Inverse Design of Grating Couplers

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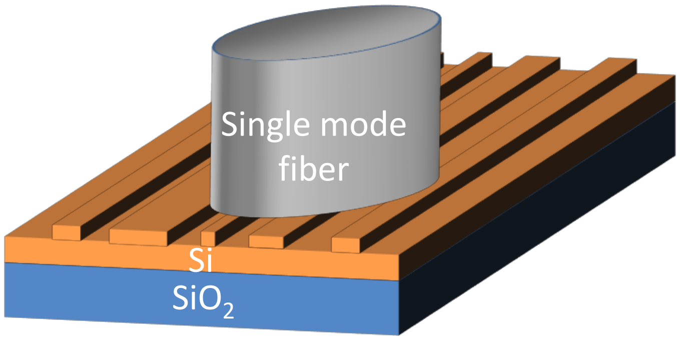
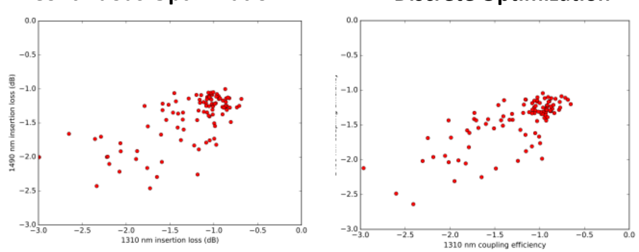
Optimization Procedure



We design a 1D grating coupler using 2D-FDFD and calculating gradients using the *adjoint method*. The optimization procedure is broken up into two stages:

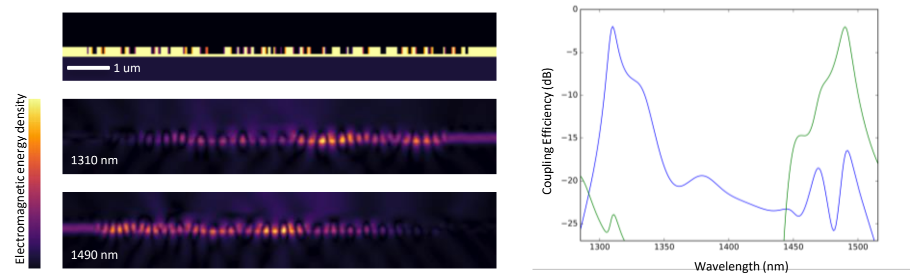
1. Continuous permittivity stage (with L-BFGS): The permittivity of the grating is allowed to vary continuously between that of silicon and air.
2. Discrete permittivity stage (with SLSQP): The permittivity of the grating is restricted either that of silicon or that of air. The distance between grating teeth is constrained to be at least 50 nm.

Continuous Optimization **Discrete Optimization**

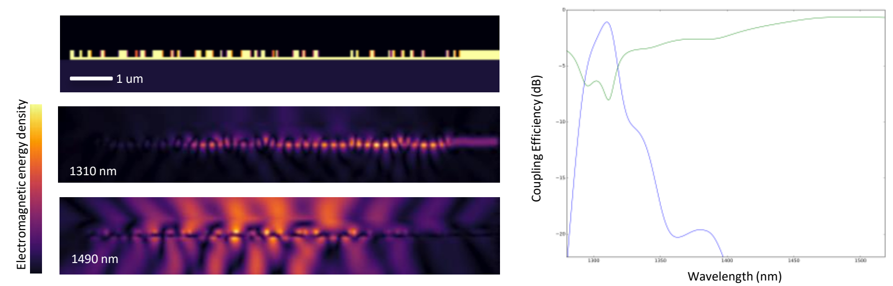


Performance of 100 4-um wavelength demultiplexing grating couplers at 1310 nm and 1490 nm designed using random initial conditions. **Left**: The distribution of devices optimizing after the continuous stage. **Right**: The distribution of devices optimizing after the discrete stage.

Designs



A 12 um wavelength demultiplexing grating coupler with an insertion loss of around **2 dB.** Light at 1490 nm is routed to the left and light at 1310 nm is routed to the right. The incident beam is a 9.2 um Gaussian beam at normal incidence.



A 12 um grating coupler couples 1310 nm light into the waveguide but lets light at 1490 nm pass through. Insertion loss is around **0.9 dB** at 1310 nm and **0.6 dB** at 1490 nm. The incident beam is a 9.2 um Gaussian beam at normal incidence.

Design with continuous permittivity achieving around **0.3 dB** loss at 1550 nm. This suggests that having angled etches could enable ultra-high efficiency grating couplers. The incident beam is a 10.4 um Gaussian beam at normal incidence.

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