Gain simulation of erbium-doped Al_2O_3 waveguide amplifiers for LiDAR applications

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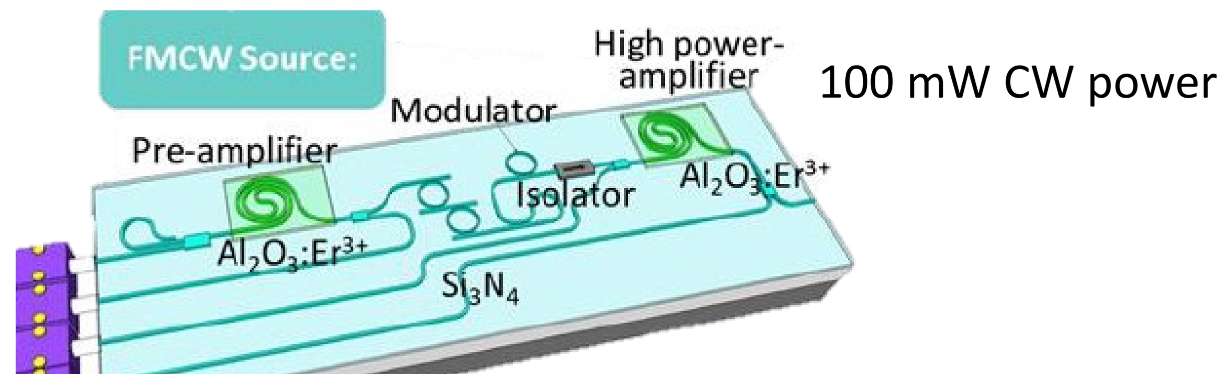
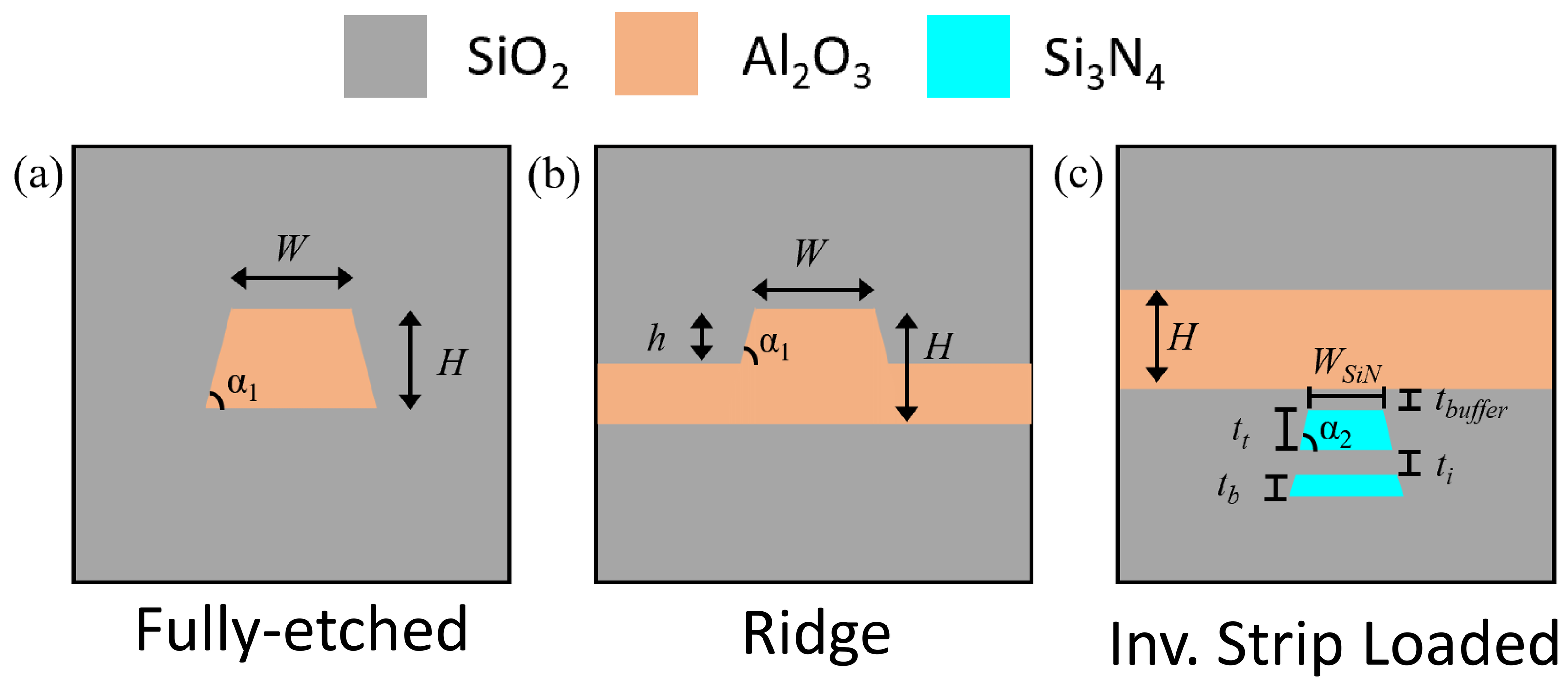
Goal

