Measurements of optical loss in GaAs/Al2O3 nonlinear waveguides in the infrared using femtosecond scattering technique

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INTRODUCTION

• Optical loss: Important in the assessment of semiconductor nonlinear waveguides (SiGe, DFG, and OPO’s)
• Difficulties
  • Inaccurate knowledge of effective refractive indices
  • Unknown facet reflectivities
• Techniques used: Cutback method, Prism coupling, Photo-thermal deflection, Fabry-Perot (FP) interference method. Photo-luminescence, Optimized end-fire coupling, Self-pumped phase conjugation, Multisection single-pass technique and Scattering technique
  • Advantages
    • For waveguides with losses > 1 dB/cm
  • Disadvantages
    • Not universally appealing: Complexity (eg. self-pumped phase conjugation)
    • Stringent frequency stability requirements
• FP technique: The most successful approach for evaluation of losses < 1 dB/cm.
  • Pros
    • Simple
    • Robust
    • Accurate knowledge of facet reflectivities
  • Cons
    • Not very accurate data for < 0.5 dB/cm losses
    • Non-destructive
  • Precision in the facet parallelism of the waveguide etalon

Scattering technique

• Pros
  • Uncomplicated
  • Not very accurate data for < 0.5 dB/cm losses
  • Non-destructive
• Cons
  • Continuous tunability
  • Knowledge about interaction/propagation of fs pulses within waveguide (useful for TDM and WDM)

RESULTS

• Loss coefficient: 
  • Sample on the 
  
• T = Le-αL, where I0 is the scattered intensity after a propagation length L through the waveguide, I0 is the initial intensity at the start of the path, and α is the overall loss coefficient

EXPERIMENT

• Source Characteristics
  • Ti:Sapphire Laser
  • Duration ~ 175 fs
  • Wavelength (~1.55 m
• Sample
  • (GaAs <001> substrate) / 1000 nm AlAs / 273 nm GaAs / 37 nm AlAs / 273 nm GaAs / 37 nm AlAs / 1000 nm Al2O3 / 38 nm GaAs
• Process steps:
  1. Ridge etching (optical confinement)
  2. Mesa etching (thermal oxidation)
  3. Oxidation
  4. Annealing (interface quality)

CONCLUSIONS

• Losses have been evaluated for a wide range of wavelengths in the infrared (1.35-1.58 m

• Loss coefficients of ~1.15-2.55 cm

• Overall loss: Linear loss due to absorption + Loss due to scattering from waveguide + Loss due to scattering from Alox + Loss due to two Photon Absorption (TPA) (~250 fs pulses).

• Loss higher for TM and TE+TM polarization compared to TE polarization

• No clear dependence on the mode structure: same loss for TE_p and higher order modes.
• α ~ 1.0 cm

• Loss lower at higher wavelengths (<1.6 μm)
• Intensity dependent nonlinear transmission studies enabled to identify the magnitude of TPA contribution.

• At very low input powers the major contribution is from absorption + scattering from waveguide and Alox with typical values of ~1.5 cm

• α is fixed with loss value at low input powers

• TPA coefficient β ~10-18 cm/GW

• Temporal pulse broadening (due to GVD)

• Temporal pulse width 

• 9 = 9 x 10^-11 cm^2/W at 1.55 μm

• 9 = 9 x 10^-11 cm^2/W and ~3 x 10^-10 cm^2/W at 1.45 μm and 1.55 μm respectively

REFERENCES