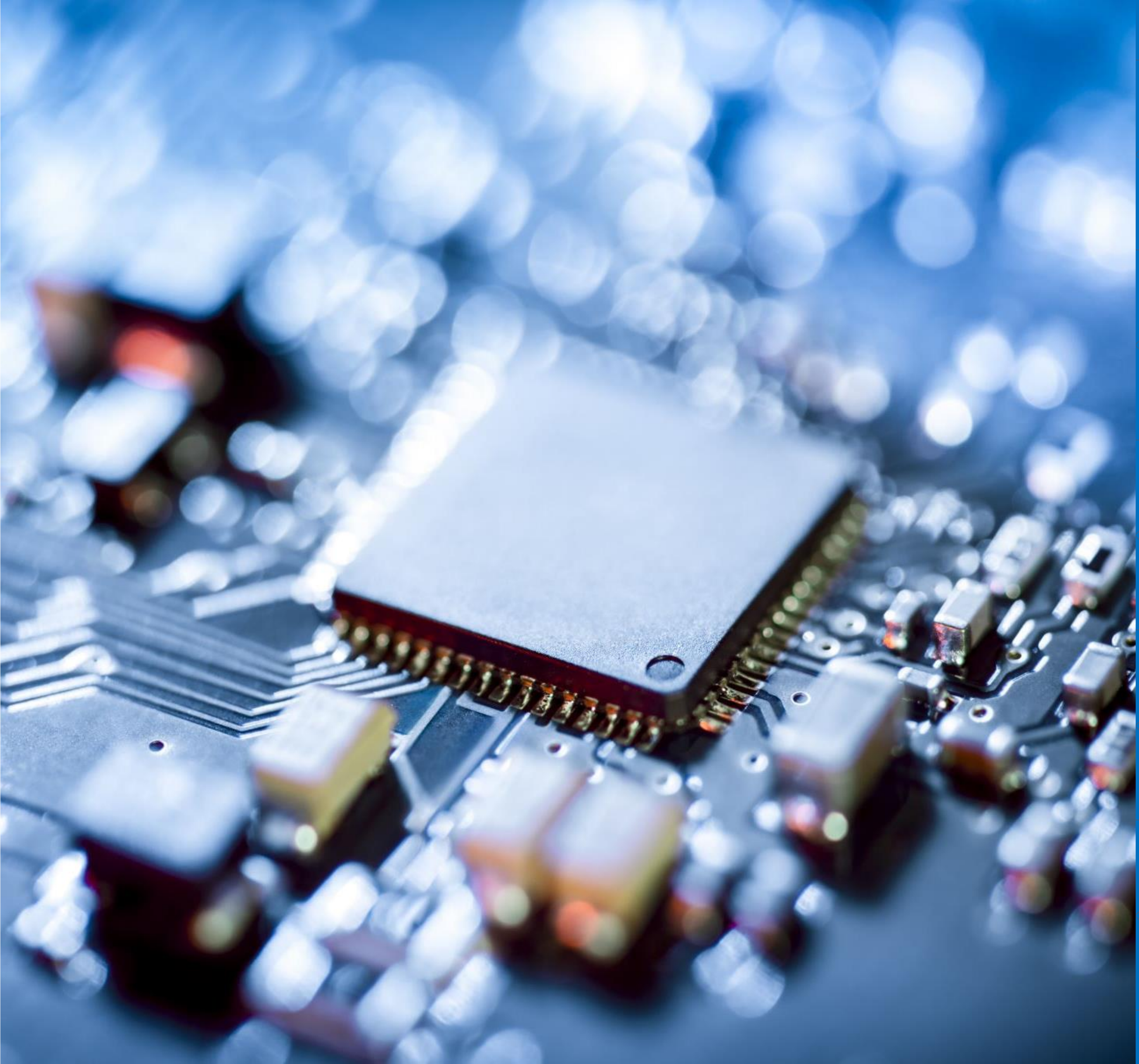


Producibility - Industry Point of View : Semiconductor and Digital Engineering

Praneetha Poloju

Semiconductor Technologist | Vice Chair NDIA Manufacturing Division

Microsoft

Content Flow

- Producibility: An important Design consideration
  - NDIA / AFRL published work
- Semiconductor Ecosystem
- Semiconductor Manufacturing flow
- DFM focused innovations for defect free products
- Digital Engineering Solutions in Manufacturing
- Resources

Producibility: An important Design consideration

Producibility an important aspect in Systems Engineering Process, however usually neglected in the early conceptual and preliminary design activities

- Hard to quantify
- Lack of available analytical tools

Missing the voice of the customer for manufacturing

Business needs are to meet the :

- Production cost
- Quality,
- Delivery,
- Inventory targets.