- Develop novel materials and integration technologies.
- Low cost, low size and lightweight.
- Same or higher performance than existing solutions.



Conceptual schematic of a FMCW source.
Not actual design

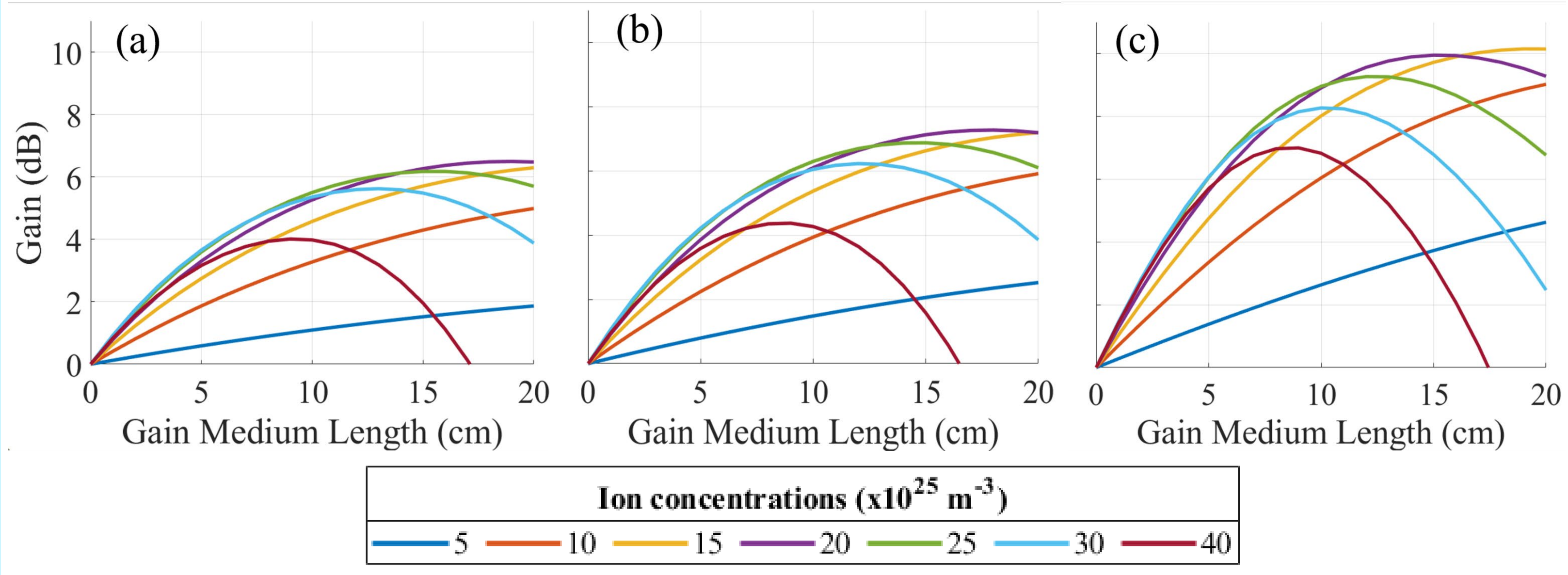
Waveguide cross-section design



Amplifier model

- Calculate optical gain of the integrated amplifiers.
- Model incorporates quenching effects of the Er^{3+} ions.
- Pumping at 980 nm.
- Forward pumping.

