Supplementary materials for

Efficient structure transformation based on sensitivity-oriented structure adjustment for inverse-designed devices

1. Details about the distance regularization term

The level set regularization term R_p introduced in ACM-DRLSE [1] is define as:

$$R_p(\phi) = \int_\Omega p(|\nabla\phi|)dx \tag{S1}$$

where $p(\cdot)$ is a double-well potential function defined as:

$$p(s) = \begin{cases} \frac{1}{(2\pi)^2}(1-\cos(2\pi s)), & s \le 1 \\ \frac{1}{2}(s-1)^2, & s \ge 1. \end{cases} \tag{S2}$$

The derivative of R_p is calculated as:

$$\frac{\partial R_p}{\partial \phi} = -div\left(d_p(|\nabla\phi|)\nabla\phi\right) \tag{S3}$$

where d_p is defined as:

$$d_p(s) \triangleq \frac{p'(s)}{s} \tag{S4}$$

2. Comparison between the process of ST-SOSA and original ST [2]

The complete optimization process of ST-SOSA and original ST applied in the design of the T-junction and 90º crossing are shown in Figure S1 and Figure S2, respectively. The blue curves in Figure S1(b) and Figure S2(b) represent the objective function value during the original ST, while the orange curves represent that during ST-SOSA. The structure of the 90º crossing and corresponding electric field intensity (normalized) obtained in each OPO during ST-SOSA and original ST are shown in Figure S1 (a) and (c), respectively. The structure of the T-junction and corresponding electric field intensity (normalized) obtained in each OPO during ST-SOSA and original ST are shown in Figure S2 (a) and (c), respectively. It can be observed that ST-SOSA simplifies the complex structures of the inverse designed devices in much less optimization rounds than original ST. Additionally, the devices obtained using ST-SOSA achieve lower objective function values, corresponding to better optical performance, in the end of the optimization.

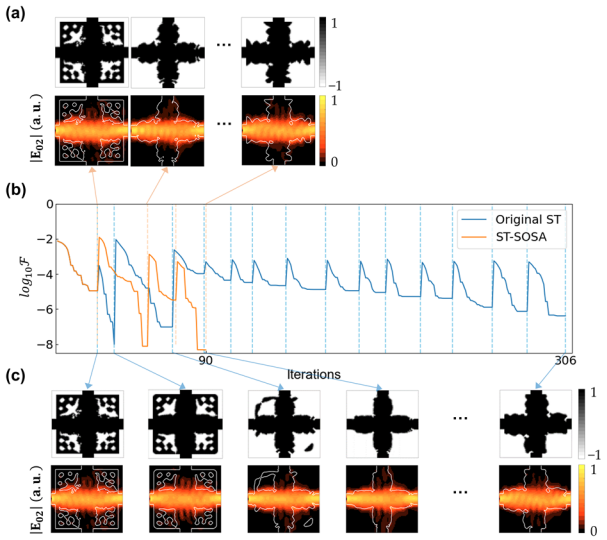

Figure S1. The complete optimization process for the 90º crossings using ST-SOSA and the original ST [2]. Top view of the structure of the 90º crossing and corresponding electric field intensity (normalized) obtained in each OPO during ST-SOSA and original ST are shown in (a) and (c), respectively. (b) $\mathcal{F}$ (in a logarithmic scale) in OPOs during ST-SOSA (indicated as orange solid line) and original ST (indicated as blue solid line).

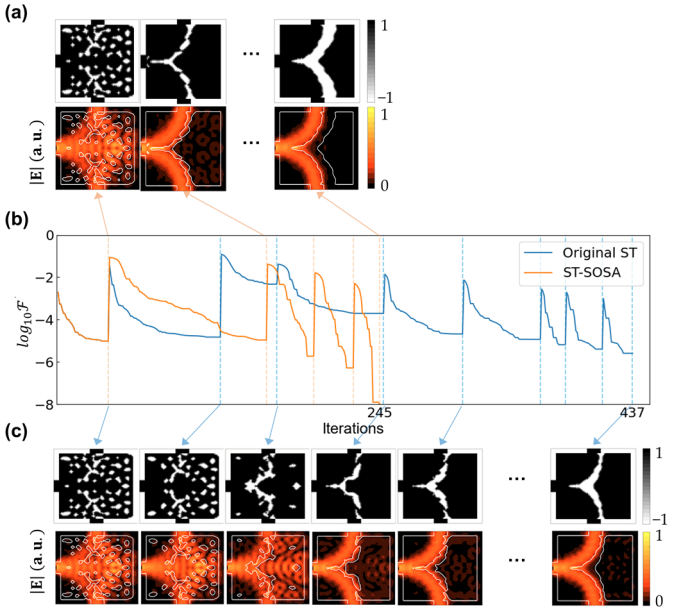

Figure S2. The complete optimization process for the T-junctions using ST-SOSA and the original ST [2]. Top view of the structure of the T-junction and corresponding electric field intensity (normalized) obtained in each OPO during ST-SOSA and original ST are shown in (a) and (c), respectively. (b) $\mathcal{F}$ (in a logarithmic scale) in OPOs during ST-SOSA (indicated as orange solid line) and original ST (indicated as blue solid line).

References

1. Li, C.; Xu, C.; Gui, C.; Fox, M.D. Distance Regularized Level Set Evolution and Its Application to Image Segmentation. *IEEE Transactions on Image Processing* **2010**, *19*, 3243-3254, doi:10.1109/TIP.2010.2069690.
2. Chen, Y.; Qiu, J.; Dong, Z.; Wang, L.; Liu, Y.; Guo, H.; Wu, J. Inverse Design of Free-Form Devices With Fabrication-Friendly Topologies Based on Structure Transformation. *J. Lightwave Technol.* **2023**, *41*, 4762-4776, doi:10.1109/JLT.2023.3242472.