Inline Maximization of EUV Power

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What is EUV Lithography?

EUV (Extreme UltraViolet) Photolithography (Fig 1) is the process of etching transistor patterns onto a semiconductor wafer to make computer chips (Fig 2). EUV Photolithography uses very high energy light in the Extreme UltraViolet spectrum to create these small patterns. The higher the energy, the smaller you can etch, leading to more computational power on one chip.

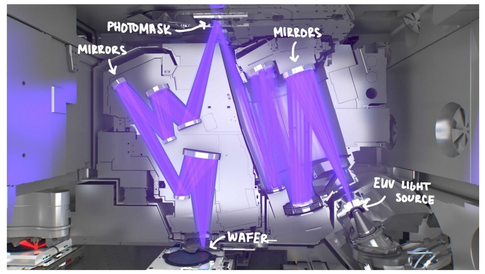


Fig. 1: EUV Lithography Diagram

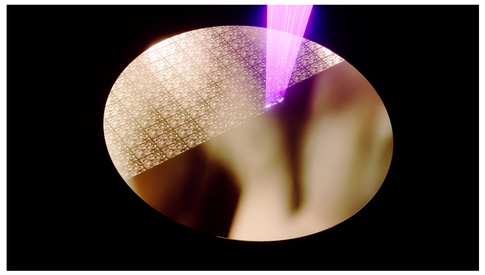
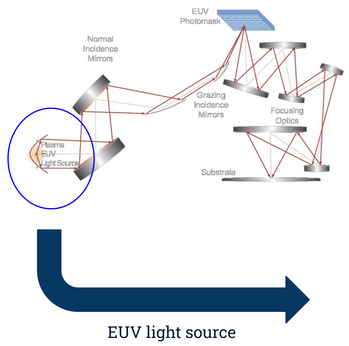


Fig. 2: EUV Lithography Semiconductor Chip

Problem Statement: Constraints



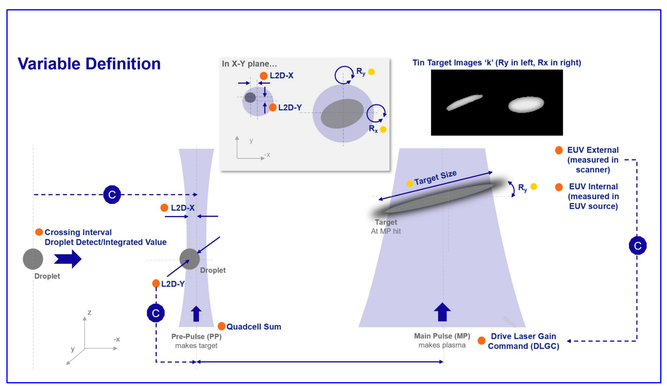


Fig. 3: EUV Light Source Diagram

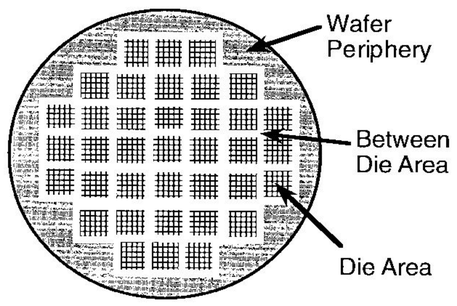


Fig. 4: Die Wafer

High energy laser pulses are fired at tin droplets forming a hot plasma which releases EUV light. This light source (Fig. 3) is controlled by 9 inputs which must be tuned to maximize EUV while maintaining a die yield of 99.5% (Fig. 4) and satisfying all other physical constraints. The goal of this project is to create an algorithm which runs continuously during manufacturing to identify the optimal operating inputs of the machine.

Black Box Model

Fig. 5: EUV Light Source Black Box Model

This problem is a black box optimization problem meaning there is no knowledge of the inner workings of the machine, just the inputs and outputs. Using the limited output information the goal is to be able to navigate to the optimal output by proposing new inputs.

Bayesian Optimization Algorithm

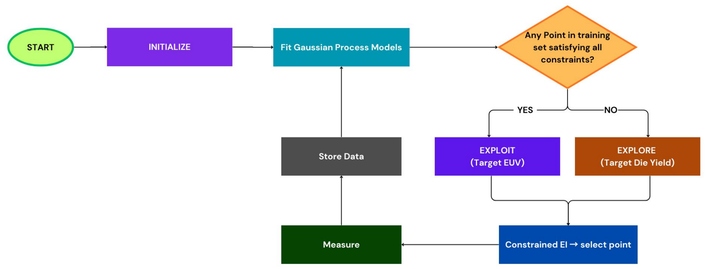


Fig. 6: Bayesian Optimization Algorithm FlowChart

We developed a Bayesian Optimization algorithm which uses a Gaussian Process to model the machine continuously and a constrained Expected Improvement acquisition function to predict new points to evaluate. The algorithm flowchart is shown in Fig. 6 and EUV and Die Yield outputs are shown in Fig. 7 and 8.

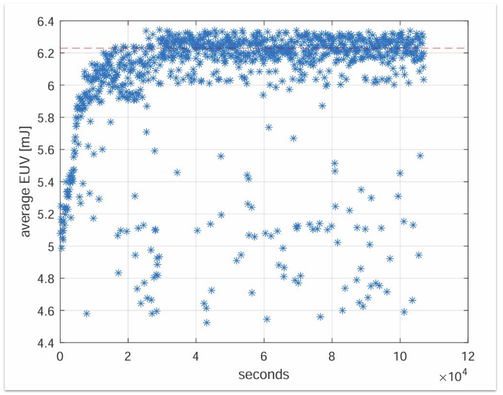


Fig. 7: Average EUV vs Time Graph

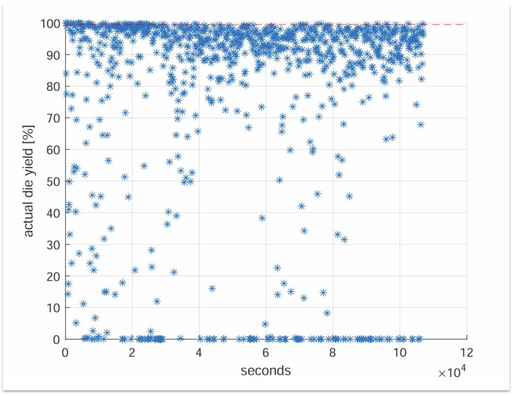


Fig. 8: Actual Die Yield vs Time Graph

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