

Final Report

A FRAMEWORK FOR STRATEGIC THINKING By Kevin J. Ilcisin (CTO, Tektronix)

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1 Company Background

Novellus Systems Inc. design, manufacture, market and service semiconductor capital equipment systems. Their Chemical Vapor Deposition (CVD) equipment is used for placing layers of either insulating or conductive material on silicon wafers, so multiple levels of circuitry can be connected. One of the major strengths of their CVD equipment is that it can process five to seven wafers at a time, compared to most other CVD systems that can only do one [1].

Novellus Systems Inc. was founded in 1984 by two former Applied Materials employees. The senior vice president of Applied Materials tried to convince his company to acquire Novellus, however this was turned down and he joined Novellus as the president and CEO in 1986. In 1987, the company shipped their first product, known as Concept One, and a year later went public at \$8 a share. In early 1990s, due to the domestic recession, the company became active in international markets, expanding into Japan and Europe. Expanding into international markets was an effective strategic which resulted in over 50% of the company's sells in 1991. In 1995, Novellus systems were used by all the world's largest semiconductor device manufacturers. Novellus now obtain about two-thirds of their sales from the Asia/Pacific regions [2].

In June 2012, Novellus were acquired by Lam Research Corporation for \$3.3 billion. Equipment from these two companies work on adjacent steps of the semiconductor manufacturing process, thereby complementing one another [3]. Their intention was to combine these complimentary technologies to create more sophisticated machinery for the semiconductor industry [4]. In 2011, Novellus had lost share of their Physical Vapor Deposition (PVD) and CVD market, and Lam research had also lost share their etch business [5], which may have brought about the need for the acquisition. After the acquisition, Lam Research became the fourth largest chip-equipment maker, and their intention was to become more of a challenge to the market leader, Applied Materials. The share price of Lam Research has continued to increase from about 4 months after the acquisition, and is currently at around \$48 per share.

2 Case Study Synopsis

The case study dealt with the development of Fluorinated Silicon Glass (FSG) film by Novellus for their customers. Their customers were semiconductor foundries and fabrication plants. From their initial analysis it was determined that they were inferior to their competitors with regards to performance, cost, and POR. Based on this position they expected no revenue from this product. The guest speaker introduced the method they followed which was a combination of the Objectives, Strategies, Tactics and Actions (OST) with the Need, Approach, Benefits to costs, and Competition (NABC) method. It was determined that their approach should be to provide solutions to their customer's customer, which was successfully achieved by offering a product that was more reliable than their competitors.

For the NABC method it was established that the **N**eed was to break into an established market, the **A**pproach was to provide solutions to the customer's customer, the **B**enefits per costs was differentiation from competitors, and the **C**ompetition had a 12 month lead. For the OST it was established that the **O**bjective was to develop the film within 6 months with a new capability, the **S**trategy was to find a way to differentiate their product, and the **T**actics were to stop existing optimization R&D, capture the needs of the end-user, and finally to cover all qualification costs.

3 Literature Review

3.1 The 5 Disciplines for Creating What Customers Want

Carlson and Wilmot [6] classify innovation as "*the process of creating and delivering new customer value in the marketplace*". In order for an innovation to be successful 5 disciplines should be satisfied, of which the NABC approach used in the case study was part of the 2nd discipline.

- 1. *Important Needs* Attention should be focused on needs that are important to the customer and market, rather than just needs that are interesting to the company. Is the important need feasible, does it align with the organization's goals, and can the company commit to it?
- 2. Value Creation As Carlson and Wilmot [6] stated, "the goal of every innovation is to create and deliver customer value that is clearly greater than the competition's". The NABC approach shown in Figure 1 is used to create a clear value proposition as the foundation to satisfy the above statement. When initially developing the value proposition the focal point should be on understanding the market ecosystem, thereby focusing on the Need and the Competition (NabC).



Figure 1: NABC Approach

- **3.** *Innovation Champions* Every innovation must have a champion, someone who proactively identifies with the customer and address all the challenges that innovations normally face.
- **4.** *Innovation Teams* These multidisciplinary teams should focus on important customer and market needs, iterate and compound ideas, use continuous feedback, and share in recognitions and rewards.

5. Organizational Alignment - Alignment of key elements such as shared vision, strategy, goals, and value; commitment to delivering the highest customer value, commitment to continuous improvement processes, etc.

Based on these disciplines the method followed by the guest speaker mainly included elements from the 1^{st} , 2^{nd} and 5^{th} discipline.

