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Follow-Up Study on Improving Core Competency of Semiconductor Design Companies of Korea

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반도체 설계기업의 핵심역량향상에 관한 후속 연구

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Abstract This study is a follow-up to existing research on the core competency of semiconductor design companies. This study analyzes changes in the importance of awareness of these companies' core competency factors and whether they have improved. Core competency was divided into product development, technological capabilities, market capabilities, human resources, and business management. The sample was 78 semiconductor design companies that are members of the Korea Semiconductor Industry Association, and they responded on a 5-point scale regarding the perceived importance of competitive factors and the degree of improvement. Competitiveness was highest in the human resources sector, followed by technological competitiveness and product development competitiveness. market development, competitor analysis, and external linkage capabilities have emerged as issues that must be supplemented. In addition, the expansion of emiconductor-related SW personnel, product planning, and product testing must be improved. Therefore, to improve the competitiveness of semiconductor design companies, they must continuously improve their ability to secure human resources, find new customers, analyze competitors, and analyze related data.

요 약 본 연구는 반도체 설계기업의 핵심역량에 대한 기존 연구의 후속 연구이다. 본 연구에서는 기존 연구시점과 비교하여 이들 기업의 핵심역량요소에 대한 중요도 인식변화와 향상수준분석에 초점을 맞추고 있다. 핵심역량(경쟁력)은 제품개발, 기술역량, 시장역량, 인적자원, 경영관리로 구분하였다. 한국반도체산업협회 회원사인 78개 반도체 설계기업을 표본으로 하였으며, 설문항목에 대해서는 5점(구간)척도로 응답되었다. 핵심역량의 경쟁력은 인적자원부문이 가장 높았고, 기술역량, 제품개발역량 순으로 나타났다. 반면에, 시장개척, 경쟁사분석, 외부연계역량 등은 보완해야 할 이슈로 확인되었다. 또한, 반도체 관련 SW인력확충, 제품기획, 제품테스트 등도 개선되어야 할 역량요소라고 볼 수 있다. 따라서 반도체 설계업체의 경쟁력 향상을 위해서는 관련 인적자원확보, 신규고객발굴, 경쟁사분석, 데이터 분석능력 등은 지속적으로 향상시켜야 할 것으로 사료된다.

Keywords : Semiconductor Design Company, Core Competency, Competitiveness Analysis, FEED, Fabless Firms

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1. Introduction

Although the economic outlook for semiconductor companies has recently improved, it has not yet fully recovered. Fortunately, Korea's memory semiconductor industry still maintains its status as number one globally. However, as the semiconductor industry is facing extreme environmental changes both domestically and internationally, now is the time to check the competitiveness of companies. Lightweighting and integration of memory & non-memory are accelerating, and demand for artificial intelligence is growing explosively. In particular, in the system semiconductor field, the division of design and production is intensifying in the comprehensive semiconductor system, and competition is becoming more intense.

Although Korea's system semiconductor consignment production foundry capabilities have greatly improved, its fabless competitiveness in the design sector must catch up with Taiwan's. In order to secure practical leadership in the global semiconductor industry in the future, securing competitiveness in the system IC industry is most important[1]. Korea's global market share of semiconductors is about 21%(as of 2019), while the global market share of the system semiconductor industry is only about 3.2%, which has been stagnant for about ten years[2].

Ultimately, it is clear that only by strengthening the competitiveness of the domestic system IC industry can Korea maintain its competitiveness and status as an advanced semiconductor country. To achieve this, the competitiveness of design-oriented semiconductor companies in charge of the design field, which is the core of the system IC industry, must be increased. The reality is that most design companies with weak management and competitiveness bases still need help in promoting business and securing competitiveness[3].

Currently, national support and policies for semiconductor design companies are urgently needed. Prior to supporting these policies, the competitiveness level of domestic semiconductor design companies must be analyzed first. In this study, we compare and analyze the core competency level of semiconductor design companies with existing research[4]. In this study, we focus on evaluating how the core competitiveness factors of existing semiconductor design companies are changing in terms of importance and whether competitiveness factors recognized as necessary have improved.

2. Overview of Semiconductor Design Firms

Semiconductor design companies include 'Fabless,' a specialized company, 'Design House,' which specializes in optimized design, and 'Foundry,' which produces and supplies products[5]. Semiconductor design refers to the front-end design of a semiconductor for a specific function and the back-end design for manufacturing a mask. Design firms can be classified as follows[6]:

① Fabless: Not own a fab and is only responsible for circuit design and sales
② Foundry: Owns a fab production facility and is mainly responsible for semiconductor wafer production
③ IDM (Integrated Device Manufacturer): Oversee the entire process from circuit design to sales.

A semiconductor design company can develop into a company that produces a variety of products based on the performance improvement of the semiconductor product itself and the development of the system. A custom semiconductor design company(ASIC) signs a design agency contract with a large semiconductor manufacturer.