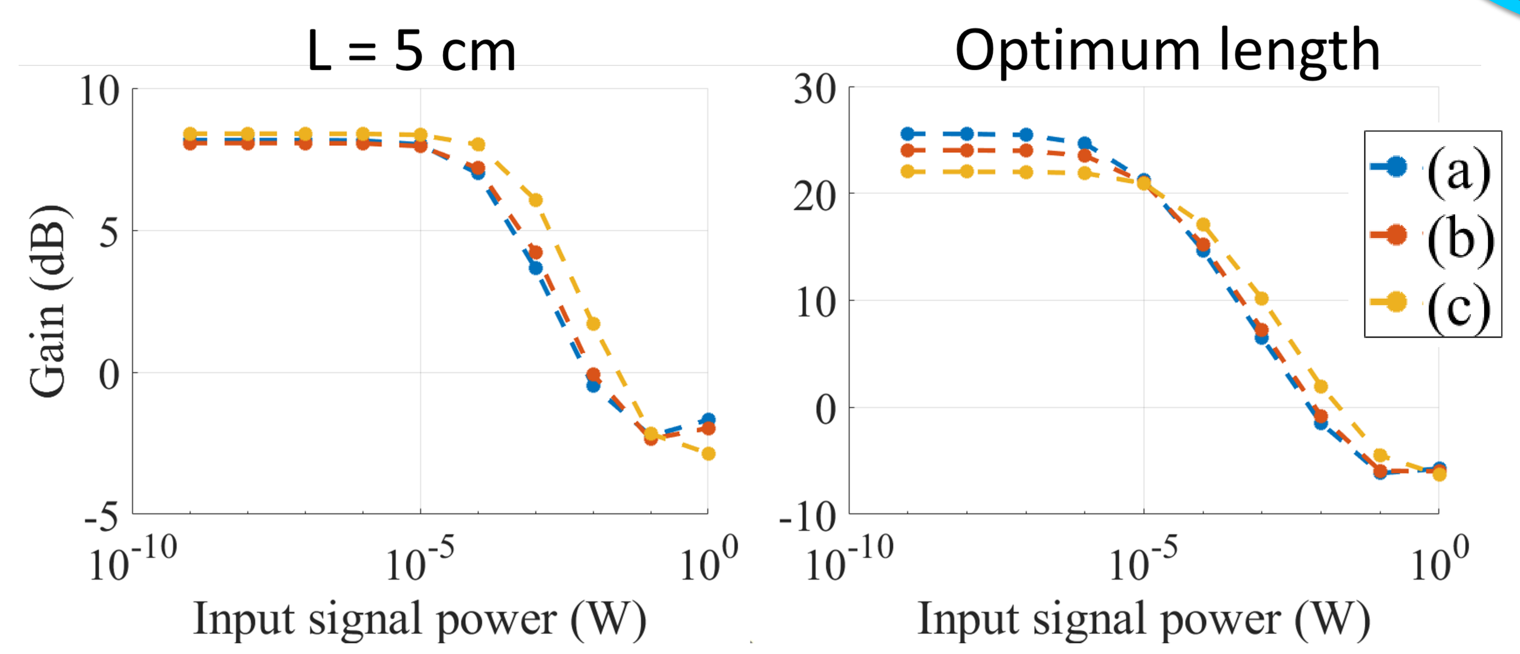
Influence of Er^{3+} ion concentration



W: 1200 nm
H: 800 nm
h: 350 nm
λ_p= 980 nm
λ_s= 1550 nm
Pump power: 300 mW
Signal power: 1 mW

