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Case study of several Israeli Start-Ups in the fables semiconductor sector and niche sectors adjacent to the fables and the semiconductor sectors

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1. Background to the global semiconductor sector

1.1 The growth of the global semiconductor industry

A brief history of the semiconductor industry

The ability to store and process information in new ways has been essential to humankind's progress from the beginning of evolution and kept increasing throughout the years. Originating in the need to process large amounts of information quickly, the semiconductor industry has come of age since the world's first electronic computer deciphered codes during World War II. The solid-state electronics age began in 1947, with the development of the transistor, and growth was propelled by the 1959 discovery of the integrated circuit (IC).

Integrated circuits made personal computers possible, and these have transformed the world of business, as well as controls that make engines and machines run more cleanly and efficiently and medical systems that save lives. In so doing, they spawned industries that are able to generate hundreds of billions of dollars in revenues and provide jobs for millions of people. All these benefits accrue in no small measure from the fact that the semiconductor industry has been able to integrate more and more transistors onto chips, at ever lower costs.

Moore’s low and advantages in semiconductors manufacturing technology

In 1965, seven years after the integrated circuit was invented, Gordon Moore, who co-founded Intel Corporation in 1968, observed that the number of transistors that semiconductor makers could put on a chip was doubling every year. Moore correctly predicted that this pace would continue in the future. The phenomenon became known as Moore's Law. Because the doublings in density was not accompanied by an increase in cost, the expense per transistor was almost halved with each doubling. With twice as many transistors, a memory chip can store twice as much data. Higher levels of integration mean greater numbers of functional units can be integrated onto the chip, and more closely spaced devices, such as transistors, can interact with less delay. The advances gave users increased computing power for the same money, spurring sales of chips.

Integration continued to increase at an astounding rate. In the late 1970s, the pace slowed to a doubling of transistors every 18 months. But it has held at this rate ever since, leading to the present-day commercial integrated circuits with more than 10 million transistors.

Chips are made by creating and interconnecting transistors to form complex electronic systems on a sliver of silicon. The fabrication process is based on a series of steps, called mask layers, in which films of various materials are placed on the silicon and exposed to light. Typically, 200 or more chips are fabricated simultaneously on a thin disk – silicon wafer.

1.2 The growth of the global semiconductor chip design sector.

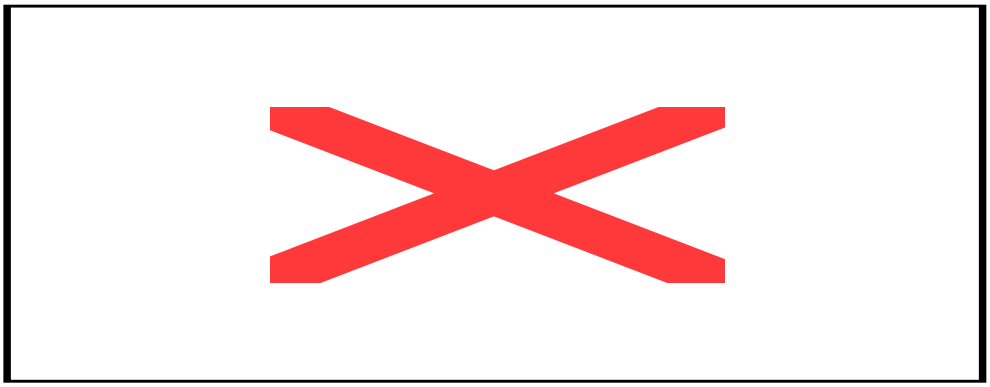
A brief history of the fables/chip design industry

Historically, disintegration/outsourcing has been driven by a high technology application of Adam Smith's specialization through "division of labor." This division achieves increased technical and operational efficiencies in fab, probe, assembly and test, creating some of the world's most competitive companies.

As the semiconductor industry continues to mature, these forces that have caused the growth in outsourcing are picking up momentum due to additional two fundamental facts: competitive pressures are speeding time-to-market, and IC complexity continues to grow exponentially. Over the last few years, not just start-ups, but also some of the largest semiconductor companies are blending a make/buy strategy to optimize their return on capital.

In the past decade we have seen the meteoric rise of one of the most important outsourcing model in the semiconductor industry - that of the fables firm, which designs and distributes integrated circuits, but contracts out the fabrication of the underlying wafers and packaging.

Exhibit 1: Semiconductor Supply Chain



The fables/Chip Design business model

The outsourcing of silicon wafers allows semiconductor companies to focus on the design and marketing of its product without the burden of building, operating and upgrading a manufacturing facility. As the cost of building a wafer fab and maintenance of leading-edge process technology escalates, the fabless model is an attractive long-term option for many semiconductor companies. By adopting a fabless business strategy, a company can focus time and resources on the design of innovative integrated circuits, while avoiding the high cost of operating an internal fabrication facility. This approach has proven highly successful. The fabless segment has been growing nearly twice as fast as the overall semiconductor market.

With the widespread availability of leading-edge technology from independent wafer foundries, many IDMs are also adopting a more fabless approach by outsourcing a portion of their manufacturing.

Fabless companies often beat traditional integrated circuits (IC) manufacturers to market. Advanced by their small size, they can turn designs around much faster. They also have the potential of being quickly profitable because they do not have to manufacture millions of chips to cover huge capital expenditures. Moreover, by using a fables model these companies reduce risk.

Applications of fables companies' products

The fables sector qualities, that were mentioned above, have contributed to the central role the fabless sector has played in fueling the current information appliance revolution, which requires a proliferation of new chips for each new generation of hand-held, networking, and communications products. Fables companies' products serve several markets and needs.

Exhibit 2: Primary Business by Market Sector and Business by Product:

(% of fabless companies concentrating on these markets, and on these products/technologies)

Market Sector/Application	Percentage	Technology Area	Percentage
Wired Communication	31%	Analog/ Mixed Signal	37%
Wireless Communication	23%	Logic	21%
PC Peripherals	17%	Microprocessor/Micro-	18%
Consumer	14%	Micro-peripheral	17%
PC	10%	Memory	7%
Industrial Medical	2%		
Defense Industries	2%		
Automotives	1%		

Source: FSA 2001.