Table 1. Classification of Semiconductor Design Companies

Type	Content	Company
Standard Product Design	Design own products with standardized specifications	Telechips
ASIC	Design products on demand from an external system vendor	ADT
Layout Service	Designed to allow foundries to produce products by requesting the back end of the design from another company	Hanatec
IP Design / Supply	Design IP that can be used as a standard function block	ADC(hips)
EAD Service	Develop design tools for product design and provide them to design companies	Synopsis
System Development & Sales	Companies developing systems using developed products	C&S
TEST Service	Companies that test to verify product reliability	Tesna
Chip Distribution	Developed Product Distributor	

References: Revised based on the study of K.H. Ahn and J.H. Lee(2005)[7].

Semiconductor manufacturers usually collaborate with external design companies or have their own design teams. System companies develop and commercialize semiconductors but focus only on system products. The semiconductor industry is attracting significant attention due to the competition for technological supremacy among major countries. Still, the domestic system semiconductor field could be in a better situation, so it is necessary to check the level of competitiveness.

The general trend among semiconductor design companies is to provide simple semiconductor design services and have standardized semiconductor development capabilities and the ability to develop high-value-added semiconductors through unique design structures and optimal library development. Therefore, it is necessary for growth strategies for related companies to seize opportunities to standardize customized semiconductors and promote collaborative development with various system companies[8].

Standardized product design companies will develop into organizations with significant technological accumulation in custom semiconductor design and design institutes or system design. Most of these companies have experts in specific fields and can develop customized semiconductor chips or chipsets optimized for the field within a short period[9].

3. Framework of Analysis

The definitions and criteria for core competencies used in this study are based on the results of previous study[4]. Core competency is associated with concepts(competence, capability, and resources) with characteristics that differ conceptually and empirically[10]. Core competencies refer to the abilities that form a company, including the overall skills, knowledge, and information its members possess. It means being superior to their competitors, i.e., providing a competitive advantage. Previous studies have confirmed that the core capabilities of the manufacturing industry affect corporate performance[7,11]. And manufacturers' managers to improve their knowledge and understanding of the company's core competencies[12].

In particular, the innovation capabilities of engineers were confirmed to contribute positively to the technological management performance of technology-oriented companies[13]. The importance of technology(choice) in core competencies can be seen in previous studies[9,14]. One of the core

competency elements of an organization is human resources, and the quality(level) of human resources is directly related to core competency[15]. In the semiconductor industry, R&D capabilities and market orientation significantly impact product innovation performance to improve customer value and competitiveness for technological innovation[16]. In addition, design capabilities, market creation(competitiveness), and knowledge creation capabilities are essential as competitive advantage factors for semiconductor design companies[17].

In this study, core competencies are divided into development, technology, market, management, and human resource competencies based on the results of the preceding studies, as shown in Table 2. These variables are critical to a company's competitiveness in today's fiercely competitive environment, whether it is a semiconductor design company or a general company.

Table 2. Classification of Core Competency

Var.	Define
P D	Competency by **Product Development** Process (Product Development Stage)
T C	Accumulated affecting the Product **Technology Competence**
M D	Capabilities that influence **Market Development**
H R	**Human Resource** Composition and their Capabilities
O M	Capabilities that affect **Organizational Management**

The analysis targets of this study are 78 non-memory semiconductor design companies. Sampling was random, considering statistical significance. The research subjects were limited to non-memory semiconductor design companies, focusing on member companies of the Korea Semiconductor Industry Association. Most of these companies are located in the Seoul and Gyeonggi regions, and design companies with less than KRW 57 billion sales account for 75% of the total. In addition, industry specialization is taking place in areas such as ASSP, ASIC, design services, and EDA.

Table 3. Sample Information

Classification	Content
Population	Non-memory semiconductor design company
Sample Size	78 companies (valid samples)
Sampling	Significant Extraction
Sampling error	± 3.10% (95% confidence level)

Statistical data was mainly collected through online surveys; some companies collected them face-to-face. A structured questionnaire was used to collect data and was structured around the company's characteristics, core competency level, and success/failure factors in new product development. Respondents prioritized the importance of competitiveness factors using a nominal scale(1 to 5). Each item's level of competitiveness improvement was expressed in a 5-point range(more than 40% improvement(Lv1), 30% improvement(Lv2), 20% improvement(Lv3), 10% improvement(Lv4), Almost the same as before(Lv5)). The sample consists of a total of 78 private companies, mainly companies established after 2000. In this study, the company's sales ranged from less than 10 billion won to 100 billion won. The employees ranged from 20 to 50, including small (less than 10) design companies.