3.2 Strategic Thinking

Strategic planning was introduced in the early 1970s and has been popularized mainly by General Electric [7]. Strategic planning has been developed into a parallel of scenario planning and forecasting. The real purpose of strategic planning is to improve strategic thinking [8]. The strategic tool linked with this view is scenario planning [8]. Michael Porter highlighted the need for strategic thinking which included the direction of competition, needs of customers, importance of gaining competitive advantage, and so on, in 1987. The pervasiveness of industry restructuring has provided a driving force toward strategic thinking [7]. Strategic thinking has been used to indicate all thinking about strategy, rather than to denote a particular mode of thinking [9]. Strategic thinking and strategic planning are distinct but interrelated and complementary thought processes that must sustain and support each other for effective strategic management [8]. Figure 2 illustrates the distinct but complementary thought processes of strategic thinking and planning.



Figure 2: Strategic Thinking and Planning [10]

Liedtka reviewed strategic thinking and strategic planning related literatures and addressed the five elements of strategic thinking, which were systems perspective, intent focused, intelligent opportunism, hypothesis driven, and thinking in time in her research [9]. She also proposes the various techniques to support each element of strategic thinking as described in Figure 3. For example, the development of thinking in time is aided by scenario building and gap analysis.

Elements	Relevant Strategy Concepts and Techniques
Systems Perspective	 Stakeholder mapping Value System Analysis Future Search Conference
Intent-Focused	• Story Writing
Thinking in Time	 Scenario Building Gap analysis Use of analogies
Hypothesis-Driven	 What if If then Knowns, Unknowns, Presumed Alaxander's question
Intelligent Opportunism	Share and compareSimulation Techniques

Figure 3: The Elements of Strategic Thinking [9]

3.3 Multi-Criteria Decision Model; AHP (Analytic Hierarchy Process)

A Multi-Criteria Decision Model (MCDM) is useful in solving higher level managerial planning and decision making problems by helping remove uncertainty and allows the decision maker to solve problems that can be represented as criteria [11]. A subset of MCDM that focuses on how to evaluate alternatives and helps decision makers select the optimum choices is named Multiple Attribute Decision Making (MADM). Data Envelopment Analysis (DEA), AHP, Analytical Network Process (ANP), Hierarchical Decision Model (HDM), neural networks weighting, interpretive structural modeling, Fuzzy cognitive maps, linear structure equation model, and PROMETHEE are just some of these MADM models.

3.4 AHP/ANP

AHP is a model within the multiple criteria decision-making models (MCDM). Analytical Hierarchy Process (AHP) and Analytic Network Process (ANP) are a family of models that use criteria and pairwise comparisons between the criteria to ascertain the relative importance of each with respect to each other. Weights and inconsistencies are found based upon algebraic methods and are utilized to apply scores to each decision alternative. Thus, the decision alternative with the highest score should be chosen [12]. AHP has "acquired wide acceptance as a method of prioritizing the elemental issues in complex problems in a variety of fields" [13]. By comparing the individual pairs of criteria, these models provide an ability to compare an issue with regards to each immediately higher level. This in turn allows a relative importance to be determined by the decision-maker [13]. However, AHP does have limitations. The "major issue" with AHP is the accuracy of the weightings leading the paradigm to be "essentially qualitative and not realistically quantitative." Regarding AHP application within academia, AHP has been utilized within manufacturing, environmental managements and agriculture, transportation, power and energy, healthcare, the construction industry, R&D, education, e-business and several other industries. ANP is not as widely used but has been found within literature within the areas of accounting or in areas where "Risk and uncertainty" are involved. It is "expected that ANP will gain more popularity in the future, as the benefits of ANP become better understood."[14]

4 Case Study Analysis

4.1 Semiconductor Equipment Industry Analysis

There is an overall industry trend towards smaller semiconductor devices, which has boosted demand for new semiconductor manufacturing machinery. Novellus is not the only major manufacturing company of semiconductor machinery and the industry in which they compete depends on the success or failure of semiconductor companies, such as Intel and Samsung. As seen below, this section aims to analyze Novellus's position in the industry using a popular strategy analysis method called Porter's 5 Forces model.



Figure 4: Porter's Five Forces Analysis of Novellus

1. Threat of New Entrants (Low)

This industry has very high barriers to entry which mean that new companies struggle to enter an industry at this mature stage. Standards are already stabilized and the adoption of this equipment is prevalent. The semiconductor industry is a very capital-intensive market which makes it hard for new company to enter into. New technologies and global demand will enable modest growth. The demand for semiconductor machinery will remain highly volatile.

