Technological Forecasting & Social Change 100 (2015) 29–38

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

Teaching case and teaching note systems equipment division at Ferrofluidics

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ARTICLE INFO

Article history:
Received 28 May 2014
Received in revised form 31 March 2015
Accepted 16 June 2015
Available online 15 July 2015

Keywords:
Ferrofluid
Nanotechnology
Project management
Management of technology

ABSTRACT

This article comprises a case and teaching note regarding the acquisition of a capital equipment business from a large company by a small nanotechnology materials firm. Specifically, in 1981, Ferrofluidics, a nanotechnology components manufacturer operating in New Hampshire, vertically integrates by acquiring Varian's silicon crystal puller division. Ferrofluidics intends to improve the Varian puller. However, there is little overlap between the firm's materials-based capabilities and competencies, and the capabilities and competencies required for the fabrication & assembly and after-sales service of the puller. Thus the case seeks to introduce students to the discipline of intelligently choosing a new project, here in the context of commercializing a novel nanotechnology component through forward or vertical integration into an oligopolistic competitive environment. The case is appropriate for a general management of technology core class, a technology strategy class, a class on project management, a class of corporate entrepreneurial action or a class on technology entrepreneurship. The teaching note provides the instructor with the opportunity to introduce students to the Strategy Technology Firm Fit Audit, core competencies, models of innovation, forward or vertical integration, the Technology Market Matrix, the technology lifecycle and winner-take-all-or-most.

1. Introduction

In 1986, the systems equipment division (SED) at Ferrofluidics[1], was in big trouble.[2] Sales, which peaked in 1985 at $9 million, were less than $3 million. They did not receive a new order during the last half of the 1986. By the end of the year it was apparent that the main product, "pullers," had severe quality problems. There were no backorders, and no prospective customers. The future looked bleak.

2. General corporate background

Ferrofluidics was founded in October 1968 by Dr. Ronald Moskowitz and Dr. James Rosensweig to pioneer the technical and market development of magnetic fluid technology. These men invented and patented this specialized materials technology while working as researchers on NASA sponsored projects in the early 1960's. NASA investigated magnetic fluid technology because of its potential as a sealed bearing which isolates hazardous environments from ambient normal conditions along a rotating shaft. These fluids, called ferrofluids, could be magnetized by suspending very fine magnetic particles in a liquid. The results were an extremely stable colloidal magnetic fluid. When a magnetic field was applied, the ferrofluid acquired a magnetic moment and could be precisely positioned and controlled.

Ferrofluids had superior properties as lubricants, sealing agents, bearings, and dampening agents. These materials had applications in many areas including the manufacture of contact lenses, hard disks, stereo speakers and semiconductors. For example, ferrofluids were used as a 'frictionless' sealed bearing which allowed a hard disk to spin at incredible rates. Another advantage of ferrofluids was that the seal prevented foreign particles from damaging the disks.

Ferrofluidics derived nearly all of its managerial, innovation and manufacturing processes based on materials research and development and manufacturing. The company developed numerous products based on ferrofluid technology. It sold ferrofluids as raw materials to some manufacturers; however, most sales and product offerings were small component parts, which were based on ferrofluid technology.

In the later 1970's, Ferrofluidics developed an innovative ferrofluidic-sealed bearing for high-temperature silicon crystal growing furnaces that were used in the Czochralski method of producing silicon. These huge machines, called "pullers" (Exhibits 1 and 2), were much more efficient with the addition of the ferrofluid seal. The machines were called pullers because in the Czochralski method (Exhibit 3) a seed crystal was dipped into a very pure molten material, and the silicon

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[1] The Systems Equipment Division was originally called the Crystal Systems Division.

[2] This case study would not have been possible without the permission granted by Dr. Kedar Gupta, Vice President and General Manager, Ferrofluidics Systems Equipment Division, and without the help of Jonathan Talbott, Operations Manager, Ferrofluidics Systems Equipment Division, Michael Osbourne, Manufacturing Manager, Kay Dorr, Executive Secretary, Rick Meier, Electrical Engineering Manager, Carl Chartier, Director of Process Technology, Dr. Jurek Koziol, R&D Manager, and many others.

http://dx.doi.org/10.1016/j.techfore.2015.06.009
0040-1625/

Exhibit 2
Physical properties of a puller.

Height	Closed: 6121.4 mm (241 in.) Full open: 6883.4 mm (271 in.)
Floor area	4108 mm (162″) × 1610 mm (62″)
Total weight	Approximately 8000 × kgs. (17,640 lbs.)
Furnace	Approximately 6000 × kgs. (13,230 lbs.)
Power supply	Approximately 1500 × kgs. (3307.5 lbs.)
Console	Approximately 500 × kgs (1102.5 lbs.)

crystal increased in size as the seed was slowly raised or "pulled" from the melt. By precisely controlling the temperature, and the speed of rotation and pulling, it was possible to extract a single crystal.

The Ferrofluidics puller was clearly superior to the incumbent sealed bearing technology and became very popular. Sales of these retrofit vacuum sealers reached $600,000 in the first year, and were the first real commercial success for Ferrofluidics. These seals became the "flagship technology" and were instrumental in making Ferrofluidics a profitable organization.