Geographic areas of Concentration of fables companies

Worldwide fabless presence is growing. Today, about 625 purely fabless companies exist worldwide, which includes 450 in North America, 75 in Asia, 51 in Europe and 25 in Israel. There are seven primary centers of excellence including San Jose, Southern California (San Diego, Orange County, Los Angeles), Austin, Canada, United Kingdom, Taiwan and Israel.

Exhibit 3: Geographical Breakdown of Fabless Company Locations

(Percentage of fabless companies located in these geographic areas)

Geographical Area	Percentage
North America	84%
Europe	7%
Asia	5%
Israel	4%

Source: FSA 2001.

Geographic areas of boundaries serving the fables industry

Taiwan foundry dominance prevails. Despite proving that the foundry business is a sustainable and lucrative business model, there was little competition to the Taiwan foundries – UMC and TSMC. The foundries in Taiwan fulfill nearly 70 percent of fables global wafer demand.

Exhibit 4: Geographical Breakdown of foundry Company Locations

Company Name	Located in	% of total fables wafer demand
TSMC	Taiwan	41%
UMC	Taiwan	24%
Chartered Semiconductor	US	10%
American Microsystems	US	7%
Other	World wide	18%

The turndown in the market

In 2001, fabless companies and their foundry partners are expected to suffer less damage from the market downturn than the IDM community. Fabless companies have traditionally fared better in both good and bad times. In good times, like 2000, fabless companies and their foundry partners demonstrated they were agile suppliers with proprietary, high margin products that gained market share within their target markets. In a down cycle, fabless companies do not incur the burden of owning a fab and the fixed costs involved in keeping up with technology. But there is some risk that this old adage will not hold true in 2001. Fabless companies are heavily communications-centric, and a lot of downside risk exists for this group. Pure-play foundries, like TSMC and UMC, have proven to be highly flexible in both good and bad times. Both made important acquisitions that strengthened available capacity in 1999/2000. And, although growth is slated in 2001, the three foundries quickly reduced capital spending plans upon first sight of a downturn.

Fabless companies are hurt by lack of funding. One of the most obvious problems in the current market is the inability of fabless companies to obtain funding. If companies do get funded, the valuations will have a significant decrease. Nevertheless, more than 25 fabless companies received funding this year (2001 or 2002?).

Outlook of the fables segment

In 2000, revenues for the public fabless segment grew by 68 percent and outsourced manufacturing by IDMs nearly doubled. There are now 19 fabless companies with an annual run rate of $1 billion or greater; 11 have reached the $500 million; and another 8 have achieved $250 million. Today's purely fabless companies holds about 13 percent of the

worldwide IC market, totaling approximately $20 billion in revenues, and IDMs and systems houses outsource another $3 billion. Together, total outsourcing sales from fabless operations equals about $23 billion and comprises 15 percent of the world's outsourced wafer manufacturing. The FSA forecasts that by 2010, half of all integrated circuit (IC) revenue will emerge from operations that exploit a fabless business model, such as pure-play fabless companies and fabless operations of integrated device manufacturers (IDMs) and systems houses. According to FSA, the projected increase in outsourcing, from 15 percent to 50 percent in nine years, will come through the organic growth of existing fabless companies; emergence of fabless start-ups; adoption of a pure-play fabless business model by second- and third-tier IDMs; and use of strategic and opportunistic outsourcing by leading IDMs.

2. Background to the Israeli semiconductor sector

2.1 The growth of the Israeli semiconductor industry.

The fundamental basis of the Israeli semiconductor industry are the very strong microelectronic academic departments in Israel from the early 60's, which created skilled manpower that later emigrated to the Silicon Valley, gained important experience and returned to Israel.

In the 70s, several international high-tech companies came to Israel and established R&D centers. In addition, local industry continued to grow, and in 1972, Elscint became the first Israeli company traded on the Nasdaq. In 1974, the value of Israel's export of products based on local R&D reached $200 million. Today, Close to 10% of the world's electronics designers make their home in Israel. Government statistics boasted exports from start-up companies of $1.8 billion in 2000.

The three most important milestones in the Israeli semiconductor industry development were the establishment of Motorola Israel, of IBM Israel and of Intel Israel. Motorola Israel was established in 1964 (today employs 550) and was the first large multinational company to open facilities in Israel, IBM Israel was founded in 1972 and Intel Israel was founded in 1974.

Intel's entry to Israel

In 1974, Intel began operations in Israel, when Dr. Dov Frohman, an Israeli electric engineer who worked in Intel as a senior manager for many years brought Intel to Israel. It began with four founders in a small, modest building and grew to a bustling center employing over 1,000 engineers and producing innovation and inventions to the glory of the world's leading producer of semiconductors.

Dr. Dov Frohman is a forefather of Israel's high tech industry: a stubborn visionary, who brought Intel International to Israel, when life outside California was as yet unknown to Intel.

In 1974, Intel established a software house in Haifa, its first outside North America R&D Center and in 1978 Intel opened a sales office in Israel. In 1979, the first mathematical processor, 8087, was developed at Haifa R&D center. In the wake of this achievement, Intel CEO Andy Grove decided to establish a production plant in Israel. In 1984, Dov Frohman brought Intel International's first semiconductor foundry, outside the borders of the US, to Jerusalem. The Jerusalem plant was not only a cornerstone of the Israeli semiconductor industry. It also constituted proof that it is possible to efficiently manage a company in Israel, and surround it with suppliers and subcontractors, while operating on sound business principles, and pampering qualified manpower as its number one resource. In 1995, Intel Israel President Dov Frohman announced the establishment of an Intel plant in Kiryat Gat. Intel received a $600 million grant for this plant from the Israeli government (38% of the setup cost).

Intel's entrance to Israel had many important effects on the local semiconductor industry: Many talented young Israeli electronic engineers gained practical experience; young Israelis imitated them and got more motivated to study micro-electronics, and other Israeli companies in the field got spill-off of human resources and technology; and there was a rapid increase in demand for products and services of auxiliary industries of the semiconductor industry.

Government support of multinational semiconductor companies in Israel

Government manufacturing grants covering up to 20% of construction costs have convinced many multinational semiconductor companies to open facilities in Israel, which brings substantial revenue back to the country. These multinationals include Intel, National Semiconductors, KLA, Tower, Vishey, SCI Systems, Intertechnology, Fujitsu and many others.