2. Threat of Substitute Products(Low)

Semiconductor machinery manufacturers are challenged to speed development of new products and to produce them more cost-effectively. It requires very high technology knowledge assets. Therefore, the threat of substitute is low. Furthermore, the number of operators in the industry is consistently falling. Industry firms are focusing on improving operating efficiency, but have future potential for technological change. Companies that anticipate future market demands by developing and refining new technologies and manufacturing processes are better positioned to lead in the semiconductor market.

3. Competitive Rivalry (High)

There are key vendors dominating this market space such as Adeka Corp., Applied Materials Inc., ASM International N.V., and ATMI Inc. Most of them have their own core competitive market segments such as; Etching equipment, Thin layer deposition equipment, Micro-lithography wafer processing equipment, Semiconductor assembly and packaging machinery, Photolithography equipment, CVD equipment, Microelectromechanical systems (MEMS) manufacturing equipment, and Surface mount machinery for making printed circuit boards. But it has a very high competitive market structure. With the current intensity of rivalry, semiconductor equipment market is somewhat overcrowded and results in Mergers and Acquisitions (M&A). Lam Research bought out Novellus Systems in a friendly merger of two technology companies looking to consolidate and reduce costs. This merger was evaluated with good reputation with a broad portfolio of market-leading products and multiple opportunities to drive value creation through significant revenue and cost synergies in the semiconductor equipment market. Furthermore, recently ASML also acquired Cymer, a leading supplier of lithography light sources used by chipmakers to manufacture advanced semiconductor devices. ASML acquiring Cymer is intended to accelerate the development of Extreme Ultraviolet (EUV) semiconductor lithography technology and will improve ASML's abilities to bring new technologies to its clients. Firms must be able to anticipate technological trends, improve existing products and develop new products in order to remain competitive.

4. Bargaining Power of Customers (High)

As the technology customer market matures and standards are developed, the bargaining power depends on demand from semiconductor and circuit manufacturer such as Intel, Samsung, TSMC and Global Foundry. Demand depends on conditions in downstream semiconductor manufacturing, which is characterized by rapid technological change. Industry performance also relies on downstream demand for electronic products, such as TVs, computers and cell phones. Concentration is considered high and the competition could get intense as new substitutes emerge. Novellus is aware of this market impact and is quickly ramping up its incorporation of the new technology approach in its available models. Downstream semiconductor manufacturers will continue to be affected by technological change, which will then flow on to affect the Semiconductor Machinery Manufacturing industry.

5. Bargaining Power of Suppliers (Low)

Upstream of the semiconductor machinery manufacturers has low bargaining power. There is small number of suppliers who have high technology knowledge assets. Firms depend on a number of suppliers for components and subassemblies, and supply shortages or loss of suppliers can result in increased costs and manufacturing delays. Semiconductor equipment manufacturers face continuing pressures to manufacture increasingly complex machinery, improve machinery yields and reduce manufacturing costs.

4.2 Market Entry

Novellus's decision to diversify from their existing business could be due to three of the four reasons specified by Betz [15]. The main two reasons however were seen as either a need for growth by

innovation by launching a new product line and business, or possibly to extend the coverage of their existing markets. The questions to ask would be whether they were trying to move their existing customers over to this new product, were they trying to obtain new customers, or were they trying to do both. It did not seem as if they were diversifying to survive economic cycles since this product would still be used in the semiconductor industry which is prone to fluctuations. Additionally, the reason was not growth by acquisition since this was developed internally and no companies were acquired.

One of the strategic precepts on competition specified by Betz [15] is "If you don't have a competitive advantage, don't compete". Based on the initial competitor analysis by Novellus, they should not have entered the market. However they found another way to enter the market by focusing on the customer's customer. It is therefore important to not blindly follow this strategic precept unless all avenues of entering the market are evaluated. Another strategic precept on competition specifies that the company should "be aware of the changing nature of your competition". This is an important factor that was probably taken into account by Novellus but was not directly stated in the presentation. This changing competitive nature would be taken into account by the process specified in next section on current and future actions.

As can be determined from the case study, Novellus were entering a large and established market. Based on the four areas introduced by Betz [15] in the industry-context analysis of a business portfolio, area 1 relates to a large and established market, as would be the case with this product. In order for Novellus to become a dominant player they would require a relatively high share of the market. How would they achieve this? This could be achieved by following the proposed process of evaluating current and future actions shown in the next section.