4. Results of the Analysis

Table 4 shows the recognition of the importance of core competencies and the level of improvement in competitiveness compared to before. The importance ranking of core competencies shows some differences from previous study[4]. The importance recognition ranking was in the following order: human resources, technical capabilities, product development, market development, and

business management. Human resource competency was still the most core competency, followed by technology and production competency. These core competencies were found to have improved by 20% to 30%. On the other hand, the improvement in business management ability is lower than in other sectors. The average was calculated for the 5-point Likert scale for priority ranking, and the level of competitiveness improvement was nominally divided into five levels, and the closest value was used. Therefore, decimal points for the average value of each survey item were rounded off.

Table 4. Priority and Competitiveness Improvement

Var.	Priority Ranking (recognition)		Rank Gap	Competitiveness Improvement	Total Importance Rank (Present×Level)
	Previous	Present		Level (1 to 5)	
P D	3	3	-	3	**3(9)**
T C	4	2	↑ 2	2	**2(4)**
M D	5	4	↓ 1	4	4(16)
H R	1	1	-	2	**1(2)**
O M	2	5	↓3	4	5(20)

As can be seen in Table 5, the most essential competencies in the product development stage were architecture, front-end, and back-end design. Compared to the previous study, market analysis was the factor that increased awareness of importance. While the importance of market development has increased, ability improvement is relatively low, and the result of this analysis has also been pointed out in previous study[18]. Conversely, it is essential to accurately analyze and design market demand during the product development stage. On the other side, sample-making and product testing capabilities needed improvement compared to other core capabilities.

Next, the technical competency level analysis results are shown in Table 6. The importance of technical capabilities appeared in the following order: quality, development period, product price, cooperation with external technology, and technical information management. The importance ranking of each element of technical ability is similar to existing research results, and the importance of quality and degree of ability improvement is noticeable. Meanwhile, continuously improving external technological cooperation and technological management competitiveness is necessary. It is well known that technical cooperation and networking with external organizations positively impact performance[19].

Table 5. Product Development Competitiveness

Product Development Stages		Priority Ranking (recognition)		Rank Gap	Competitiveness Improvement	Total Importance Rank(Present ×Level)
		Previous	Present		Level(1 to 5)	
Market Analysis	Market Analysis	11	5	**↑ 6**	4	6(20)
	Product Planning	12	9	↑ 3	4	9(36)
Development	Architecture Design	2	2	-	3	**2(6)**
	Front-end Design	7	3	↑ 4	3	**3(9)**
	Back-end Design	1	1	-	3	**1(3)**
Verify	Sample Manufacture	7	10	↓ 3	4	10(40)
	Product (Test)	10	11	↓ 1	4	11(44)
Production	Revision	7	12	↓ 5	4	12(48)
	Production	5	6	↓ 1	3	5 (18)
	System Application	4	7	↓ 3	4	7 (28)
Sales	Sales	6	8	↓ 2	4	8 (32)
	Customer Service	2	3	↓ 1	3	**3 (9)**

In particular, in the case of semiconductors, as technology and product specifications become more sophisticated and converge, cooperation through external networks is becoming essential.

Table 6. Technology Competitiveness

Var.	Priority Rank (recognition)		Rank Gap	Competitive-ness Improvement	Total Importance Rank (Present ×Level)
	Previous	Present		Level (1 to 5)	
Quality	2	1	↑ 1	2	**1(2)**
Price	3	3	-	3	**3(9)**
Develop Period	1	2	↓ 1	2	**2(4)**
External Cooperation	4	4	-	3	4(12)
Information Management	5	5	-	3	5(15)

An essential recognition of market competence was found to acquire customer development and customer demand information, Table 7. Regarding market competitiveness, the acquisition of customer demand information, customer discovery, and acquisition of market information were found to be significant (Table 7). In particular, the ability to obtain customer demand and market information was confirmed to have improved compared to other market competitiveness factors. On the other hand, data analysis capabilities, competitor information analysis, and sales network construction aspects have slightly improved. The impact of involvement between suppliers and customers on product success is high in new product development[20]. Therefore, semiconductor design firms must enhance their market-related capabilities to secure their core competitiveness.

In today's world, the most important criterion for determining an organization's competitiveness is the ability to attract talented people with high quality[21]. As shown in Table 8, human resource capabilities generally improved(20% to 30%) compared to the previous study. In particular, it was confirmed that the importance of S/W capabilities has increased. It is in the same context as the recognition that S/W competitiveness is essential to establish its status as a powerhouse in the semiconductor industry in the future[22]. In comparison, the capabilities of technology marketing experts are relatively low.