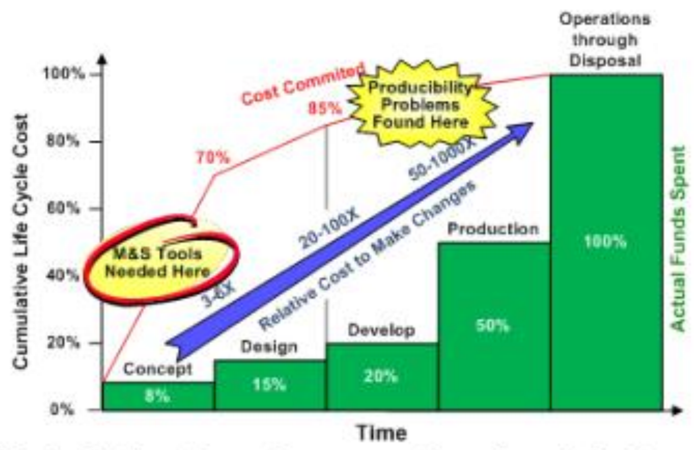


Figure 1: Life Cycle Cost Commitment as a Function of the System Life Cycle

https://www.nist.gov/system/files/documents/el/Sanders.pdf
Sanders, A., "Modeling & Simulation Investment Needs for Producible Designs and Affordable Manufacturing: Systems Engineering Implications", NDIA JCSEM M&S Sub-Committee Final Report,

Producibility: An important Design consideration

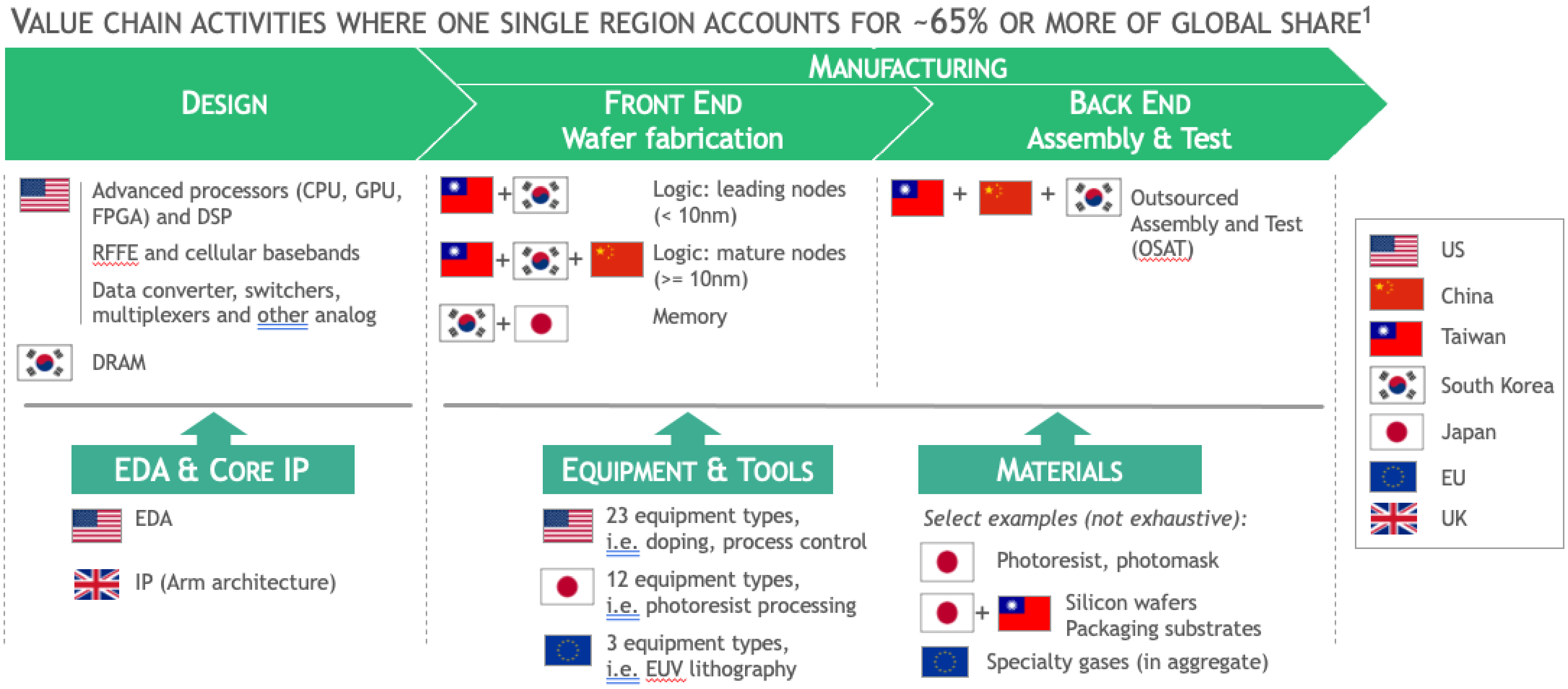
Producibility problems often drive up WIP inventory due the additional cycle time, safety stock, and lead time buffers required to address unanticipated yield fallout and manufacturing inefficiencies associated with inadvertently "designed in" producibility issues that are impacting production rate and delivery performance.