In the early 1980's, Ferrofluidics realized that ferrofluid technology had many applications. Corporate management also reasoned they might be able to increase profits by forward integrating into industries where ferrofluid technology was important. With this strategy in mind, the company searched for possible acquisition candidates. When it became known that Varian wanted to divest itself of a silicon crystal puller division, management thought they had a perfect match. As a supplier of a materials based component (i.e., ferrofluidic sealed bearing) used in the manufacture of silicon crystal pullers, they were familiar with the semiconductor silicon industry and thought it had great potential. However they had no experience in making any complex fabrication and assembly based product let alone one that had major separate subsystems and hundreds of thousands of parts. Embracing this opportunity is the antithesis of competence theory. During 1981, Ferrofluidics purchased the puller division from Varian for approximately $1.5 million. Pullers contained millions of parts, many major subsystems and sold for upwards of $500,000. Overnight, Ferrofluidics became a capital equipment supplier.

3. Systems equipment division (SED) division history

Management at Ferrofluidics was attracted to systems equipment division (SED) for a number of reasons. They projected that the silicon puller market would grow from average sales of 70 pullers per year to sales of 100 to 150 pullers per year. They wanted to be part of this burgeoning market. In addition, they perceived the production of silicon pullers as a relatively "low technology" industry, where the application of their technological expertise would give them a huge advantage.

Exhibit 4
Financial information (1980–1986).

	(000)						
	1980	1981	1982	1983	1984	1985	1986
Ferrofluidics including SED							
Revenue	3153	5056	7020	10,786	21,131	31,289	28,184
Operating income	199	437	(2418)	366	1739	2077	(261)
Net income	196	279	(2176)	127	1176	1207	(2512)
Earnings per share	0.03	0.04	(0.24)	0.01	0.12	0.12	(0.13)
Working capital	655	685	1670	1624	10,492	10,517	27,449
Total assets	2516	5099	7207	10,103	26,210	30,740	54,216
Long term debt	582	470	2038	2089	8971	11,368	20,564
Net worth	1,2242	2052	3178	3326	9831	12,575	25,025
SED							
Revenue			366	929	3548	9135	3106
Operating profit			(2414)	(884)	(618)	883	(1396)
Identifiable assets			877	1311	2156	3737	4822
Capital expenditures			75	2400	46	562	232

Ferrofluidics built their reputation by utilizing their strong research and development capabilities to deliver innovative products. The management at Ferrofluidics was convinced they could apply their "materials" based technological capabilities to the fabrication and assembly of silicon pullers.

During 1982, Ferrofluidics marketed the puller design they purchased from Varian and enjoyed limited success. During that year, Ferrofluidics began development of a new puller, the "Six-Four-Two" puller. This puller derived its name from the fact that it could produce silicon ingots with a six inch diameter, as well ingots with diameters of four and two inches. After a six-month design phase, the new puller was introduced to the market. The general manager of SED, Walter Hegaland, believed that the "Six-Four-Two" puller would be the technology leader in the industry. It was the most automated and most technologically advanced puller available. As this quote from the 1981 annual report shows, Ferrofluidics anticipated great things from the new product:

> The successful integration of ferrofluid technology to subsystems and systems is exemplified in the development of our innovative Six-Four-Two computer controlled, silicon crystal growing furnace. The system was designed to meet the total processing requirements for converting polycrystalline silicon into semiconductor grade, single crystal ingots at high productivity and yield. This new system incorporates a number of evolutionary advances including a sophisticated process control computer, complete vacuum integrity with Ferrofluidic rotary sealing, and a proprietary new simplified materials handling system, which in aggregate results in a revolutionary machine that meets the needs of the industry in the 1980's.[3]

The market for pullers was tied to the demand for silicon. The demand for silicon in turn was dependent on the demand for microelectronic devices. During the early 1980's, the silicon industry was experiencing rapid growth due to the demand for microelectronic devices. Silicon producers such as SHE, Monsanto-MEMC, and Wacker purchased pullers to produce the silicon ingots, which were converted into wafers. These wafers were the substrate on which most microelectronic devices were produced.

To better market the newly designed puller, Ferrofluidics attempted to increase their international presence in the market. Ferrofluidics purchased Sloan Technology Gmbh of Germany to market the pullers in Europe and established Nippon Ferrofluidics to sell the puller in Japan. As they improved their international presence, they also continued to improve the "Six-Four-Two" puller. Based on preliminary marketing survey information, the customers overwhelmingly preferred the new automated system to the more manual puller purchased from Varian. During the years 1982 and 1983, Ferrofluidics spent $2.4 million developing the new puller. This included a total write-down ($1.3 million) of the Varian technology and assets, which were considered obsolete. Despite attempting to market both the new and the old machines, 1982 was a dismal year. They did not sell a puller of either type. The $366,000 in sales was limited to replacement parts.

Yet Ferrofluidics was still enthusiastic about the future of SED. In the 1982 letter to stockholders, President Moskowitz stated that Ferrofluidics would be delivering the third generation of the Six-Four-Two puller in early 1983. The letter also stated SED was expanding their customer base by taking the first steps to develop pullers for manufacturers of other crystal based materials, such as gallium arsenide.

The first completely automated silicon production system, the fourth generation of the "Six-Four-Two" puller, was sold to Osaka Titanium Corporation (OTC) in 1983. This culminated over two years of development and innovation. In addition, Ferrofluidics entered into a program to jointly develop a gallium arsenide puller with Harris Semiconductor.

[3] Ferrodfluidics annual report Fiscal 1981.