4.3 Current and Future Actions

The analysis of the Novellus case is illustrated in Figure 5, which includes all the elements of a strategic and operations plan. All the sections marked in orange represent the strategy proposed by the guest speaker, which has been extended to more of a long-term strategy. The overall goal of the strategy proposed by the guest speaker was to enter an established market, which is illustrated in this figure as the **first Goal**. In order for Novellus to be a dominant player in this market their overall **Mission** should be to become the leader in the FSG film market. The communality between the three proposed goals should be the mission. Therefore once Novellus has entered the market, their **second Goal** should be to expand their market share, followed by the **third Goal** of differentiating further from their competitors, thereby becoming the market leaders. The three main **Objectives** identified that would realize the mission, would be to become flexible to changing customer needs, maintain profitability, and to improve the reliability and performance while reducing cost. The **Metrics** for these objectives would be the profit and the yield of the product. A description of the long-term **Strategy**, the **Tactics**, **Stakeholders, Competition, Knowledge,** and **Scenarios** are also shown in the figure.

One important addition to this process is to include the NABC method at each milestone. It is crucial at each of these milestones to analyze whether important customer **N**eeds have changed, determine whether the current **A**pproach meets these changing needs, determine whether there still are **B**enefits

per costs to the current or updated approach, and finally to ensure that the benefits per costs are still superior to the **C**ompetition. By following this process, the tactics can be updated accordingly to ensure that the Goals can still be met, and ultimately that the mission of the company is also met.



Figure 5: Current and Future Actions

5 Lessons learned

The guest speaker emphasizes the strategic thinking methods of NABC and OST. The two methods jointly work to make a good plan for technology or product R&D. In the real operation, the process of NABC and OST is a process of decision making. We summarized the process into the following 5 steps:

- 1. Step 1 Obtain information about customer and market needs;
- 2. Step 2 Obtain information about the competitors' product features;
- Step 3 Propose approaches to meet the needs of customers and differentiate from competitors. In this step, the problem of "What product should we develop in order to meet the needs of customers and to obtain competitive advantage?" is answered;

- 4. Step 4 Compare the benefits per costs of the alternative approaches. In this step, the problem of "What product will bring the greatest benefit per cost to development?" is answered;
- 5. Step 5 Specify the objectives, strategy, tactics and action plans based on step 1 to step 4.

6 Recommendations

The NABC and OST process could be quantified using an upgraded Hierarchical Decision Model (HDM) with desirability values based on the customers' feedback.

Gerdsri and Kocaoglu [16] used desirability functions to obtain the desirability measures of alternatives for different factors/sub-criteria. Desirability functions are used to evaluate different R&D alternatives. The metrics and values ($t_{nr, jkr, k}$) under each factor and criterion are first obtained by data collection, then the research method is conducted by sending research instruments to experts to obtain the desirability values of a wide range of data points for each metric. These values could also be obtained from a linear or a nonlinear function based on the developed functional relationship defined by the experts. Then the technological metrics are mapped to the desirability values. The calculation of the Technology Value [TV_n] as based on the equation below:

$$TV_{n} = \sum_{k=1}^{K} \sum_{jk=1}^{Jk} w_{k} \cdot f_{jk,k} \cdot V(t_{n,jk,k})$$

Where,

 TV_n : Technology value of alternative (n) determined according to an objective,

 w_k : Relative priority of criterion (k) with respect to the company's objective,

 f_{jk} k: Relative importance of factor (jk) with respect to criterion (k),

 t_{n, jk_k} : Performance and physical characteristics of technology (n) along with factor (jk) for criterion (k), $V(t_{n, jk_k})$: Desirability value of the performance and physical characteristics of technology (n) along factor (jk) for criterion (k).

In the NABC and OST methods, the benefit per cost is a concern. The HDM with desirability values doesn't include the cost as a concern, so the following step needs to be taken additionally.

The costs for the R&D approach alternatives should be estimated. This could be done by estimating the cost of personnel and materials. The benefit of the alternatives is the TV values. However, the risk aspects should be estimated too. If the possibility of failure is given, the benefit per cost value could be calculated as:

$$BpC_n = \frac{TV_n(1-f_n)}{C_n}$$

Where,

- BpC_n: Benefit per Cost of alternative (n),
- f_n : The estimated possibility of failure for alternative (n),
- C_n: Cost of alternative (n),

TV_n: Utility (Desirability) value of alternative (n) determined.