In addition, these same producibility issues often impact the factory cost of poor quality (COPQ) metrics, with additional WIP associated with the "hidden factory" rework loops and associated quality control and oversight required to ensure products continue to meet design specifications that are on the ragged edge of producibility once they enter production.

The overall vision is thus to define a roadmap for the development of advanced simulation-based producibility and supply chain analysis capabilities and frameworks that will enable true concurrent engineering and virtual prototyping of both product, and industrial base design concepts through the use of advanced modeling and simulation and systems engineering techniques.

https://www.nist.gov/system/files/documents/el/Sanders.pdf
Sanders, A., "Modeling & Simulation Investment Needs for Producible Designs and Affordable Manufacturing: Systems Engineering Implications", NDIA JCSEM M&S Sub-Committee Final Report,

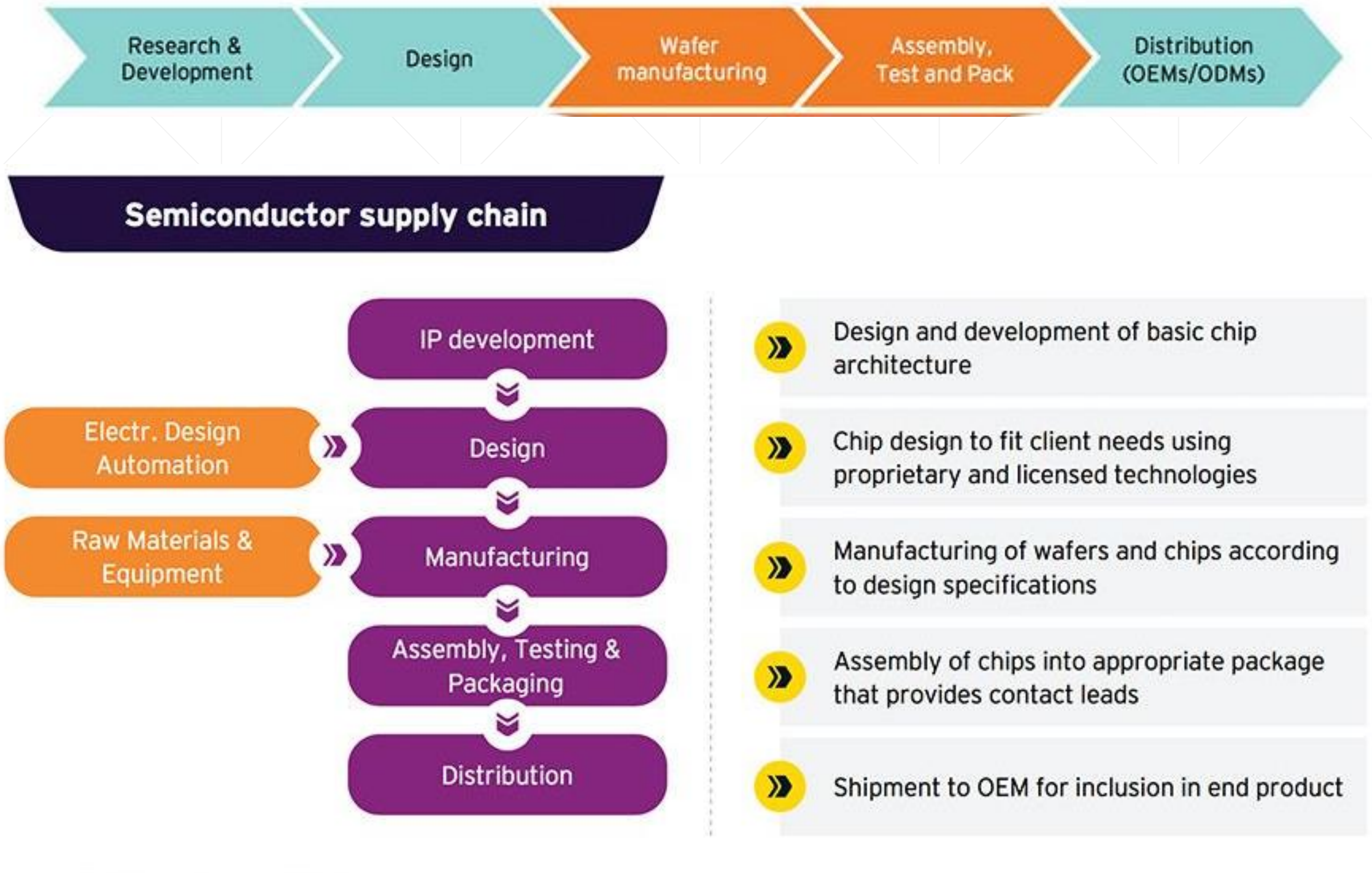
Semiconductor Value chain Global Ecosystem



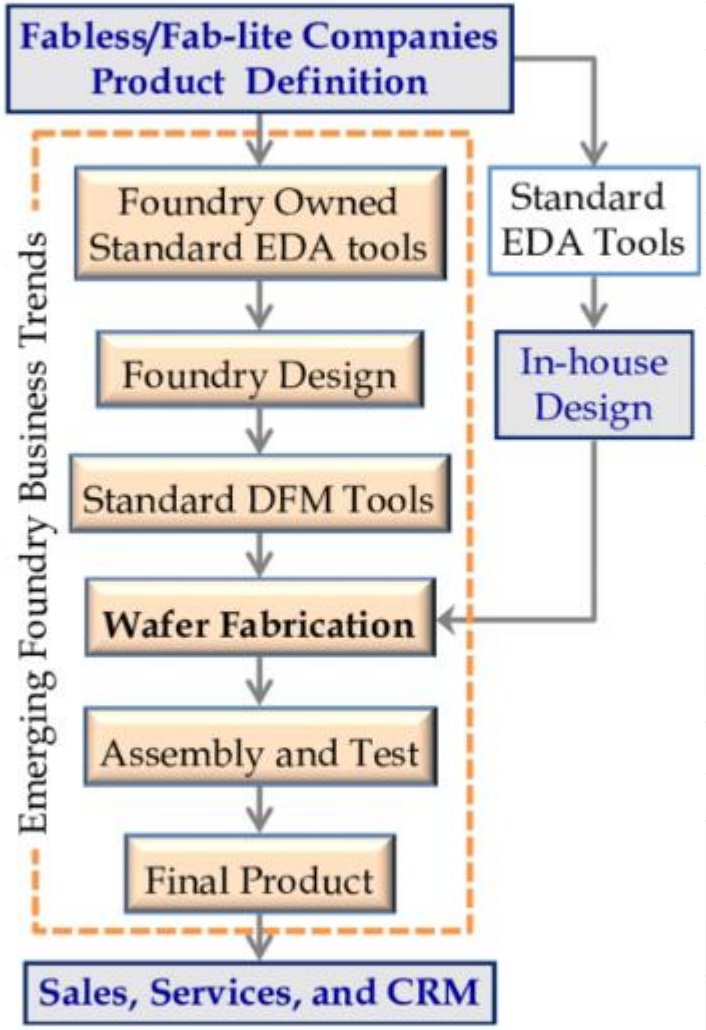
1. For Design, EDA & Core IP, Equipment & Tools and Raw Materials: global share measured as % of revenues, based on company headquarter location. For Manufacturing (both Front End and Back End) measured as % of installed capacity, based on location of the facility