In 1978, National semiconductor established its first facility in Israel, which today employs about 250. In 1993, Tower semiconductors established its first foundry in Israel, which today has 700 employees, after receiving Israel government grants. In 1999, Tower announced they hope to establish their second foundry in Israel (Migdal Ha'Emeq). With mainstream 0.18-micron CMOS processing capability, the fab is expected to draw a wide range of local customers, largely fabless communications IC developers that today must go to Taiwan or Singapore for manufacturing support. At first, Tower expects to generate about 10% of its revenue from Israeli companies, growing over time to 30%. Tower Semiconductors investments in the new plant will amount to more than $1 billion, and will bring employment for more than 1,000 workers. Israel is giving Tower a $250 million cash subsidy for the project. On top of that, Tower will receive tax benefits in the form of a tax holiday for the first

two profitable years, and for a 10-year period after that will pay a reduced tax rate on the order of 15%. Ordinarily, the company would be taxed at a rate of 35%.

In the early 90's, KLA Israel, wholly owned by the US KLA- Tencor Company, was established. It operates out of the Ramat Gavriel industrial zone in Migdal Ha'emeq, and has more than 140 employees.

In the mid 90's Vishay first entered Israel. Vishay Israel is engaged in the manufacturing of passive components for the electronic industry. In 1998, sales of Vishay Israel were about $335 million and in 1999, Vishay announced on a $480 million expansion (Vishay will receive a grant from the Israeli government of $100 million) of its facilities in Be'er-Sheva, Dimona, Holon, and Migdal Ha'Emeq.

Today, the company has four plants in Israel, in Migdal Ha'emek, Holon, Beer Sheva and Dimona, and has 3,300 employees.

In 1999, SCI Systems purchased a Ma'alot-based facility from telecom equipment maker Telrad Networks, in a deal that included a multiyear supply agreement worth more than $500 million.

In 2000, the Japanese concern Fujitsu began setting up an R&D center in Israel. The center, located in Herzliya will specialize in microelectronics. This is the first R&D center the giant Japanese concern is setting up in Israel. Fujitsu is among Japan's four leading concerns, with annual sales turnover totaling $40 billion. Fujitsu Microelectronics Israel will be a fully owned subsidiary of the Japanese Fujitsu group. The company will serve as the VLSI planning center of the Fujitsu Semiconductors group.

In 2000, Japanese company Tokyo Semitsu (TSK), which in practice is an international conglomerate with its head office in Japan, decided to set up and operate a development center in Israel.

Many other multinational semiconductor companies open different kinds of facilities in Israel, with Israel government support.

2.2 The growth of the Israeli semiconductor fables/chip design sector

Followed by the global trend toward fables, many Israeli companies adopted the fables model. The entrance of multinational semiconductor foundries to Israel supported this trend. This model also suited Israel's disadvantages, which are related to the size of the economy, the distance from the market and the high manufacturing costs.

Chip design startups are among the most important sectors of Hi-Tech companies in Israel. Chip design startups in Israel are responsible for a large portion of private placement capital

raised (it is hard to see this in the IVA survey due to the fact that usually chip design startups are categorized according to the sector they serve/ their technology application).

Many of the most important Israeli Hi-Tech success stories of the 90's are related to chip design companies including: Galileo, DSPC, Libit, AudioCodes, M-Systems, Zoran, Metalink, VisionTech, Saifun, and many others.

In 2000, more than a quarter of the M&A deals of Israel Hi-tech companies were related to chip design and five out of ten biggest M&A deals in this year were related to chip design (Galileo was acquired by Marvell for $2.7 billion – which was the largest M&A deal in Israel till then, VisionTech was acquired by BroadCom for $700 million, NogaTech was acquired by Zoran for $158 million, Shavhan was acquired by Infinion for $147 million and Firm8 was acquired by Orkit for $140 million).

Moreover, in 1999 the two largest M&A deals in Israel until the end of 1999, were also related to chip design startups - DSPC was acquired by Intel for $1.6 billion and Libit was acquired by IT for $465 million.

During the interviews and research on the chip design sector we found evidence, which gave us the feeling that the global crash in the Hi-tech sector will only emphasize the chip design sector's significance to Israel's Hi-tech cluster in the long run.

This evidence includes a higher portion of VC money spent on "deep technology" startups such as chip design, less decrease in chip design startups valuation in the last year, and the fact that today the private hi-tech company with the highest valuation (according to the last private placement valuation) is Saifun which is a chip design company. Moreover, among the top 10 private companies in Israel (according to the private placement valuation) there are at least three chip design companies (Saifun, EZchip and Mobilian).

Chapter B: Case studies of Israeli Start-Ups in the sector

3. Case studies

3.1 Research summary

We believe that our sample of chip design startups is a representative one, with few biases. Considering the fact that the entire population of chip design companies in Israel is 25 companies (according to FSA – fables semiconductor association), we believe it will be reasonable to look on the sample statistics as representative. We included in our sample startups with different characteristics in many aspects such as the founders background, the startup technology and target markets, their data of establishment and their potential or actual success.

We have identified very strong entrepreneur background (education, work experience…) and strong technologies (for significant segments) in many of the companies interviewed. These characteristics are strongly related to the future success of these startups.

We believe, relying on the interviews, that the Yozma program had significant influence on the growth of the chip design sector in Israel. On the other hand, the existence of many high potential chip design startups (as well as other hi-tech startups) in the early 90's (prior to Yozma emergence) was critical for Yozma's success.

We found that startups in this sector had different strategies towards capital rising, which was not related only to their potential success or reputation.

The availability of early stage capital (due to Yozma program) and the increase of the Israeli hi-tech reputation opened the door to companies in the sample to get finance (late stages usually) from global investors (mostly US and Japanese VCs and strategic investors).

As the sector grew faster than the academy adjustment, human resources shortage increased throughout the 90's and became severe during the Nasdaq "bubble" years. Today, there is still a shortage of high quality human capital but these are reasonable difficulties.

We have suggested an optimal growth profile model (with few paths) for Israeli startups in the chip design sector. The optimal growth profile depends on the startup's (and its management team) capabilities.

The basics characteristics incorporated into this growth model (companies that don't suit the model have very low chances of becoming successful companies in this field) include very strong entrepreneur background, strong technology, additional strong initial team and use of a business model based on OEM and strategic agreements.