This methodology discussed above is a quantitative transformation of NABC and OST for the following reasons:

- **N (Need)**: The customers' needs are quantified using criteria and sub-criteria with the weights identified;
- A (Approach): The approaches are the company's alternatives for developing new products or technologies;
- **B** (Benefits per Costs): Benefits per costs are taken into consideration by the calculation of the BpC values for each alternative (approach);
- **C** (Competition): The competitor's products or technologies are listed out as alternatives to compare with the company's alternatives (approaches). In this way, the company can calculate what the competencies of the competitors are and what approaches the company should take in order to differentiate it from the competitors.
- **O (Objective)**: The objective is selecting a R&D approach;
- **S** (Strategy): The strategy is to differentiate the new product or technology from the competitors';
- **T (Tactics)**: The tactics are done by the decision of investment in one specific R&D alternative (selected using the quantified HDM model). In this way the resources are invested into the best approach of obtaining the most customer value with the least cost. The action following the tactics is to adjust the personnel and cost in order to focus on the most desirable R&D approach.



Figure 4: The Hierarchical Decision Model with Desirability Values

References

- [1] Answers, "Gale Directory of Company Histories: Novellus Systems Inc." [Online]. Available: http://www.answers.com/topic/novellus-systems-inc. [Accessed: 01-Jun-2013].
- Hoovers, "Novellus Systems, Inc. Company Profile." [Online]. Available: http://www.hoovers.com/company-information/cs/companyprofile.Novellus_Systems_Inc.b8f18122131f252e.html. [Accessed: 01-Jun-2013].
- [3] Lam Research, "Lam Research Completes Its Merger With Novellus Systems," 2012. [Online]. Available: http://investor.lamrc.com/releasedetail.cfm?ReleaseID=679833. [Accessed: 01-Jun-2013].
- [4] E. M. Rusli, "Lam Research to Buy Novellus Systems for \$3.3 Billion," New York Times, 2011.
 [Online]. Available: http://dealbook.nytimes.com/2011/12/14/lam-research-to-buy-novellus-systems-for-3-3-billion/. [Accessed: 01-Jun-2013].
- [5] R. Castellano, "Can Novellus Reinvigorate Lam Research?," 2012. [Online]. Available: http://seekingalpha.com/article/552401-can-novellus-reinvigorate-lam-research. [Accessed: 01-Jun-2013].
- [6] C. R. Carlson and W. W. Wilmot, *Innovation: The Five Disciplines for Creating What Customers Want*. New York, NY: Crown Business, 2006.
- [7] I. Wilson, "The State of Strategic Planning: What Went Wrong? What Goes Right?," *Technological Forecasting and Social Change*, vol. 37, pp. 103–110, 1990.
- [8] L. Heracleous, "Strategic Thinking or Strategic Planning?," *Long Range Planning*, vol. 31, no. 3, pp. 481–487, 1998.
- [9] J. M. Liedtka, "Strategic thinking: Can it be taught?," Long Range Planning, vol. 31, no. 1, pp. 120– 129, Feb. 1998.
- [10] F. Graetz, "Strategic thinking versus strategic planning: Towards understanding the complementarities," *Management Decision*, vol. 40, no. 5, pp. 456–462, 2002.
- [11] T. Stewart, "A Critical Survey on the Status of Multiple Criteria Decision Making Theory and Practice," *Omega*, vol. 20, no. 5–6, pp. 569–586, 1992.
- [12] I. B. Huang, J. Keisler, and I. Linkov, "Multi-criteria decision analysis in environmental sciences: ten years of applications and trends," *The Science of the total environment*, vol. 409, no. 19, pp. 3578–94, Sep. 2011.
- [13] H. A. Donegan and F. J. Dodd, "A New Approach to AHP Decision-Making," *The Statistician*, vol. 41, no. 3, pp. 295–302, 1992.

- [14] S. Sipahi and M. Timor, "The analytic hierarchy process and analytic network process: an overview of applications," *Management Decision*, vol. 48, no. 5, pp. 775–808, 2010.
- [15] F. Betz, *Executive Strategy: Strategic Management and Information Technology*, 1st ed. Wiley, 2001, p. 544.
- [16] G. Nathasit and D. F. Kocaoglu, "A Quantitative Model for the Strategic Evaluation of Emerging Technologies," in *PICMET*, 2004.