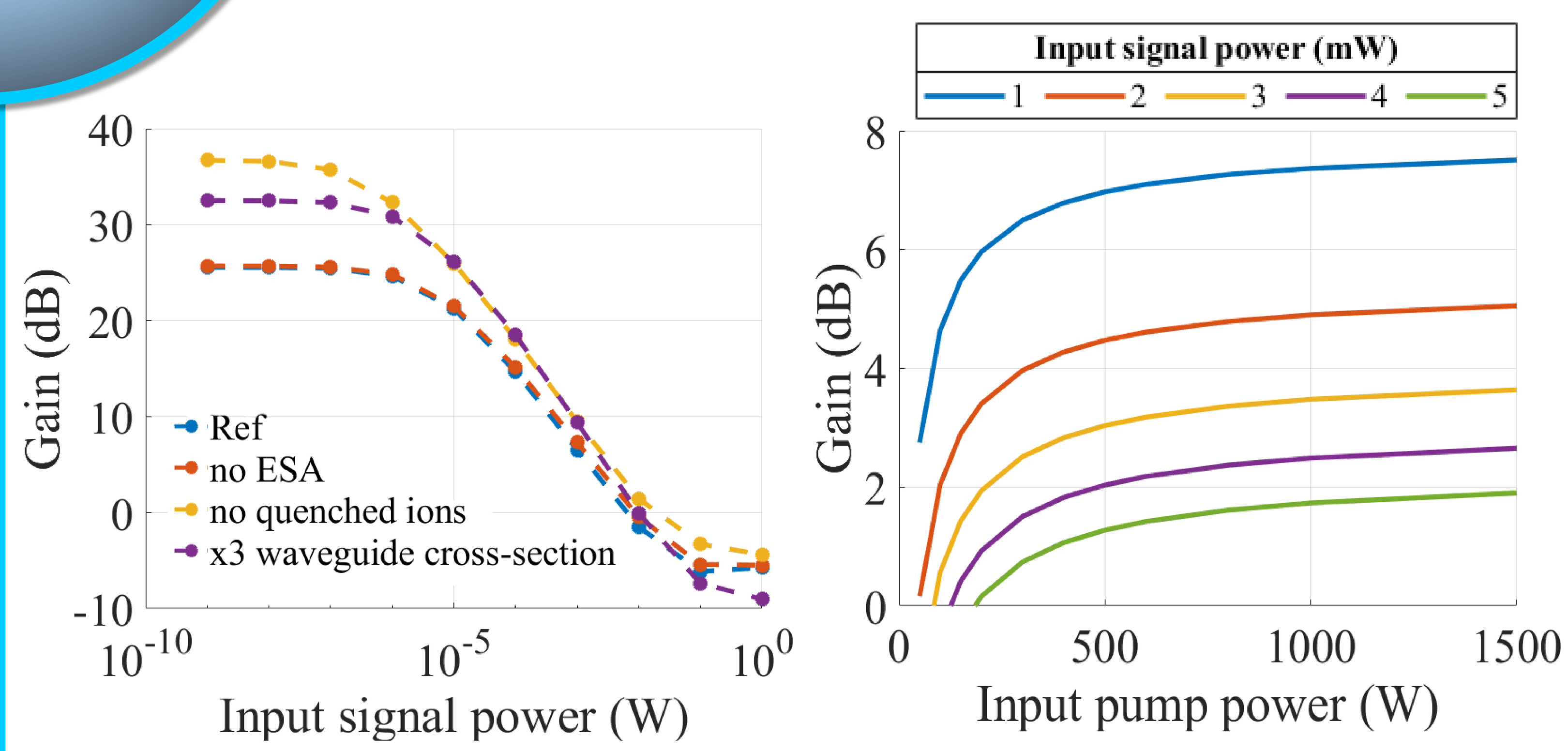
- **Strong** quenching effect for concentrations higher than 30x10^{25} m^{-3}
  - Optimum Er^{3+} ion concentration:
    - For 5 cm: 30x10^{25} m^{-3}
    - For optimum length:
      (a) (b) 20x10^{25} m^{-3}, (c) 15x10^{25} m^{-3}

Gain as a function of signal power



- Fully-etched and ridge cross-sections have comparable performance.
- For **long amplifiers**, fully-etched cross-section is more suitable.
- For **short amplifiers**, inverted strip loaded is a promising configuration since in practice it is the easier to fabricate.

Parameters affecting the gain



- Ion quenching has the most **detrimental** impact on the optical gain.
- Increasing waveguide core dimensions result in **multimode** cross-sections.
- Increasing pump power is **inefficient** because of ETU and quenching effects.

Conclusion

- Fully-etched amplifier → **4.5 mW** output power.
- Gain **limited** by ETU, ESA, and quenching effects.
- Explore alternative pumping schemes.
- Measure spectroscopic parameters for optimized material.

References

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