A Depressed-Index Cladding Filter For Suppressing 1.06 µm Emission in a Nd-Doped Silica Fiber Amplifier

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Outline

- Introduction
- Depressed-index cladding fiber filter
- Measurements
  - Filter characterization
  - Oscillator efficiency
- Results
- Conclusions

Introduction

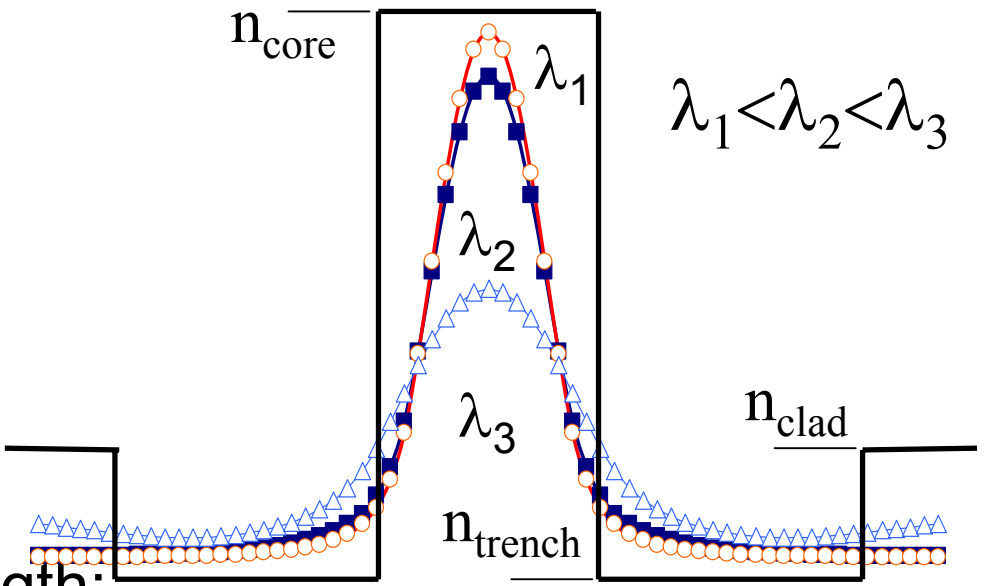
- Fiber amplifer for 900-940 nm
  - amplifier for blue light source
  - water vapour absorption band
- Nd-doped silica fiber amplifier
  - Ground state absorption < 950 nm
  - $\sigma^e_{920} < \sigma^e_{1060}$ (approx $\times 10$)
- G_{920nm}=40 dB $\Rightarrow$ G_{1060nm}=400 dB!
- Up to 400 dB(/m) loss required at 1060 nm
- Distributed all-fiber filter used*

*M.A. Arbore et al.,"Greater than 30-dB gain at 1500 nm is S-band erbium-doped silica fiber with distributed ASE suppression", Proceeding of SPIE, Optical Devices for Fiber Communication IV.

Depressed-index cladding fiber

- Low index trench
- Cutoff when:

$$\int_{core\&trench} n \cdot dA \leq n_{clad}$$



- To tune the cutoff wavelength:

A) bend the fiber B) index profile design*

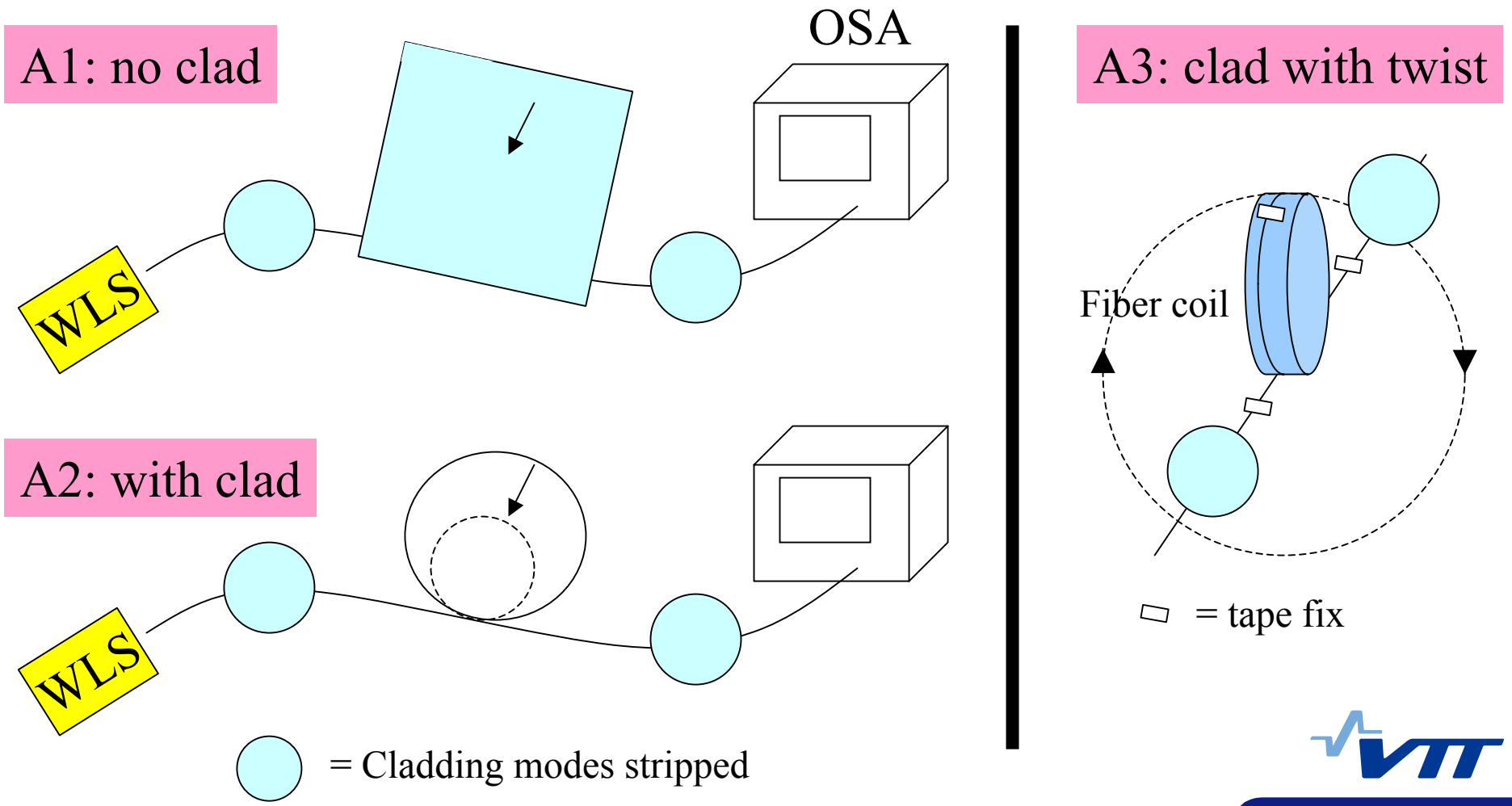
*Lightwave Electronics, US pat. 6563995

Nd-doped single-mode double clad fiber

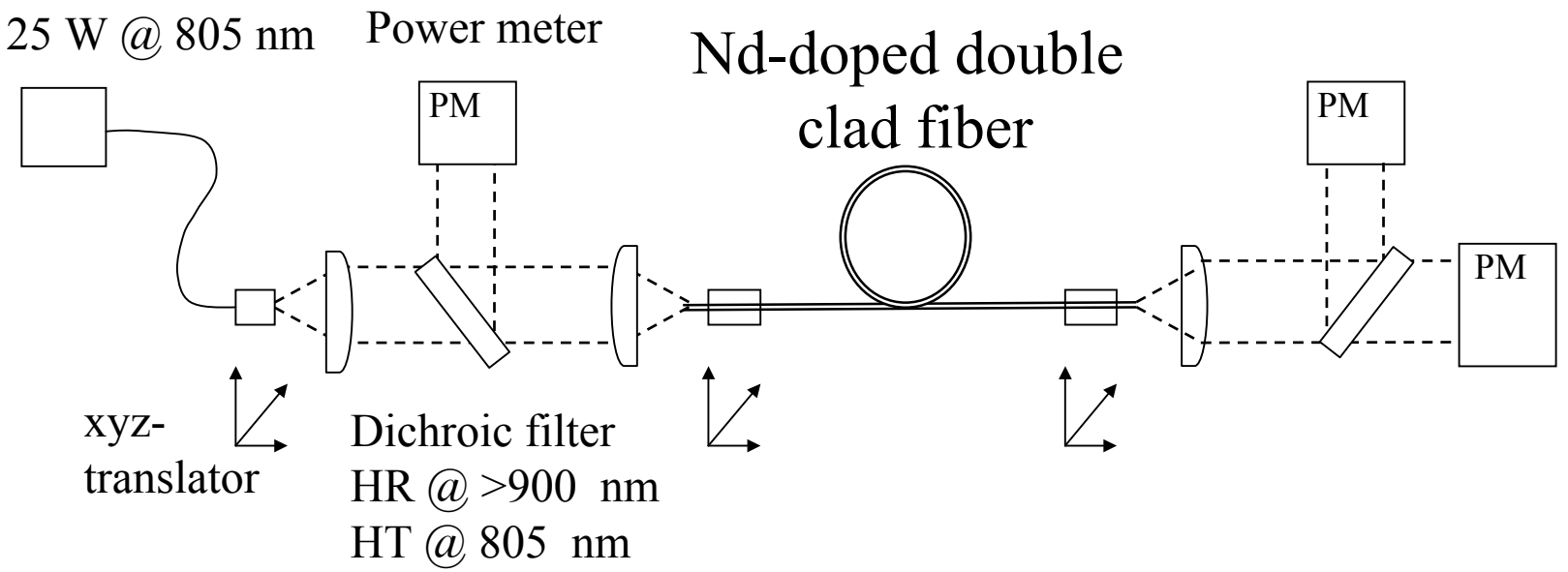
- Aluminum co-doped core, Δn_{core}: $3.28*10^{-3}$
- Fluorine-doped trench, Δn_{trench}: $-1.7*10^{-3}$
- Pump absorption: 0.5 dB/m
- Coating NA: 0.36
- Dimensions
  - Core diameter: 4.6 µm
  - Trench: 14 µm
  - Cladding: ~125 µm
- Note! Slight D-shape in the second cladding