The strong background should include strong educational background - at least M.S.c in electric engineering/micro electronics/applied physics (usually PhD), very strong work experience – few years experience from both multinational semiconductor company and a semiconductor startup, diversified work positions - managerial positions, R&D positions and marketing positions, strong and significant technology – a technology in a significant segment of the market that gives the startup a significant advantage over mature companies in the market.

Although these characteristics seem trivial, we believe the difference is that for Israeli startups in the fables semiconductor industry these characteristics not only contribute to chances of success, but also are vital to having any chance of success.

According to our initial model, companies satisfying the model characteristics may go through 4 main paths:

Path1 (very successful companies): companies with founders with very strong background and experience and very strong technology. These factors often leverage the company into strong OEM and strategic agreements with leading multinational companies. The companies' initial success enables them to go through a successful IPO, which helps them keep growing. Later on, when the technology gap closed and the market consolidation in their segment began, they were attractive enough to be acquired by one of the competitors for a significant amount. In Israel, we identified 2 companies, which have gone through path1.

Path2 (tremendous success or moderate success): path2 is divided to 2 types of companies. Type1 (tremendous success) - companies with the same characteristics of companies in path1 (or maybe even stronger background and technology), which went through successful IPO and succeeded in leveraging their initial advantages better than companies from path1, and as a result succeeded in staying independent companies despite the consolidation on the market. These companies are market leaders in their segment and become large multinational companies. Type2 (moderate success) - companies with weaker characteristics of companies in path1 (weaker background and technology or technology which applies to less significant market segments), which went through successful IPO but were not attractive enough when the market consolidation began and as a result were not acquired and remained a medium company. In Israel, we identified 6-8 companies, which have gone through path2 (most of them from type2 but same may become type1).

Path3 (successful companies or successful technology exits): Paths3 is divided into 2 types of companies. Type1 – companies with very strong technology in a significant segment that due to weak managerial capabilities or due to entrepreneur preferences decided to make an early sale exit. These companies due to their very strong technology were able, in spite of their early stage, to be acquired for a significant amount. Type2 – companies with strong technology but with weak managerial abilities and/or work experience that their only chance to have any profit from the startup was to sell their technology/company in an early stage for a moderate amount.

In Israel, we identified 3-4 companies, which have gone through path3 (only 1 was from type1).

Path4 (young startups) – companies that suit the model but are still too young to determine which path they will pursue.

We believe that most companies that don't suit the growth profile have small chances of becoming successful companies in the chip design sector.

Most of the startups that suit the model fit into it sooner or later. We identified between seven to ten companies in our sample that fit this model, and five of these were already successful (between moderate success and tremendous success).

We believe that in most cases our model can be helpful to policy makers in choosing an appropriate policy/program to use in order to promote chip design companies and the successful growth of the chip design sector.
We also believe that this model can be helpful to venture capitalists as a checklist prior to any investment in this sector. Moreover, this model can help the entrepreneur to decide whether they are ready to establish their own startup.

3.2 Case studies analysis

3.2.1 The Sample

The case study analysis is based on interviews with 10 Israeli startups and another 5 in-depth studies on Israeli startups, both in the chip design core business and in industries related to semiconductor industry. These industries include fables/chip design segment (11 startup – 6 interviewed and 5 in-depth studies), and the niche segments of tools for different steps in the chip production (4 startups – 2 products for simulation during chip design, and 2 products which assist in wafer production).
Chip design companies develop applications for several different technology sectors. Among the startups we researched we observed six categories of applications for different technology segments. These segments include chips for cellular phones (3 startups – 2 interviewed, 1 in-depth study), chips for modems (2 startups – 1 interviewed and 1 in-depth study), Flash Memory (2 startups – 1 interviewed and 1 in-depth study), chips for DVD and TV (2 startups – 1 interviewed and 1 in-depth study), other applications (2 startups – 1 power line communication and 1 IC communication chips). The startups, which were interviewed, were chosen according to our ability to find information on the companies and their willingness to meet us. As a result, we believe there is a bias in our sample toward interviewing startups with above-average performances. On the other hand, our sample includes 15 Israeli startups in the field out of a total population of 40-55 startups (according to the FSA there are 25 fabless/chip design companies in Israel, according to other resources there are about 10-15 Israeli startups in related fields and another 15-20 companies in industries that are very weakly related to the semiconductor industry).
Two startups in the sample were established before the 90's and therefor had to raise early stage capital prior to the first phase of the Israeli VC industry (see VC report). Five startups in the sample were established between 1992-1994, which means the early stage finance took place in the first phase of the Israeli VC industry. Among these startups there are three companies (Galileo, Libit and DSPC) that played a significant role in building

and strengthening the Israeli hi-tech reputation, and as such had a critical role in the Israeli hi-tech success in the 90's. Five startups in the sample were established between 1995-1997, which means their early stage finance took place in the second phase of the Israeli VC industry. The last three startups in the sample were established between 1998-1999, which means their early stage finance took place in the third phase of the Israeli VC industry.

Exhibit 5: Sample description

	Company	Establishment	Field	Application
1	Firm2	1996	Semiconductor related	Tools for production of wafers
2	FIRM13	1992	Chip Design	DSP Chips for Cellular
3	Firm15	1992	Chip Design	Chips & IC for communication
4	Firm4	1997	Semiconductor related	Tools for production of wafers
5	Firm7	1996	Chip Design	Power Line Communication chips (PLC)
6	Firm10	1994	Chip Design	Chips for Cable Modems
7	Firm11	1999	Chip Design	Chips for Cellular 3G
8	Firm5	1998	Chip Design	Chips for Cellular 3G
9	Firm12	1989	Chip Design	Flash memory Chips
10	Firm6	1993	Chip Design	Chips for Digital TV
11	Firm9	1998	Chip Design	Flash memory Chips
12	Firm1	1993	Semiconductor related	Tools for Chip Design
13	Firm8	1995	Chip Design	DSL Chips
14	Firm3	1997	Semiconductor related	Tools for Chip Design
15	Firm14	1982	Chip Design	Chips for DVD

3.2.2 Company profiles

Firm2

Firm2 started its operations in 1995 as part of the Technion Incubator (TEIC). During this stage, within the incubator, Firm2 developed its Electrophoretic Deposition (EPD) core technology. Later in 1998, Firm2 had spun-off transferring all the IP rights from the Technion under its ownership. Based on its proprietary technology, Firm2 develops new Ceramic Multi Chip Modules (MCM-C) and their production technology for microelectronics, automotive and primarily for RF telecommunication products like cellular phones, various PDAs, and for the implementation of the Bluetooth standard (the new standard for personal area wireless communications).

