Optical Access Network Extension Technologies: Semiconductor Optical Amplifier Solutions, Requirements and Development

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Project Objectives

- ❖Propose a cost effective architecture for future optical access networks
  - ❖Focus on Passive Optical Networks (PONs)
  - ❖Get more out of current deployments
- ❖Provide the extended capabilities in terms of:
  - ❖Reach, number of customers, services and capacity
- ❖Design a semiconductor optical amplifier for the proposed architecture:
  - ❖Wide band, low noise, polarization independent and high gain
  - ❖Operates over a number of wavelength bands
  - ❖Amenable to low cost manufacture in volumes

Project phases (Jan/2008 - Dec/2009)

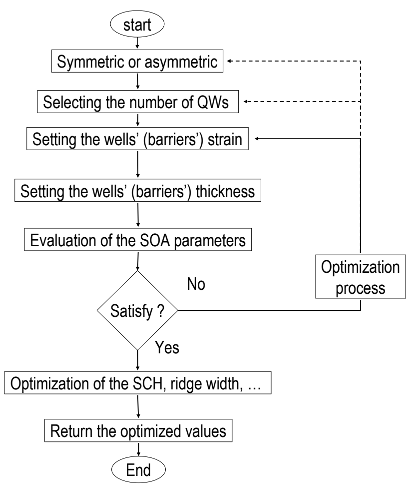
- ❖Phase 1 : Network and Physical Layer modeling
  - ❖Implement simulation models of access network extension scenarios
- ❖Phase 2 : Design a high performance SOA
  - ❖Gain > 10 dB, broadband (1260-1360 nm), NF<6, PDG< 0.5, ripple< 0.1
- ❖Phase 3 : Incorporate the functionality of the SOA into the access network models
- ❖Phase 4: Refine the models incorporating results

Device Development

SOA design flowchart

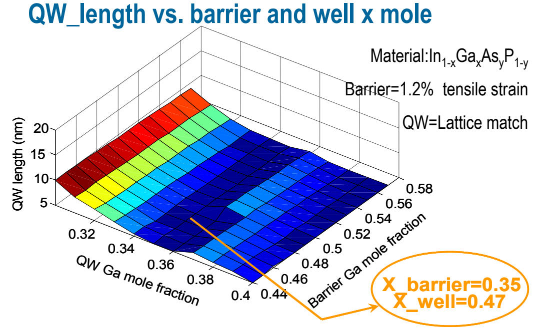
Constraints:

- -2.2% < (Barrier, well strain) < 2..2%
- 5 nm < QW_thickness < 13 nm
- Gain peak at 1310 nm

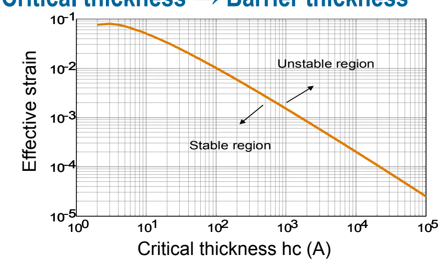


Example of design space:

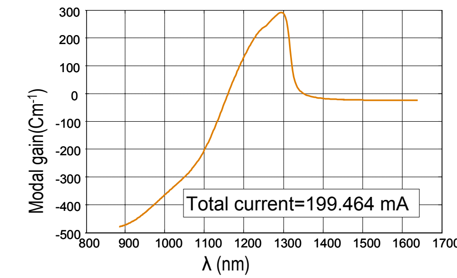
QW_length vs. barrier and well x mole

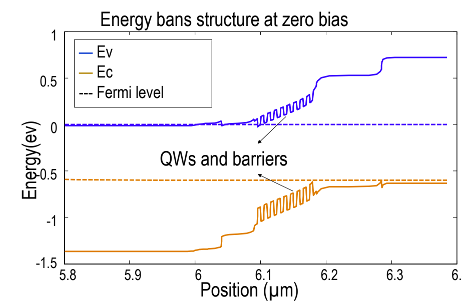


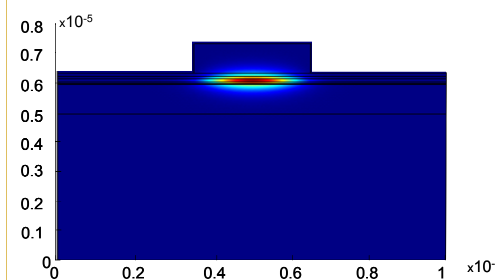
Critical thickness → Barrier thickness



Results







Fundamental mode

(Width ridge=3 μm, Dept ridge=1 μm)

Trade-off in characteristic modification

Bulk	Output saturation power	Gain	Noise figure	Polarization sensitivity	Band width
Increase the thickness of the active waveguide	↘	↗	↘	↘	
Tapering	↗	↗	↗	↗	↘
MQW					
Increasing the mode cross section (Thin QW layers)	↗	↘	↗	↗	
Increase of the number of the well	↘	↗	↘	↘	↘
Asymmetrical QWs (gain region)	↗	↘			↗

Layout of designed SOA in 1310 nm

	Material	Thickness (μm)
P-cap	p -InGaAs	0.18
Ridge	p $-In_{0.8}Ga_{0.2}As_{0.415}P_{0.58}$ (1.17Q)	0.02
Ridge	p-InP	0.93
Upper cladding	P-InP	0.1
SCH	$P-In_{0.9019}Ga_{0.098}As_{0.2154}P_{0.7846}$ (1.19Q)	0.1
Barrier (Repeat 9)	$In_{0.53}Ga_{0.47}As_{0.6424}P_{0.3576}$	0.005
Qwell (Repeat 9)	$In_{0.65}Ga_{0.35}As_{0.74}P_{0.26}$	0.005
Barrier	$In_{0.53}Ga_{0.47}As_{0.6424}P_{0.3576}$	0.005
SCH	$In_{0.9019}Ga_{0.098}As_{0.2154}P_{0.7846}$	0.05
Lower cladding	n-InP	0.04
Buffer	n-InP	1
Sub	n-InP	5

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Discussion

- A wide band SOA can be achieved by:
  - Using asymmetrical quantum wells (QWs), at the cost of design complexity
  - Adding tensile strain in the barrier
- Distribution of the current injection over the length of the ridge can lower the SOA noise figure and increase saturation power.
- Appropriate asymmetric designs can give flatter gain spectrum than a symmetric design.