Measurement A

- Bend and transition loss in a single fiber-loop



Measurement B

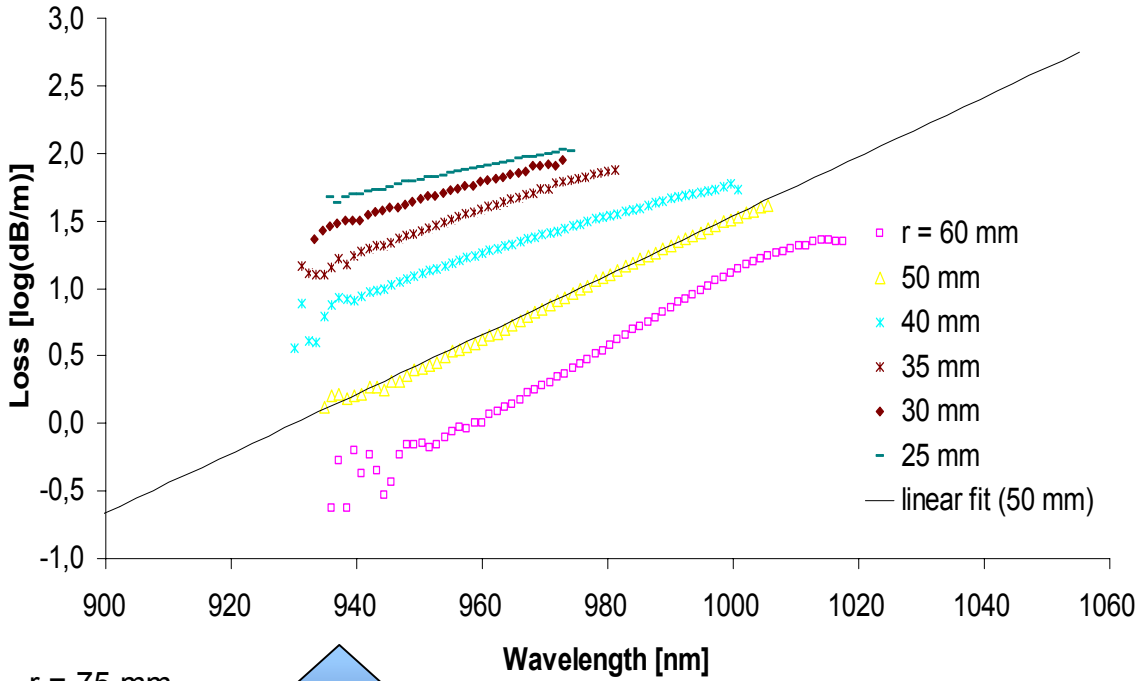


- Feedback: 4 % Fresnel reflection
- Slope efficiency & spectrum measured

