Since the 28nm node, the industry has been able to double the amount of transistors in a single device, but not at lower cost. Escalating wafer costs takes away the higher transistor density gains. Larger wafer diameters have historically helped control costs, this philosophy be applied to masks to improve ArF productivity. Can these investments be leveraged for high NA EUV options?

Abstract

Regardless of the direction in future patterning technology at 10nm and beyond, a mask based patterning process will surely help enable the technology roadmap and also play a pivotal role in design cost and cycle time optimization. State of the art wafer patterning utilizes a complex assembly of 193nm based multi-patterning mask layers, resolution enhancement techniques such as mask phase shifting and a careful co-optimization of tools, software, mask and materials to deliver the total patterning solution. Whether this existing approach is extended through 7nm and beyond or gradually replaced with an alternative such as EUV lithography, we will have many opportunities and challenges to tune the performance, cost and delivery speed of advanced patterning processes.

We will discuss the interplay between mask cost, substrate size, mask layer count and patterning approach for various sub 14nm patterning scenarios. How these factors might impact device cost, design starts and cycle time through access to advanced mask making processes and equipment will be presented as well.

Introduction

Cost Model Assumptions

EUV Assumptions

Mask Cost Assumptions

Mask Area Assumptions

Set Composition – Optical only

N10 ArF Litho Cost

N7 ArF Litho Cost

N5 ArF Litho Cost

Set Composition – with EUV

N10 Litho Cost with EUV

N7 Litho Cost with EUV

N5 Litho Cost with EUV

Mask Set Cost Difference - ArF only to EUV

Summary

Role of mask in cost and capability dynamics for sub 14nm patterning

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Larger substrates offer larger field size that allow more chips/field and fewer fields/wafer increasing scanner productivity

Modest ArF wafer volumes are required to reach cost parity with 6 inch substrate

Projected increase in productivity of ArF scanners can help reverse rising Litho cost trend

Business model for large EUV substrates only makes sense if adopted with other wavelengths

- Initial high EUV mask cost is not an impediment from being competitive with ArF
- Improves multi-patterning strategy by allowing for more single or worst case double patterning
- Scanner throughput will dictate product adoption
- Early benefactors will be high volume runners
- Earlier adoption (at any substrate size) will help drive crossover from ArF multi-patterning

Modest Litho Cost improvement can be realized with EUV

- Blank cost is key mask affordability driver, requires industry support
- Increased volumes will reduce CapEx depreciation per mask
- Continuous improvement of source power will only offer more long term gains