# Fast Aerial Image Simulations Using One Basis Mask for Optical Proximity Correction

Xiaofei Wu, Wei Liu
*Wuhan National Laboratory for Optoelectronics, Huazhong University of Science and Technology, Wuhan 430074, China.*

Shiyuan Liu, Chuanwei Zhang
*State Key Laboratory of Digital Manufacturing Equipment and Technology, Huazhong University of Science and Technology, Wuhan 430074, China.*
*shyliu@mail.hust.edu.cn*

With ever-decreasing feature size and pushing the limit of optical lithography, OPC (optical proximity correction) has become a must have process to improve the performance of lithography. Generally, the process of OPC contains the forward modeling and the inverse process which aims to optimize the mask layout. Since the forward modeling process are usually required to be repeated a number of times in the inverse optimization, fast aerial image simulation algorithm are highly desirable for practical OPC systems.

In recent years, the lookup table method in which the preimages defined as the convolution of basis masks with kernels are pre-calculated is a popular approach for the forward modeling of OPC systems. The pioneer work was presented by Cobb considering right-upper masks as basis masks[1]. Pati adapted masks with different width that are well-suited to describe integrated circuit patterns as basis masks for fast aerial image simulation[2]. Although these algorithms work relatively well for the forward modeling, a number of basis masks are needed to generate the lookup table, which would be a huge storage requirement especially for dense and large area of aerial image simulation.

This paper proposes a lithographical simulation algorithm using only one basis mask to generate the lookup table. Fig. 1 illustrated a rectangle mask can be constructed through several infinite basis masks. By exploiting the space shift invariant characteristic of 2D convolution, the preimages of these masks can be obtained by shifting the preimage of the one basis mask. Hence the storage requirement of the lookup table can be largely reduced. The aerial image simulation result shown in Fig. 2 based on this algorithm demonstrated a very good fidelity compared with the commercial software PROLITH. We also present an inverse optimization algorithm based on the edge movement, and find that only the changed parts of the mask are needed to be calculated in the iteration. The proposed algorithm could be very favorable especially for dense and large area of aerial image simulation, and have a promising application lithography simulation based OPC systems.

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[1] N. Cobb and A. Zakhor, *Proc. SPIE* ***2440***, 313 (1995).

[2] Y. C. Pati, A. A. Ghazanfarian, and R. F. Pease, IEEE Trans. Semicond. Manuf. **10**, 1 (1997).

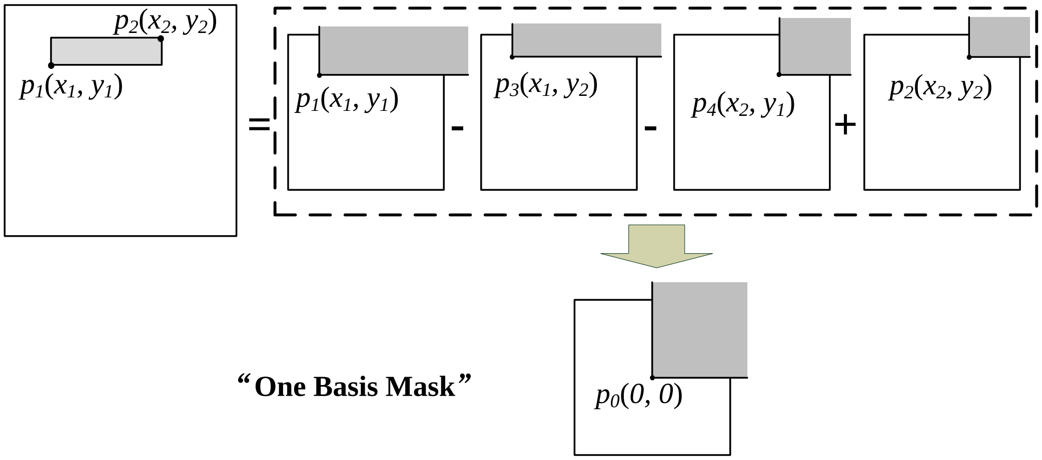

*Figure 1:The Manhattan shape mask can be constructed through several infinite right-upper masks, and the preimages of these mask can be obtained by shifting the preimage of the one basis mask, defined at (0, 0) directly.*

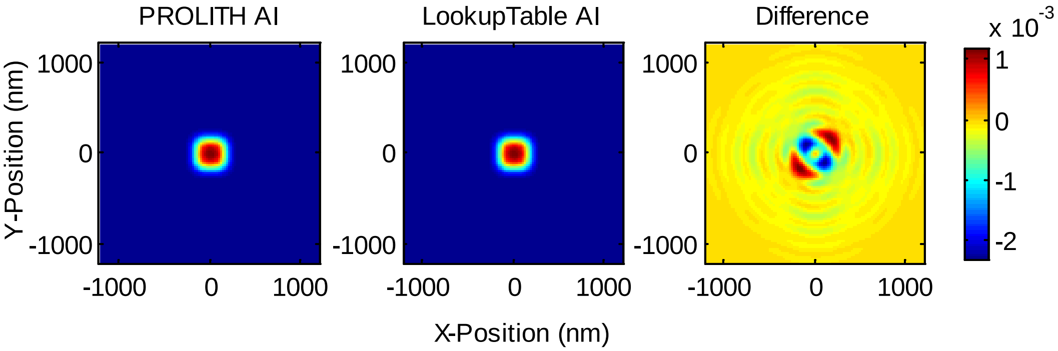

*Figure 2: Aerial Image simulation for a contact, CD=400nm.NA = 0.60, $\lambda$=193nm, conventional illumination source with $\sigma$=0.6. The results demonstrated the aerial image obtained by our algorithm have a very good fidelity compared with PROLITH.*

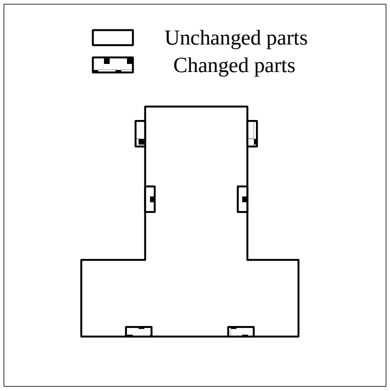

*Figure 3: Only the changed parts need to be calculated in the iteration of inverse optimization, which can reduce the time cost in practical Optical proximity correction systems.*