Results

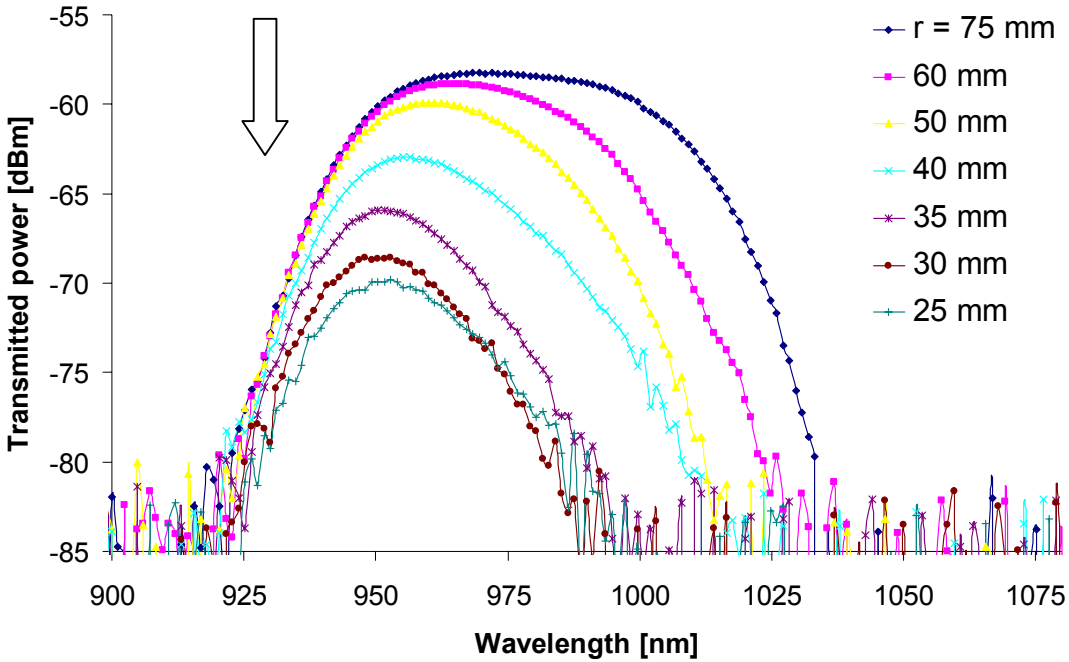
A1: no clad

- Transmission measured
- Coil radius: 25 - 75 mm
- Good initial cutoff



log(dB/m) scale

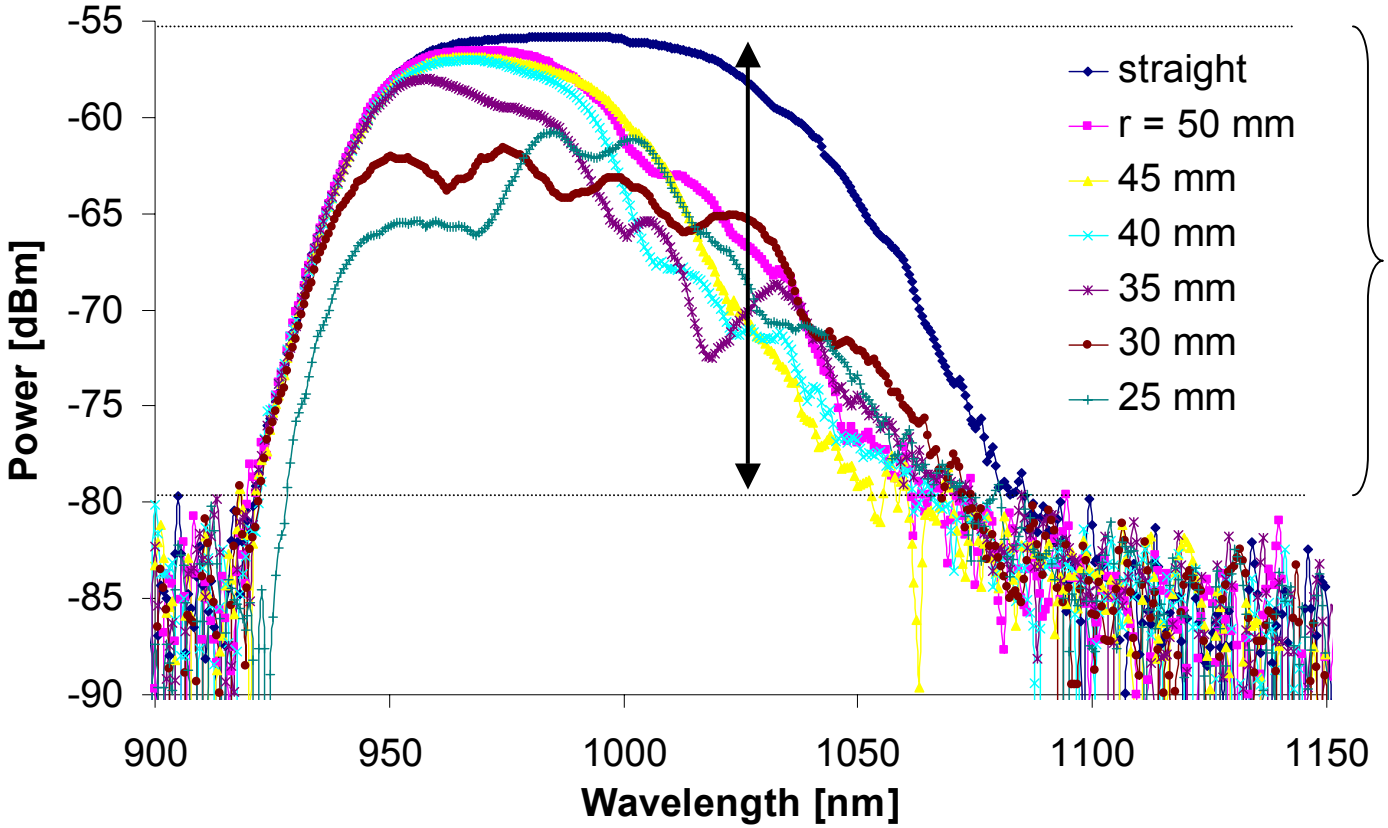