Sources: BCG analysis with data from Gartner, SEMI, UBS; SPEEDA

Semiconductor Chip Manufacturing Flow / Supply Chain



Source: SIA, Beyond Borders, 2016[5]



Design for manufacturing (DFM) in Microelectronics Chip Manufacturing

- DFM refers to actions taken during the physical design stage of IC development to ensure that the design can be accurately manufactured.
- Semiconductor foundries typically analyze design layouts for criticality as a precursor to manufacturing flows. Risk assessment is performed on incoming layouts to identify and react to critical patterns at an early stage of the manufacturing cycle, in turn saving time and efforts.

A highly optimized 22FDSOI Logic Architecture for Power, Performance, Area (PPA) and cost is presented in this paper. Unique features of FDSOI technology including channel strain based PFET transistor performance enhancement are further advanced with innovative low cost MOL/BEOL based special constructs. This Logic Architecture offers FinFET like performance with 28nm bulk like simple MOL and cost structure.

Advanced Technology Development requires detailed and extensive Design and Technology Co-optimization (DTCO), from device to design to application, to balance system-dependent Power, Performance and Area (PPA) with manufacturability of the technology for steep yield ramp in production. The multi-dimensional exploration and trade-off analysis requires deeper understanding of the process, lithograph

https://ui.adsabs.harvard.edu/abs/2020SPIE11328E..0HR/abstract
https://ieeexplore.ieee.org/document/8421481
https://ieeexplore.ieee.org/author/37264885600

Design for manufacturing (DFM) in Microelectronics Chip Manufacturing (contd.)

Design-enabled manufacturing enablement using manufacturing design request tracker (MDRT)

- A. Sultan, R. Desineni, R. Madge
- Published 14 May 2013
- Computer Science
- ASMC 2013 SEMI Advanced Semiconductor Manufacturing Conference

The shrinking dimensions with advanced technologies pose yield challenges which require continuous enhancement of yield methodologies to quickly detect and fix the marginal layout features. In this paper, we present a practical approach to enhance the DFM and DEM capabilities suite provided by GLOBALFOUNDRIES for 28nm technology and beyond. The MDRT system has been implemented in the Product Lifecycle Management (PLM) system within GLOBALFOUNDRIES.

Framework for identifying recommended rules and DFM scoring model to improve manufacturability of sub-20nm layout design

- P. Pathak, S. Madhavan, L. Capodieci
- Published in Advanced Lithography 29 March 2012
- Business

This paper addresses the framework for building critical recommended rules and a methodology for devising scoring models using simulation or silicon data. Recommended rules need to be applied to critical layout configurations (edge or polygon based geometric relations), which can cause yield issues depending on layout context and process variability. Determining of critical recommended rules is the first step for this framework. Based on process specifications and design rule calculations, recommended rules are characterized by evaluating the manufacturability response to improvements in a layout-dependent parameter. This study is applied to critical 20nm recommended rules. In order to enable the scoring of layouts, this paper also discusses a CAD framework involved in supporting use-models for improving the DFM-compliance of a physical design.

https://www.semanticscholar.org/paper/Design-enabled-manufacturing-enablement-using-Sultan-Desineni/dad4c35962e6b207a344b9b583cc31de857c01be/figure/0

https://www.semanticscholar.org/paper/Framework-for-identifying-recommended-rules-and-DFM-Pathak-Madhavan/40ca2d868f722623f48be76adbd79ea588654725

Design for manufacturing (DFM) in Microelectronics Chip Manufacturing (contd.)