Firm2 has ten full time professional employees in the fields of Physics, Materials, Chemistry and Engineering.

Management

***Ashaf Thon**, CEO* - Dr. Thon has engineering and management experience in the microelectronics industry. He has academic background in Chemical Engineering and

Applied Physics from the Technion, the Hebrew University in Jerusalem and the University of Wisconsin in Madison.

***Israel Schustur**, CTO* - Dr. Schuster received his Ph.D. in Physics from the Technion. He holds a Doctoral Position at the University of California in Berkeley. During his academic career he worked on remote temperature sensing in the microelectronics equipment industry and later as a Project Leader developing Electro-optical systems.

FIRM13

In 1987, Dodi Gila acquired two companies DSP and CallTalk. He merged them into one firm called DSP Group. CallTalk was established in 1985 by a group of engineers that researched wide areas including speech and voice identification, noise reduction, voice compression, voice processing and frequency duplication. The company focused on outsourcing projects mainly for the military. DSP concentrated on DSP technologies. Dodi Gila decided to change the merged firm's concept from military voice equipment to civil phone equipment and focused the company's core business into improvement of voice quality and developing technologies. In 1992, he split the DSP Group into two companies DSPG and FIRM13. The trigger to this split was that while DSP Group was established in the business of voice processing to telephony, the company identified a new rapid growing segment of voice processing for the cellular market. FIRM13 went to an IPO in NASDAQ at March 1995. In 1999, Intel acquired FIRM13 for $1.6 billion.

Management

***Dr. Joseph M. Perl**,* President and CEO - Dr. Perl was the CEO of FIRM13 Until June'99, shortly before Intel acquired the company. Dr. Perl had been with FIRM13 since July'90, serving in various management positions.

Prior to FIRM13, Dr. Perl's career combined adjunct academic appointments with Tel Aviv University, Florida State University and University of Nebraska with full-time positions at Tadiran Electronics and Elbit Computer. Dr. Perl received his academic degrees in Electronic Engineering from the Technion and Colorado State University.

Firm15

In early 1992, Avigdor Willenz founded Firm15, which focused on the field of very complex communications chips. At the end of Firm15's first year they raised seed money from private investors and later, they had another 2-3 rounds of private placements from VC. In 1997, they went to an IPO in NASDAQ and raised $61 million with a valuation of $334 million. Today, Firm15 develops, manufactures and markets, system controllers, switching controllers and remote access controllers, which provide key functionality for data-communication OEMs.

Management

***Avigdor Willenz**, CEO and founder* **-** He served as Firm15's CEO and chairman of the board from 1992 until 2001. Before Firm15 he was Chief Engineer for Integrated Device Technology (IDT) from August 1988 until 1992. Before joining IDT, Mr. Willenz worked for four years at Elbit Computers Ltd., where he was a design manager of avionic computers. Mr. Willenz holds a B.Sc.E.E from the Technion.

***Eliaz Lavi**, VP of Operations* **-** Eliaz Lavi has over 17 years of experience in the electronics-semiconductors industry. As a manager at Intel Corporation, he was responsible for the X87 Numeric Co-Processors product family. From 1992 until 1996, Mr. Lavi held the position of Test Engineering and labs Manager of Intel's Israel Development Center. In 1996 Mr. Lavi joined Firm15 Technology as VP of Operations and has established and built up the operations organization. Mr Lavi holds a B.Sc.E.E from the Technion.

***Manuel Alba,** President* – Manuel has 22 years of experience in the electronics industry. Mr. Alba was President of Firm15 from 1993 until its merger with Marvell in January of 2001. Prior to establishing Firm15 Technology's business operation, he spent five years at IDT, working in all aspects of marketing. Prior to IDT, Mr. Alba spent six years at National Semiconductor. Mr. Alba spent three years as a hardware design engineer at Philco-Ford. He holds a BSEE from the National Polytechnic Institute (Mexico City), an MSEE from the University of Southern California, and an MBA from the University of Santa Clara.

Firm4

Michael Gefen established firm4, in 1997, after recognizing that many companies in the industry often neglect the semiconductor back-end. This has led Firm4 to revolutionize application-oriented vision inspection, by developing and marketing interdisciplinary systems that increase the throughput and yield of back-end semiconductor processing technologies. These systems are fully automated kerf inspection systems for wafer dicing operation. In August 2001, Comtach acquired Firm4 for $2.25 million.

Management

***Michael Gefen,** CEO and founder* - worked for a few years in KLA (a multinational semiconductor company) both in Silicon Valley and in Israel. In 1990, he left KLA and began to work as a subcontractor, during his work he identified an unsolved problem and as a result in 1997, he established Firm4.

FIRM7

FIRM7 was established in the end of 1996. FIRM7, designs, develops and markets proprietary mixed-signal integrated circuits for Home Networking applications. FIRM7's initial product lines are high-speed and low-speed power line modem chips for communicating data, voice and video over existing electrical wiring infrastructure. FIRM7 offers a wide spectrum of broadband and narrowband solutions aimed at home networking, residential access and home automation markets. FIRM7 also develops an advanced line of reliable long-distance components that enable transmission control, telemetry and low-speed data transmission.

FIRM7's Chips are the least expensive chips available on a price/performance basis due to the simplicity of FIRM7's IC architecture and the Chips' low power consumption and small form factor.

Management

Mr. Avner Matmor*, co-founder and CEO* - Matmor serves as President and CEO of FIRM7. In 1981, Mr. Matmor received his B.Sc. from the Ben Gurion University. Since 1990, Mr. Matmor has been assigned to several managerial positions for corporations in operations, marketing, business development and finance. Between 1993 and 1995 Mr. Matmor was VP of operations for QualiTau's Israel.

Dr. Dan Raphaeli*, founder and CTO* - Dr. Raphaeli, received his B.Sc. (Cum Laude), at age of 18, from the Ben Gurion University (1986) and PhD (1994) from the CALTECH. Dr. Raphaeli served 5 years working for the Electronic Research Department of the Israel Ministry of Defense, in various areas of communications.

