Available online at www.sciencedirect.com

ScienceDirect

Procedia CIRP 36 (2015) 53 – 58

www.elsevier.com/locate/procedia

CIRP 25th Design Conference Innovative Product Creation

A method to set up a complexity index to improve decision-making performance.

Lukas Budde[a]*, [b]Oliver Nagler[b], Thomas Friedli[c]

[a]*Lukas Budde, Insitute of Technology Management of the University of St.Gallen, St.Gallen 9000, Switzerland*
[b]*Dr. Oliver Nagler, Infineon Technologies AG, Neubiberg, Germany*
[c]*Prof. Dr. Thomas Friedli, Institute of Technology Management of the University of St.Gallen, St.Gallen 9000, Switzerland*

* Lukas Budde. Tel.: +41-(0)71-224-7219; fax: +41-(0)71-224-7311. *E-mail address:* lukas.budde@unisg.ch

Abstract

Engineering companies face the challenges of increasing product variety and technology induced increasing complexity of products. If the company is not able to manage this complexity within the design process it will cause productivity losses and rising complexity costs along the value-chain. Lack of information and information asymmetries lead to sub-optimal decision-making and thus to sub-optimal product-production-system designs. Companies struggle to evaluate product designs out of a broader, multi-functional perspective to derive the optimal design for the customer and company. The central question which needs to be solved is how companies can overcome these disadvantages in the early stages of product and process development. Based on the existing product design assessment methodologies proposed by academic and industrial communities this paper addresses these problems by developing a novel concept to improve decision-making performance in the early design phase by integrating the complexity perspective into decision-making. The paper delivers a guideline how to build up a complexity index to condense complex information.

Peer-review under responsibility of the scientific committee of the CIRP 25th Design Conference Innovative Product Creation

Keywords: Complexity management; decision-making; complexity index; product complexity;

1. Introduction

1.1. Problem and research relevance

Making the right decisions within early development design phase is a complex problem [1]. Multiple system elements and interdependences, uncertain and changing information, dynamic opportunities, multiple goals as well as the consequences along the life cycle need to be considered. Garvin and Roberto [2] state that “decision-making is arguably the most important job for the senior executive and one of the easiest to get wrong”. Product design decisions in manufacturing companies result in allocations of resources to achieve certain objectives [3]. Companies seek to increase the level of rationality in the decision-making processes [4]. This is realized by using more information and by integrating multiple perspectives. Researchers criticize that most decision-making approaches over-simplify the issue of decision-making. This paper will explain a methodology how companies can systematically built up a complexity management system to improve the evaluation of complex problems and thus their decision-making performance. Researchers as well as practitioners agree on the significance of having well-defined decision criteria [5].

1.2. Context of the study

The introduced methodology will be explained along the test development decision-making of a semiconductor producing company. Figure 1 shows an excerpt of the product structure of the interface board of the testing solution.

Peer-review under responsibility of the scientific committee of the CIRP 25th Design Conference Innovative Product Creation
doi:10.1016/j.procir.2015.01.052

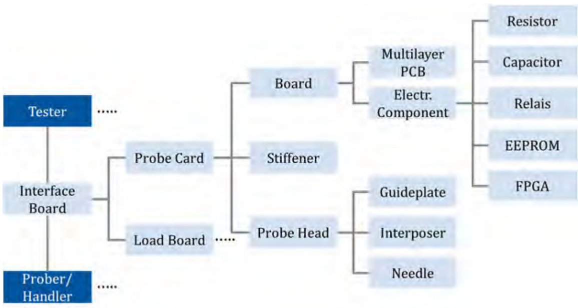

Fig. 1. Exemplary product structure of the interface board.

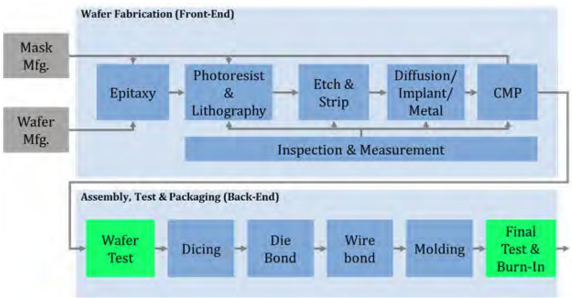

Fig. 2. Wafer production processes.

The test solutions contain different hardware and software components which are linked to product, customer as well as production process constraints and requirements (s. figure 2). Hence choosing the optimal test solutions (in terms of costs, speed and quality) for the variety of products and diversity of requirements is a complex challenge due the high number of interdepencies. Chapter 2 presents a review of different evaluation concepts to support the decision-making.

2. Existing approaches to evaluate product designs

2.1. Complexity evaluation concepts

Different approaches are carried out in research to evaluate projects (see Table 1). A typical scorecard for the decision to go to development is introduced by Cooper [6]. This scorecard contains different decision-making dimensions like strategic fit and importance, product and competitive advantage, market attractiveness, core competencies, technical feasibility and financial risk.

Table 1. Existing evaluation approaches to support decision-making.

Approaches	Author
Scorecard	Cooper (2009, p.51) [6]
Design for variety	Martin & Ishii (1996) [7]
Product complexity effectiveness	Schuh et al. (2010) [8]
Product portfolio complexity measurement	Orfi et al. (2011) [9]
Optimal variety	Rathnow (1993), p.42 [10]
Variant mode and effect analysis	Caesar (1991), p.36 [11]
Variant tree	Schuh & Schwenk (2001) [12]

Going a step deeper in the hierarchy level, the evaluation of product architectures can be done with the design for variety methodology [7]. Coupling indices are defined based on the engineering characteristics to reveal modularization and standardization potentials. They are used to evaluate the implementation of the product architecture and support the definition towards the optimal design. The approaches by Schuh et al. [8] and Orfi et al. [9] contain different indicators to evaluate the product-process design out of different perspectives in order to reveal optimization potential. For the evaluation of the technical implementation of a project based on the requirements, different indicators are introduced in the research community. The evaluation of the complexity of product architectures can be conducted with products per function [13], commonality index [7], the dependency index [14] or the general complexity index (GCI) [15] to assess the complexity of different product architecture designs and to enable a systematic and objective comparison.

The common idea behind these different approaches is to integrate different information into indices to make it transparent, comparable and usable for decision-making. Thus the major goal of it is to improve the information basis for decision-making. It builds the systematic bridge between system elements and information streams which are scattered along different functional departments. Thus complex problems become more tangible for decision-maker.

2.2. Complexity drivers within decision-making of product and production process designs

Several researchers have identified complexity drivers for manufacturing companies which have an impact on the decision-making performance. These indicators can be used to evaluate product and process design effectiveness. Different functional departments are affected by these drivers. Table 2 illustrates some of these drivers and potential indicators to measure the complexity. Hereto belong for instance the number of SKUs, the number of functions or unique parts implemented in the product architecture, the demand variability or the different lot sizes required.