Nd-absorption



925 nm 1060 nm

- R60: 0.15 dB/m & 350 dB/m
- R50: 0.86 dB/m & 400 dB/m

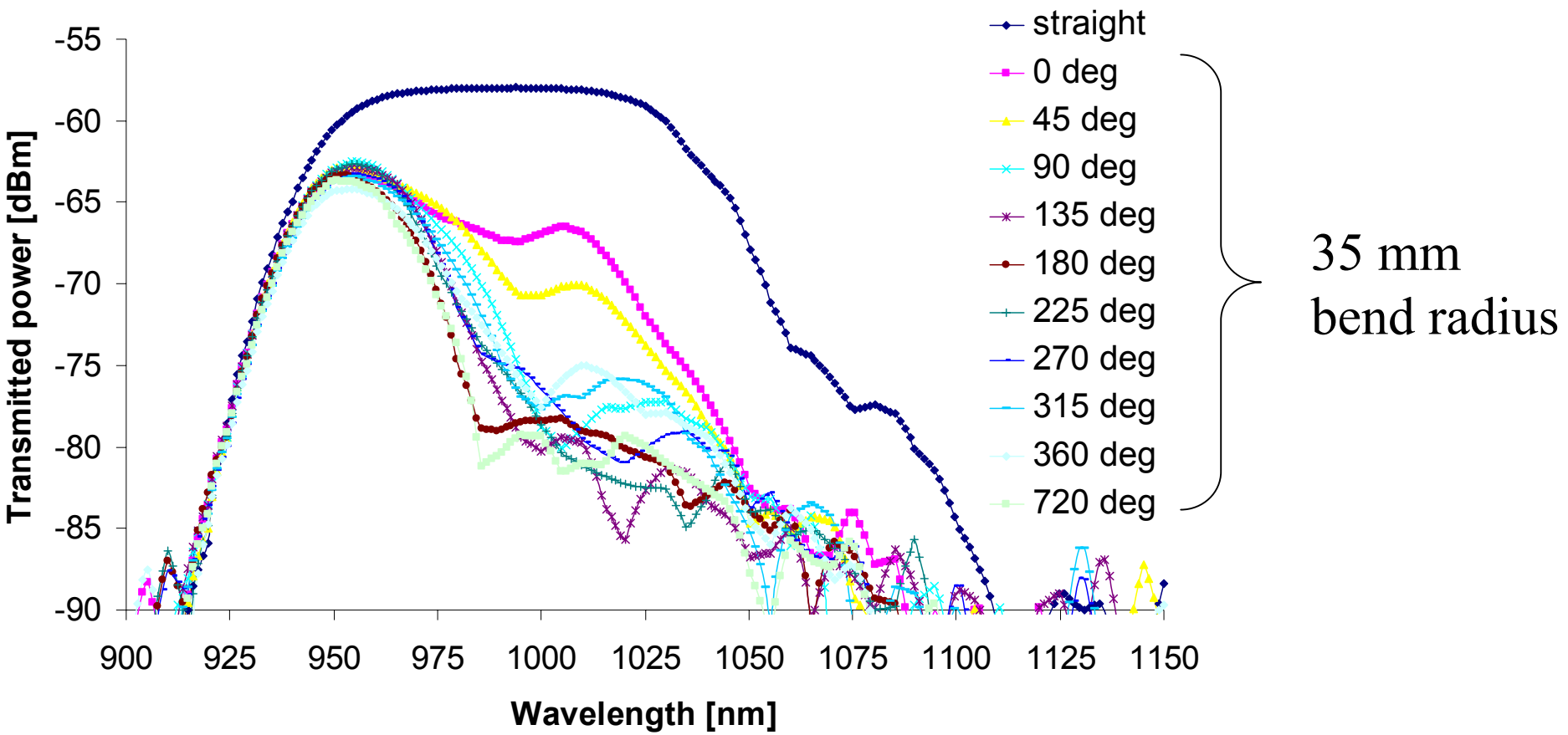
Results A2: with clad



25 dB expected
($\propto A_{core}/A_{clad}$)