From 1992-1994 Dr. Raphaeli was at the Communication Research Section of the JPL, NASA. Since 1994, Dr. Raphaeli is with the Department of Electrical Engineering-Systems at the University of Tel Aviv where he is an Associate Professor. Dr. Raphaeli has contributed to the areas of power line, wireless and satellite communications through his published works and consulting services for leading communication companies active in modulation, coding, RF, DSP and MODEM architectures.

Firm10

Firm10 develops and markets highly integrated silicon solutions for broadband access. Firm10 targets its products to the cable modem, cable set-top box, and digital TV markets, empowering high-speed Internet access, IP telephony and digital TV applications. Firm10’s products are fully compliant with all leading international standards.

Firm10 was founded, in 1994, by three entrepreneurs who all had both PhD in electric engineering and industrial experience in the IDF top units.

The company's first development (95'-96') was a joint project with Analog Davis with support from the BIRD fund. In 1996, they began developing the chip for cable modems and in end of 1997 they already had a finished prototype of the chip that will be the center of the cable modem.

In the end of 1998, the leading international standards became obliging, and Firm10 became one of the two firms in the world that were working according to the standards (the second company was Broadcom). At this point, the interest in Firm10 rose, and leading firms in the semiconductor industry began to co-operate with Firm10. In 1999, Texas Instruments acquired Firm10 for $365 million.

Management

Prof. Ehod Winshtian*, co-founder and CEO* - Before establishing Firm10 he was the head of electronic engineering in Tel Aviv University and a leading member in MIT. He had experience in IDF top electronic unit. Prof. Weinstein is an internationally recognized authority in the field of signal processing. He has received several awards for his scientific contributions. He has filed and holds several patents in the fields of signal processing and communications. He has been a consultant to several high technology companies in Israel and in the US.

Dr. Modi Segal*, co-founder and VP* - Before establishing Firm10 he was the CTO of Orkit and was in leading positions in an R&D unit in the IDF. He holds a PhD in electric engineering from Tel Aviv University (he was a PhD student of Prof. Ehod Winshtian).

Dr. Ofhir Sheloi*, co-founder and VP* - Before establishing Firm10 he was leading positions in an R&D unit in the IDF. He holds a PhD in electric engineering from Tel Aviv University (he was a PhD student of Prof. Ehod Winshtian).

Mr. Tanz, VP of Sales and Marketing - Prior to Firm10, Mr. Tanz devoted several years at Terayon in establishing their SCDMA technology in the Broadband Cable industry. Mr. Tanz held various sales, marketing and business development positions at Intel Corporation for 15 years and, prior to his departure, led Intel's Broadband Cable activities. Mr. Tanz holds a BSEE from UCLA.

Firm11

Senior executives from Qualcomm and Intel founded Firm11 in 1999 to address the increasing market demand for wireless connectivity to the Internet, corporate data and personal information. Firm11 is a wireless systems company that designs and develops analog and digital integrated circuits and host and embedded software for standards-based wireless data communications. Firm11's TrueConnectivity™ architecture enables computing and

communication devices to automatically detect wireless networking opportunities, select the ones needed, and connect to them seamlessly and reliably.

Firm11's first product is called TrueRadio™, which is a two-chip WPAN/WLAN solution that integrates Bluetooth and Wi-Fi radios on a single analog chip, and performs all baseband processing on a single digital chip. The company operates out of threes sites: San Diego, CA and Israel.

Management

***Manpreet Khaira**, Chairman, President, CEO, and Founder* - Manpreet is an industry-recognized expert in VLSI design and management. Prior to founding Firm11, he was principal engineer and director of an advanced design technology group at Intel. He founded the group in 1994 and advanced it to one of the largest and most prolific advanced design technology groups in the industry. Manpreet began his career in the Intel super computer systems division where he developed validation and verification technologies to reduce the number of steps for chipsets to get to high-volume manufacturing. Later on he served in many other R&D and management positions in Intel. Manpreet received his B.S. in computer science and engineering from the Indian Institute of Technology, Kharagpur, and won the distinguished President of India Gold Medal for academic excellence. He earned his M.S. in computer science at Carnegie-Mellon University. Manpreet has seven patents and 20 publications to his credit.

***Brett Monello**, VP Country Manager, Israel, and a co-founder* - Brett brings 11 years of broad-based, cross-functional business and technology experience to Firm11. Prior to co-founding the company, Brett worked at Silicon Graphics Computer Systems (SGI) for eight years. His most recent position was director of marketing at SGI. Prior to that, Brett had direct responsibility for both a desktop and desk-side production line. Brett graduated from Stanford University with distinction in economics and psychology. He earned his M.B.A. from the Harvard Business School, graduating with Highest Distinction (Baker Scholar) and being named the John E. Thayer Scholar, a faculty-selected excellent student award.

***Ephi Zehavi** CTO and co-founder* - Prior to founding Firm11, Ephi was VP of engineering and the thirteenth employee at Qualcomm. He also earned the position as general manager of Qualcomm Israel. Ephi is one of the original developers of CDMA technology, and the co-inventor of the "pragmatic trellis coding" technique, which is widely used in Cable TV, LMDS and other communication standards. He holds 26 patents and 30 papers to his credit. His latest patents are key to 3G cellular systems in the United States including co-inventing the "multi-carrier" approach, which allows 2G and 3G systems to coexist. Currently, Ephi is a leader in Firm11's patent portfolio. He received his B.S. and M.S. in electrical engineering from the Technion, and his Ph.D. from the University of Massachusetts at Amherst.

***Ran Ginosar** , VP of Product Architecture and Israel Site Manager* - Ran brings 17 years of experience as an expert in VLSI and signal processing as well as startup experience to Firm11. Most recently, he was the director of the VLSI Systems Research Center at Technion. Ran co-founded i-Sight, in 1990 to commercialize a digital video camera, which he co-invented. In 1995 he co-founded UltraGuide, a manufacturer of a proprietary guidance system for minimally invasive medical procedures. Ran has 12 patents, with other patents pending, and 65 papers to his credit. He received his B.S. from the Technion, where he graduated summa cum laude, and his Ph.D. from Princeton University, both in electrical engineering and computer science.

Firm5

Firm5 is an Israel fabless semiconductor Start-up that designs and markets programmable and integrated silicon-based communication engines for wideband and broadband communication systems.

Firm5 is focused on providing its first Baseband Processor designed for the 3rd Generation cellular market, which supports the evolving Wideband Code Division Multiple Access (W-CDMA) mode of the IMT-2000, 3GPP, ARIB and ETSI (UMTS) Standard.