- CMP Hotspot Analysis
- Critical Area Analysis
- Via Enhancement
- Critical Feature Analysis
- Pattern Matching
- DFM Scoring

*A framework for producibility and design for manufacturing requirements in a system engineering context

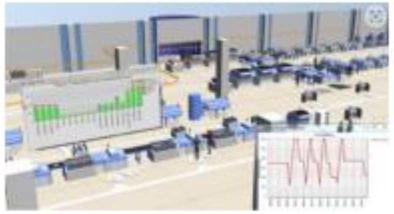
Aircraft engine technology has evolved and matured over a 70-year period under a continuous pressure to become more sustainable, fuel efficient, noise efficient, etc. while ensuring robustness and cost efficiency in production and product operation through life.
Through systematically building a framework and making use of state-of-the-art modeling and simulation technologies, the introduction of the novel technologies necessarily to increase the engine sub-system performance can be realized without compromising risk and cost.

A more integrated framework to tie a systems engineering approach with the use of advanced modeling and simulation technologies in a reusable manner, is a way to balance between product performance and producibility.

Introducing a framework for robust development, a practical framework consisting of several parallel principles and mechanisms that together give a business impact
Key features that constitute the base for robust development, namely:

- The use of platforms
- The use of virtual methods
- The introduction of through life engineering
- Set based and Systems Engineering

Manufacturing Capabilities



Model physical environments

Simulate production and materials flows

Design for Digital and Sustainability

Build Fab Digital Twin

Fuse IoT and business systems for rich insights with the live graph

Industrial Metaverse

Production Efficiency

Analytics & Yield management

RL enhanced Fab Scheduling & Optimization

Machine/Vision based Inspection and Quality

Industrial Robots/Cobots

Machine Calibration

Workforce Transformation

Sustainable Operations

Predictive Maintenance (Chiller, MFC, DI Cooler, Pump, Valve, Robot Bearings)

Energy Optimization

Prototyping and manufacturing for enterprises

Businesses have been finding applications for virtual reality in the prototyping and manufacturing spaces.

Prototyping and manufacturing in VR: What it is and how it works

Backup

Virtual training for manufacturing scenarios in VR

What resources does the Windows Mixed Reality platform have to assist with virtual training for manufacturing scenarios?

Businesses often benefit from virtually training new hires for potentially hazardous systems, equipment, and processes without directly exposing them to the risks of these scenarios in the real world. Learn more by visiting the training and simulation page.

Designing and developing immersive manufacturing and prototyping experiences

What resources does the Windows Mixed Reality platform have to assist with designing and developing immersive prototyping and manufacturing experiences?

The Mixed Reality Docs hub contains several pages covering different components of the design and development process for building immersive prototyping and manufacturing experiences. Visit the Design and development FAQ to learn more.

What resources does the Windows Mixed Reality platform have to assist with building immersive prototyping and manufacturing experiences that are capable of hosting multiple users in one session?

The Mixed Reality Docs hub contains several pages covering the information needed for building immersive prototyping and manufacturing experiences capable of hosting multiple users at once. Visit the Multiuser FAQ to learn more.

Setting up, deploying, and managing immersive prototyping and manufacturing experiences.

What solutions does the Windows Mixed Reality platform have to assist with configuring virtual play spaces for use with immersive prototyping and manufacturing experiences?

Many VR experiences require setting up a play space to use them safely. Play spaces are designated real-world spaces that have been cleared of obstacles and deemed safe to use VR in, corresponding to the player's location in virtual space to prevent them from colliding with anything in the real world. For guidance on setting up simple room boundaries up to 5mx5m, see the set up your room boundary documentation. For guidance on setting up larger and more complex play spaces by utilizing the Spatial Anchors capability in the Windows Holographic API stack, visit the coordinate systems documentation.

How can the Windows Mixed Reality platform and Azure Cloud Services help managing and deploying immersive prototyping and manufacturing experiences?

A: Azure-based onsite and remote management can help your business scale your immersive prototyping and manufacturing experiences. Visit the Cloud Services & Azure FAQ to learn more.