- Coupling to & from lower-order modes
- Transition & bend loss induced effect

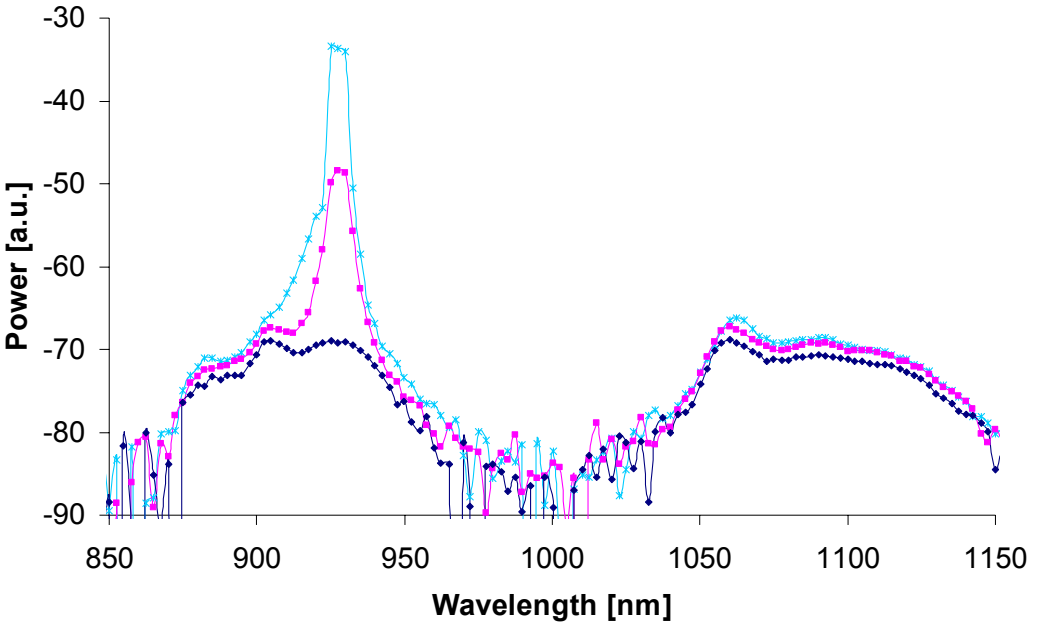
Results A3: clad with twist

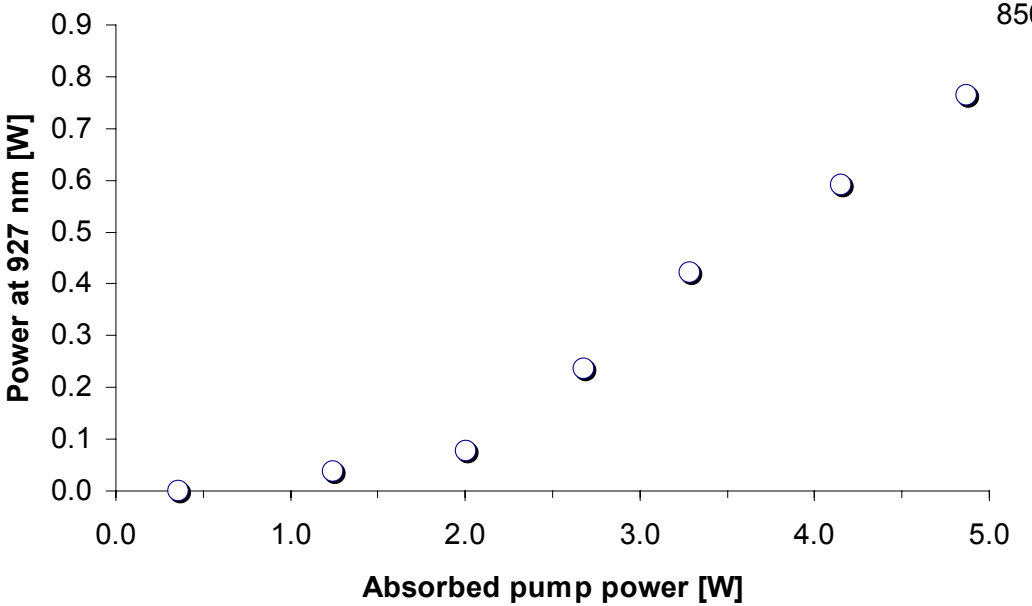


- Twisting helps → increases mode-mixing
- Should not be a problem with amplifying fiber

Oscillator efficiency

- Coil radius: 50 mm
- Pump absorption: 3 dB
- Slope efficiency: 19 %
- Threshold: ~1.6 W
- Lasing at 927 nm!





- High coating loss 0.2 dB/m
- Elevated core loss

Conclusions

- All-fiber filter for 900-940 nm fiber amplifier
  - High loss (400 dB/m) at 1060 nm achieved
  - reducing 925 nm loss $\Rightarrow$ less tight coil, filter desing
- Coupling to/from low-order modes
  - Twisting the fiber helps
  - gradual ΔR?
- Nd-fiber amplifier performance
  - Optimization: losses, cutoff, non-linearities
  - Lases at 927 nm $\Rightarrow$ filter works ok

Acknowledgements

Thanks to Lightwave Electronics