Firm5 was founded at the beginning of 1998 in Israel, by Shlomo Gadot and Dr. Yossi Kofman, with the mission of providing programmable, highly integrated, system level silicon solutions to the emerging broadband digital communications markets. Firm5 today employs more than 40 experienced and highly motivated individuals.

Firm12

Firm12 (Nasdaq) develops, manufactures and markets innovative electronic disks that provide data storage based on flash memory for markets such as set-top boxes, mobile phones, thin clients, embedded systems, telecommunications, military/rugged applications, audio/video servers, PCs and laptops.

Firm12 leads the market in flash-based data storage products. They were the first to introduce a complete flash disk on a single-die, with their breakthrough DiskOnChip technology - the most cost-effective flash disk solution in the world. The DiskOnChip Millennium, developed from their joint agreement with Toshiba, remains the only single-die flash disk solution available today.

Firm12 family of flash-based data storage products includes both removable and non-removable storage media in a wide range of capacities, interfaces, form factors and technologies. Firm12 has offices in the United States, Japan, Taiwan, Korea, China, Israel and Europe.

Management

Dov Moran, co-founder, President, CEO and Chairman of the Board - From 1984 to 1989, Mr. Moran was an independent consultant in the computer industry. Prior thereto, Mr. Moran served in the Israeli Navy for seven years and was director of its microprocessors department. Mr. Moran received a B.Sc. in Computers and Electronic Engineering from the Technion, in 1977.

Amir Friedman, co-founder - Mr. Friedman served as VP for U.S. operations from 1991 to 1994, as the President of MSU from 1989 to 1994. Mr. Friedman is also a founder and director of Connect-ONE, and has served as its President since 1995. Mr. Friedman received a B.Sc. in Electronic Engineering from the University of Wisconsin in 1981 and an M.B.A. from Tel-Aviv University in 1989.

Aryeh Mergi, co-founder and director - Mr. Mergi has been Executive VP of Business Development of the Company since 2000. From 1995 to 2000, he served as Executive VP of Sales and Marketing. From 1989 to 1995, he served as VP of R&D. Mr. Mergi received a B.Sc. in Electronic Engineering (with honors) from the Technion in 1988.

Firm6

Firm6 has developed a multi-path Digital Signal Processing (DSP) technology. The company was founded on a proprietary DSP and complex digital filters used in military applications. As this technology was perfected, a group of investors had the vision of applying it to the consumer electronics and broadband communications markets. This technology was developed, tested, and improved in a number of deployments, with a number of industry partners.

Firm6 engineers refined this application experience and developed a series of algorithms aimed at correcting distortions in terrestrially transmitted signals. Firm6's mission is to enable analog and digital broadband communication and image enhancement through the design, manufacture, and marketing of its patented digital filter and digital signal processing (DSP) technology. Firm6 Semiconductor has offices in Israel, Japan, and the United States.

Management

Rafi Retter*, Vice President and General Manager* - Mr. Retter leads all aspects of Firm6 engineering and manufacturing activities. Mr. Retter has over twenty years of experience in the development and management of microprocessor and DSP-related programs. Mr. Retter was a project engineer at Intel responsible for RISC and numeric processor projects, and was the lead designer of the 8088 microprocessors. In 1983, Mr. Retter joined Zoran as director of engineering. Mr. Retter was VP of R&D for Zoran from 1990 to 1993. Mr. Retter holds BScEE and MScEE degrees from the Technion Israel Institute of technology.

Dr. Yonatan Manor, System & Algorithm Design Director - Dr. Manor joined Firm6 (before the spin-off from Zoran) in 1993 where he was responsible for ghost cancellation development. Prior to joining Firm6, Dr Manor was Technical manager at Elbit Computers. From 1981 to 1983, Dr. Manor was a senior research engineer at Occidental Research Corporation in California. Dr. Manor holds a BSc degree in chemical engineering from the Technion, and MSc and PhD degrees in Chemical Engineering from the University of Illinois.

Firm9

Dr. Boaz Eitan founded Firm9 in February 1998 in Israel. The company is about to change the NVM market in its high-end products and applications (Flash, EEPROM and Embedded NVM). In many current applications, the NVM technology is a limiting factor. Firm9 NROMTM technology successfully overcomes those limitations.

Firm9 has developed a leading edge Non Volatile Memory (NVM) technology. The Firm9 NROM revolutionary technology places 2 physical bits per cell, enabling production of the most cost-effective, best performing NVM products in the market. The Firm9 NROMTM technology offers various advantages over the existing technology for NVM products.

Up until now, NVM technology has been a bottleneck that prevented faster technological progress in many evolving applications such as cellular phones, networking systems, smart cards, digital camera, and internet appliances. Firm9's patented NROMTM offers a significant leapfrog for those bottlenecks.

Management

Dr. Boaz Eitan*, Founder, President and CEO* – From 1981 to 1983 Dr. Eitan served as a physicist at Intel's R&D Center in California. In 1983 he joined WSI, as a developer of embedded memory products, in California. There he served in several managerial and R&D positions. In 1992 Dr. Eitan returned to Israel and established WSI's design center. In the last few years, Dr. Eitan has led several R&D projects in the microelectronics area, focusing on Embedded EPROM and FLASH based products. Dr. Eitan holds 36 patents, and 15 more are pending.

Dr. Eitan holds a B.Sc. Physics and Mathematics, Hebrew University, Jerusalem; M.S.c and Ph.D. Physics, Physical limitation of Microelectronics components, Hebrew University, Jerusalem.

Kobi Rozengarten*, COO* – From 1983 to 1987, Mr. Rozengarten worked at Elbit Computer as manager of Finance planning and control. From 1987 to 1997 Mr. Rozengarten served with Kulicke and Soffa, Industries, a supplier of equipment for the semiconductor industry, in several high management positions. In 1993 Mr. Rozengarten returned to Israel, where he was Managing Director of Micro-Swiss a subsidiary of K&S. He holds a B.Sc. in Industrial

Engineering, Information Systems and an M.Sc in Industrial Management, from the Technion.

***Dror Avni**, VP Product Development* – From 1981 to 1996, Mr. Avni was on staff at Intel, at the Haifa Design Center. Up to 1991, Avni served as senior project manager. Since 1991, he served as a Department Manager in various departments. From 1991 to 1996, Mr. Avni was a member of the Haifa design-center management staff. Mr. Avni then joined Ross Semiconductors, and served as an Engineering Manager. Mr. Avni holds 4 patents in the circuit design sector. Avni holds B.Sc.EE, from the Technion; and MBA from Tel-Aviv University.