Table 7. Market Develpoment Competitiveness

Var.	Priority Rank (recognition)		Rank Gap	Competiti-veness Improve-ment	Total Importance Rank (Present ×Level)
	Previous	Present		Level (1 to 5)	
Obtain Market Data	6	3	**↑ 3**	3	**3(9)**
Data Analysis	7	5	↑ 2	4	5(20)
Information: Competitors' Development Trends	4	6	↓ 2	4	6(24)
Customer Demand Information	1	1	-	3	**1(3)**
Customer Development	3	2	↑ 1	4	**2(8)**
Sales Network Building	5	7	↓ 2	4	7(28)
Service Mind	2	4	↓ 2	3	4(12)

According to the Korea Institute for Advancement of Technology, there was a total shortage of 1,621 semiconductor workers in 2020. The government is also working to develop future

Table 8. Human Resources Competitiveness

Var.	Priority Rank (recognition)		Rank Gap	Competiti-veness Improve-ment	Total Importance Rank (Present ×Level)
	Previous	Present		Level (1 to 5)	
Front-end Designer	4	3	↑ 1	2	3(6)
Back-end Designer	1	3	↓ 2	2	3(6)
H/W Sys. Engineer	2	2	-	2	2(4)
S/W(F/W) Programmer	5	1	**↑ 4**	2	**1(2)**
Technical Marketing Expert	3	5	↓ 2	3	4(15)

original technologies and foster convergence experts to secure the mid-term to the long-term competitiveness of the domestic semiconductor industry, especially the system semiconductor industry. Semiconductor design companies must also recognize the level of design personnel as a critical element of corporate competitiveness and invest more in talent development.

Table 9 shows that the priorities of factors considered important in business management competitiveness are similar to previous research results. Regarding importance perception, there was the most minor difference compared to other sections of this study. Moreover, the CEO's leadership is the most critical factor in business management competitiveness. Next, the company's IT system level and work standardization were confirmed as core competitiveness in business management. It is interpreted to be because IT systems and work standardization are becoming more required in a digitalized corporate environment. However, internal cohesion, public relations/IR, and external network capabilities could be higher, so their activities need to be strengthened.

Table 9. Organizational Management Competitiveness

Var.	Priority (recognition)		Rank Gap	Competitive-ness Improve-ment	Total Importance Rank (Present ×Level)
	Previous	Present		Level (1 to 5)	
CEO Leadership	1	1	-	3	**1(3)**
Funding & Operating Capacity	5	4	↑ 1	4	4(16)
Internal Unity	6	6	-	4	6(24)
PR & IR	8	9	↓ 1	4	9(36)
IT System (ERP, SAP, SCM etc)	2	2	-	3	**2(6)**
External Network	7	7	-	4	7(28)
Public Policy	9	8	↑ 1	4	8(32)
Work Standard	3	3	-	3	**3(9)**
Industrial Relations	4	5	↓ 1	4	5(20)

5. Conclusions

This study compared the perceived importance of core competencies and the degree of competency improvement for 78 semiconductor design companies with previous studies. The categories of core competencies were analyzed by dividing them into product development, technology, market, human resources, and business management. It was confirmed that the importance ranking of awareness of core competencies and the degree of core competency improvement differed by category. The order of importance of core competencies was human resources, technological competitiveness, product development, market competency, and business management. Compared to the previous study, the ranking of technological competitiveness increased, while the management competitiveness factor was ranked lowest. The difference in perception of the importance of competitiveness factors compared to previous studies is that the competitive structure is becoming fiercer due to changes in the industrial environment, and each design company faces different situations.

Regarding product development competitiveness, design development capabilities were relatively excellent, but product planning, sample manufacturing, and product testing capabilities needed improvement. Technology is competitive in quality, development period, and price, but external cooperation and information management require effort. Market development capabilities have improved in customer demand information, customer discovery, and market information acquisition, but the capabilities in competitor information analysis were somewhat low. The human capabilities of semiconductor design companies were found to be good in terms of importance and improved competitiveness. However, it still needs to be revised regarding workforce scale, so it is necessary to focus on training human resources, especially S/W human

resources. It was confirmed once again that the CEO's capabilities, IT system level, and work standardization are essential in business management competitiveness. Therefore, the government must expand foundry investment support to foster system semiconductors, promote the growth of fabless companies, and take the lead in building a talent training ecosystem that will lead future strategic industries such as system semiconductors. Semiconductor design companies must also continue to invest to improve their core competitiveness

Design-oriented semiconductor companies must conduct thorough market analysis, improve technology and competitor information management capabilities, and strengthen product planning, technology marketing, and external networks. These companies need more marketing capabilities because most design companies belong to small and medium-sized businesses and need more technical marketing experts and investment capacity. Therefore, the government should make efforts to support policies that increase the marketing capabilities of these companies. Based on the main results of this study, we hope that additional research will continue to strengthen the core capabilities of semiconductor design companies. In carrying out this study, we hope that the limitations of not being able to expand further the size of the analysis target and the inability to perform various quantitative statistical analyses can be supplemented through future research.

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