These elements may cause power loss, inter-symbol interference and jitter, and therefore, should be kept as low as possible. A very accurate model of the input laser network is then necessary to allow the correct design of the matching network. Moreover, obtaining a model of the intrinsic laser is also extremely important in order to understand how the laser shapes the modulating electrical signal.

This can be obtained through the subtraction of the measured response at different specific bias currents by the response of the laser at low bias current, therefore eliminating the effect of parasitics, and allowing the estimation of the laser parameters alone. The method consists then in using optimisation techniques to fit this curve to the analytical response of the semiconductor laser (which results from the linearisation of the rate equations). The parameters used in the simulation are shown in the table below.



Parameter	Symbol	LD 1550 nm	Units
Active region volume	V	$9.7987e^{-19}$	m^3
Gain slope constant	g_0	$2.2286e^{-12}$	m^3s^{-1}
Gain compression factor	ϵ	$2.5802e^{-23}$	m^3
Carrier density at transparency	N_{0m}	$1e^{24}$	m^{-3}
Spontaneous emission factor	β	$3e^{-4}$	-
Optical confinement factor	Γ	0.01	-
Photon lifetime	τ_p	0.78697	ps
Electron lifetime	τ_s	0.96045	ns
Threshold current	I_{th}	10.523	mA
Internal quantum efficiency	η_i	0.9	-

Above: Measurement data and intrinsic laser model simulation (1550 nm)

Left: Table showing values used in the simulation

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