Generating Scanning Electron Microscopic Images from Optical Designs using image to image translation with Conditional GANs.

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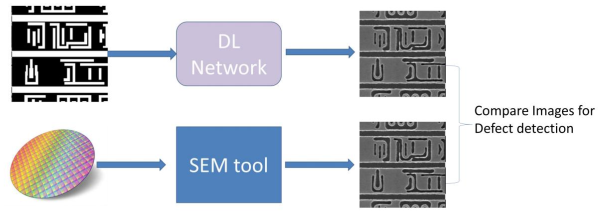
Motivation

Detection and classification of defects during semiconductor manufacturing is critical in enhancing the production yield of electronic chips. Scanning Electron Microscope (SEM) tools are used to identify these defects by scanning the silicon wafers in each manufacturing step. In this work, a new methodology is implemented to enhance the defect detection by artificially generating SEM images from optical designs of the electronic chip using conditional GANs[1]. These images serve as reference images to the original images obtained from SEM tools to identify the defects



Data Set

Data Preparation: In order to train GAN networks, the data was prepared by obtaining optical designs, rendering them to binary images and grabbing its corresponding SEM images from the Semiconductor wafers. The optical design images were aligned to SEM images by using image correlation. The SEM images were downscaled to image size of 256x256, while the design images were upscaled to the same size. These aligned image pairs form the data set for the GAN network. Fig 1a shows an example of these aligned image pair.

Data set: 500 aligned pair images

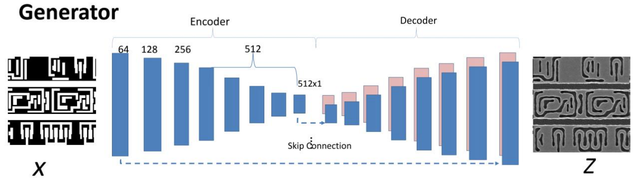
Training 400 , Validation 100

Data Augmentation :

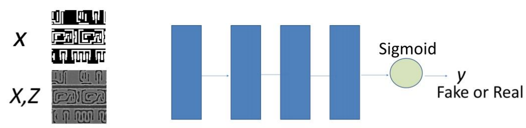
Image flipping, Random cropping

Network Architecture

Generator



Discriminator



Conditional GAN network described in [1] was adopted as Network architecture.

Generator Network: Unet Architecture [2], 8 Conv layer encoder, 8 conv layer decoder with skip connection from encoder

Discriminator Network: Consists of four Conv layers followed by sigmoid.

Gan Loss:

$$L_{cGAN}(G,D) = \mathbb{E}_{x,y}[\log(D(x,y))] + \mathbb{E}_{x,z}[\log(1-D(x,G(x,z))]$$

$$L_{L1}(G) = \mathbb{E}_{x,y,z}[\|y - G(x,z)\|_1]$$

Objective:

$$G^* = \arg max_G min_D \; L_{cGAN}(G,D) + \lambda \, L_{L1}(G)$$

Results

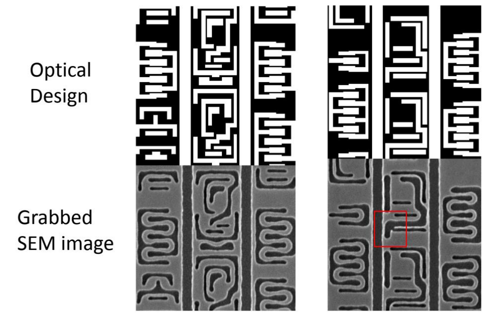


Fig 1. a b

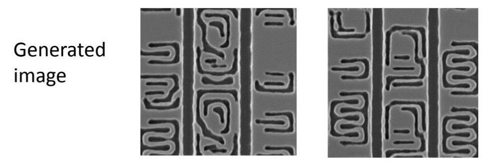


Fig 2. a b

Conclusion

Image to image translation via conditional GANs is effective in learning mapping from optical design to real world SEM images

Finds potential application in simulating chip designs and detecting defects in chip manufacturing

Future Work

Fix undesirable aberrations caused in the Generated Image

Acknowledgment

KLA-Tencor

References

1. Isola, Phillip, et al. "Image-to-image translation with conditional adversarial networks." *arXiv preprint* (2017).
2. Ronneberger, Olaf, Philipp Fischer, and Thomas Brox. "U-net: Convolutional networks for biomedical image segmentation." *International Conference on Medical image computing and computer-assisted intervention*. Springer, Cham, 2015.

Video @ https://youtu.be/uasaufGysvQ