Generative AI for Tin Target Images

UCSB Senior Year Capstone Project with ASML

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Project description: Design and train a generative AI which generates tin target images from signals measured on the Extreme Ultra-Violet (EUV) light source. As part of the design process, survey and compare well-known methods from different fields in Artificial Intelligence (AI) research, for example the variational autoencoder or image diffusion methods, as well as determine the best set of inputs and model structure. Extract meaningful metrics from generated tin target images and classify which metrics increase or decrease the efficiency of EUV plasma generation.

Background: ASML is the only company in the world that produces EUV machines. These machines etch very fine patterns onto silicon wafers, which is vitally important for the semiconductor industry to create smaller and more powerful computer chips. ASML's EUV machines are essential to producing high-end computer chips that are used by essentially every company involved in AI.

ASML San Diego, CA develops and supplies the critical EUV light source component. The light source uses LPP (Laser Produced Plasma) technology which takes place inside a large vacuum chamber by first shaping a ~30 micrometer tin (Sn) droplet with a laser pre-pulse and then converting the resulting tin disk (pancake) using a more powerful (tens of kW) main laser pulse to produce plasma and EUV light. This operation occurs at a rate of 50-60 kHz. Video 1 shows a behind-the-scenes tour of ASML San Diego, explaining the works and components of the EUV light sources. For this project, the highlight is 3:08 "Just blast tin with lasers" which shows the first pre-pulse hit of tin droplet to create tin disk and the second main pulse blast of tin disk to create EUV plasma.

The location and shape of tin targets influence the efficiency of EUV plasma generation. Both the tin droplet and disk targets are captured by using high-speed cameras from which some metrics are extracted of the images, like the target positions and angles. During operation, the tin target images are not typically stored due to storage limitations. Generating tin target images from signal measurement could give more insights to more efficient and stable EUV plasma production.

Problem Statement: For this project, a training data set will be provided containing ~6000 tin target images and relevant measurement signals. These will include for example the laser actuator signals, and measurement signals like the extracted target angle metrics from the tin target images, and the EUV power obtained. The project should aim to achieve the following:

- Preprocess training data.
    - Filter to removes some unwanted noise components or outliers from signals
    - Select region-of-interest of training images to specify area or volume of interest

    - Input (feature) selection to choose best features for your model from the large quantity of measurement signals
    - Format data set to improve weight of certain metrics or characteristics
- Explore and compare a variety of methods and tools for AI image generation, for example
    - Diffusion Method
    - Variational Autoencoder (Figure 2)
- Train generative AI models using selected methods and determine their performance.
    - Evaluate and compare metrics of generated and validation image set
    - Train models that includes and excludes signal inputs based on tin target image metrics to determine if image generation is observable without metric image data
- Make a recommendation for the preferred architecture and to fine-tune its performance.
    - Define architecture and layers of model for the selected methods
    - Report used optimization algorithm and settings
    - Improvements to training data set as the quantify of images with certain features
- If time permits, use the trained AI model to research new tin target metrics that can benefit the EUV plasma generation.
    - Classify images for which tin target shapes produce best and worse EUV power
    - Investigate meaningful metric options to discriminate, for example target disk volume, curvature, or density.

Further information:

https://en.wikipedia.org/wiki/Extreme_ultraviolet_lithography
https://www.asml.com/en/technology#lithography
Laser and tin in the light source - ASML - YouTube
The full EUV optical light path - ASML - YouTube
The reticle and reticle stage - ASML - YouTube
How An EUV Light Source Works - YouTube

Video 1: You Didn't Build your PC... This Did. - ASML Cymer Tour

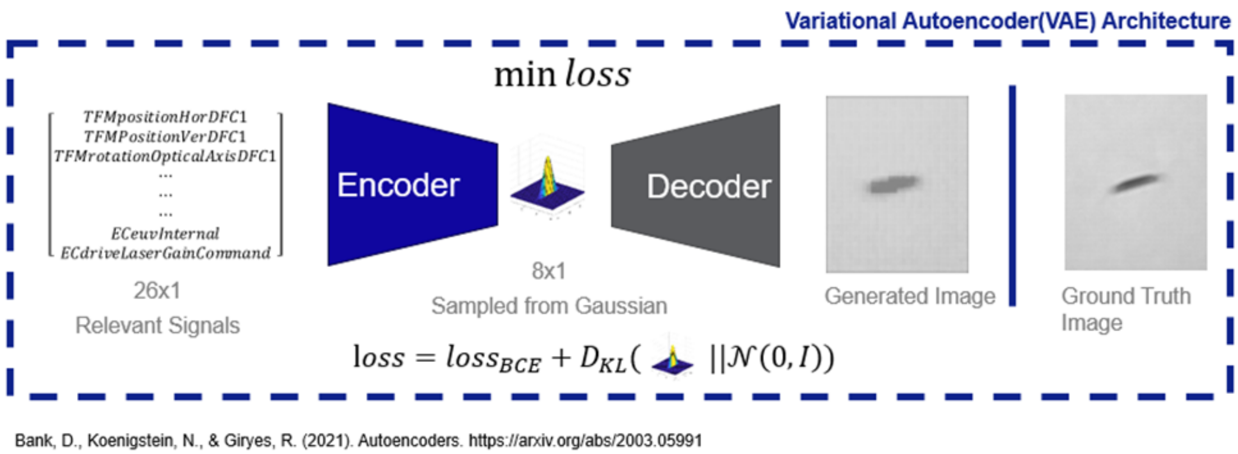

Figure 2: Variational Autoencoder