Supplementary Materials

A Multi-Objective Genetic Algorithm Approach for Silicon Photonics Design

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Algorithm S1. Genetic Algorithm (GA) routine.

```
INPUTS: N // Number of generations
        C // Number of chromosomes in a generation
        CROSSOVER, MUTATION, SELECTION // percentages of cross mutation
    i = 0
    G(0) = A random generation of random chromosomes
    WHILE (i<N OR termination criterion not achieved) DO
        Evaluate solutions in the population using the fitness function
        Select best solutions in G(i) using the select method
        Create a new population G(i+1) using crossover and mutation
            i = i + 1
    END WHILE
RETURN the best solution in the generation G(i)
```

Note S1: The main components of a GA:

A) Population, chromosome, and genes: A chromosome, known as a solution or individual, is a string of genes (bits). The population, or generation, is a set of chromosomes; Mainly, the population is updated by evolving during all GA execution till achieving some stop condition(s). The number of chromosomes of a population is a parameter to be tuned. Through trials, researchers try to find the ideal (minimum) number of chromosomes and iterations which lead to solution for the problem under consideration.

B) Fitness function: A fitness (objective) function is responsible for evaluating the solution, it measures how ‘well’ a solution is. In fact, the GA is based on discovering and exploring the "fitness landscape" in multiple directions. A fitness landscape, or "response surface" [1], depicts the shape of the fitness function and makes the problem more challenging when it is not convex.

C) Genetic operators: selection, mutation and crossover: As mentioned in line 8 of

D) Algorithm, a solution or more should be selected to contribute to the creation of the next generation. In order to avoid local optimum problem, the selection operator does not have to 'always' select the best solutions of the generation to survive, instead, it should choose individual(s) according to a proportional probability to the fitness function or other criteria. One of the most known operators are Roulette wheel and Tournament selection. Regarding the mutation operator, it changes in one (or more bits) in a solution. Every bit of the individual will have a probability (mutation percentage ~ 5%) to be flipped. However, the crossover (or mating) operates on two chromosomes (P_1, P_2); it produces two new chromosomes (C_1, C_2), using one-point, multipoint or uniform techniques as depicted in Fig. 1. For example, the multi-point crossover operator produces two children (offspring) by taking different portions of the parents. The portions of the parents are identified according to random or fixed crossing sites. In the implementation, researchers can choose one or more types of crossover. The percentage of applying each operator is also to be tuned.

Parent P_1	0 0 1 1 0 0 0
Parent P_2	1 1 0 1 1 0 1
Child C_1	0 0 1 1 1 0 1
Child C_2	1 1 0 1 0 0 0

1-point crossover

Parent P_1	0 0 1 1 0 0 0
Parent P_2	1 1 0 1 1 0 1
Child C_1	0 0 0 1 1 0 0
Child C_2	1 1 0 1 1 0 1

multi-point crossover

Parent P_1	0 0 1 1 0 0 0
Parent P_2	1 1 0 1 1 0 1
Child C_1	0 1 1 1 0 0 0
Child C_2	1 0 0 1 1 0 1

uniform crossover

Before mutation	0 0 1 1 0 0 0
After mutation	0 1 1 1 0 0 0

mutation

Figure S1 Cross-over and mutation genetic operators.

Note S2: Calculation of coupling coefficients and the transmission characteristics.

The field coupling coefficient, k, between two neighboring elements can be found using [22]:

$$k = \sin \kappa L \qquad \rightarrow \text{(S1)}$$

Where κ is the coupling coefficient per unit length and L is the length of field interaction.

The free spectral range for a ring resonator, FSR, is calculated using [31]:

$$FSR = \frac{\lambda_o^2}{2\pi R n_g} \qquad \rightarrow \text{(S2)}$$

Where λ_o is the free space wavelength, R is the ring radius and n_g is the group refractive index.

The bandwidth for the transmission of a ring resonator, BW, is found using [31]:

$$BW = \frac{(1-ra)\lambda_o^2}{2\pi^2 R n_e \sqrt{ra}} \qquad \rightarrow \text{(S3)}$$

Where $r = \sqrt{1-k^2}$, $a = e^{-\alpha\pi R}$, α is the power loss coefficient and n_e is the effective propagation constant of the mode.

The dispersion of the signal, D, can be calculated using:

$$D = -\frac{\lambda_o}{c} \cdot \frac{d^2 n_e}{d\lambda_o^2} \qquad \rightarrow \text{(S4)}$$

Where c and λ_o is the speed of light and the wavelength in free space.