***Dr. Yair Alpern**, VP Business Development* – From 1986 to 1989 Dr. Alpern served as a physicist and later on as R&D manager at the Electro Optical Component Center of Tadiran. Between 1989 and 1991 Dr. Alpern served as a project manager at Luz Industries responsible for a large multidisciplinary project in the field of solar energy. At 1991 Dr. Alpern joined Semiconductors Devices as VP of R&D and between 1992 and 1999 led the company as a CEO. Dr. Alpern holds BSc in Physics and mathematics from the Hebrew University, MSc. and PhD Physics from Microelectronics Department, Hebrew University.

Firm1

Firm1, which was founded in 1994, develops and markets software based solutions for reuse, migration and re-implementation of integrated circuit (IC) physical design in deep sub-micron (DSM) processes. Firm1 enables semiconductor companies to very quickly implement and introduce to the market System-on-Chip (SoC) products in the latest available fabrication technologies.

Firm1 tools ensure designers can efficiently implement systems on silicon; meet time to market and time to volume requirements; and take full advantage of the latest process technology, while being assured true process independence.

Firm1's corporate headquarters for sales, support and marketing is in Fremont, California.

Firm1's research and development centers are located in the Netherlands and Israel.

Firm1 initial technology was developed in the Netherlands and was sold to Israeli VCs, which founded the company.

Firm8

Firm8 designs and manufactures ultra-high density full-custom **ASiX**s for the deep-submicron age. Compared to traditional cell-based ASICs, Firm8's **ASiX**s can: reduce die area and cost by fifty percent or more; improve performance and power consumption by 2X or more; achieve faster timing closure.

Firm8 is fab-independent and relies on state-of-the-art independent foundries for its wafer production. Current foundry partners include TSMC, Chartered Semiconductor and Amkor. Firm8's technology offers Access to the most advanced deep-submicron processes (0.18-micron and 0.13 micron)

Firm8's customers are communications and consumer electronics companies that need high-complexity devices that challenge the limits of the prevalent ASIC technology in performance, power and/or cost.

Firm8 was Aquired by Orkit in 1999; spun off by Orkit in 2000 along with Tioga; and acquired again by Zen Research from Tioga in 2001.

Management

***Vacit Arat**, co-founder and CEO* - Vacit has 18 years of experience in the semiconductor industry. As the VP of Marketing & Sales for the company, Vacit opened Firm8's U.S. office in 1998. Later as the U.S. General Manager, he helped set up the company's design center in the Silicon Valley and positioned the company to focus on high-end specialty ASICs. Previously, he was part of IBM Microelectronics sales force in the Silicon Valley, and a co-founder of Crosspoint Solutions. In the 80s, Vacit held various sales and marketing positions at Samsung Semiconductor, LSI Logic and Honeywell. He holds a B.S from the University of Birmingham (U.K.), and an MS in Electrical Engineering from the University of Houston.

***Udi Kara**, co-founder and president* - Udi has over 15 years of experience in the semiconductor industry delivering innovative new ways to shrink integrated circuits and automate chip design. Prior to founding Firm8, he was a member of the Digital Semiconductor Design Center design team in Israel where he established and managed the CAD Development Group, bringing a completely new approach to the design of full-custom ICs. He holds a BSEE degree from the Technion Institute of Technology in Haifa, Israel

Firm3

Firm3 was established in 1997 in California and in 1999 the company relocated to Israel. Firm3 is a supplier of design automation solutions used to verify electronic products constructed from programmable logic, application specific integrated circuits (ASICs), and off-the-shelf semiconductor devices.

Firm3's flagship product, DeskPOD™, is a hardware modeler that provides fast, accurate models for system design and HW/SW co-verification. Firm3's products help users to identify design flaws early in the design process. This results in faster time-to-market, in higher quality products, and in reduced development costs.

Firm3, Inc. is a supplier of design automation solutions used to verify electronic products constructed from programmable logic, application specific integrated circuits (ASICs), and off-the-shelf semiconductor devices.

Firm3 products are sold using a combination of direct sales and distributors in the United States, Canada, Europe, Japan, Korea, and Taiwan. Firm3's products have been shipping since May 1998

Management

***Yiftach Tzori**, CTO and founder* – has 10 years experience as subcontractor in the semiconductor industry. Yiftach holds B.S.c. degree in electric engineering from the technion.

Firm14

Firm14 Corporation (NASDAQ:ZRAN) is a leading provider of digital solutions-on-a-chip in the growing multimedia and Internet consumer markets.

In 1983, Firm14 was established to develop and deliver DSP processor technology. Firm14 has pioneered high-performance processing in various audio, video, and imaging formats, which is enabling many of today's digital products. Firm14's leading compression technologies combined with strong expertise in integrated circuits solutions-on-a-chip design, algorithm development, and system integration allows Firm14 to deliver complete solutions for OEMs. Today Firm14 is a leading supplier in the exploding DVD and digital camera markets.

Firm14 has focused on the specific requirements of digital cameras, DVD players, audio speakers and receivers, video recorders, and other new categories of Internet-connected appliances. Using Firm14's digital solutions, many of the world's leading OEMs are bringing cutting-edge digital multimedia products to market quickly and cost effectively.

Management

***Mr. Uzia Galil,** Chairman of the Board* - From 1962 until 1999, Mr. Galil served as President and CEO of Elron Electronic Industries, an Israeli high technology holding company, where he also served as Chairman of the Board. From January 1981 until leaving Elron, Mr.Galil also served as Chairman of the Board of Directors of Elbit, an electronic communication affiliate of Elron, and as a member of the Board of Directors of Elbit Systems, a defense electronics affiliate of Elron. From 1980 to 1990, Mr. Galil served as Chairman of the International Board of Governors of the Technion. Mr. Galil holds an M.S. in Electrical Engineering from Purdue University and a B.S. from the Technion. Mr. Galil is also a recipient of the Israel Prize.

Dr. Levi Gerzberg, *co-founder, President and CEO* - Prior to co-founding Firm14, Dr. Gerzberg was Associate Director of Stanford University's Electronics Laboratory. Dr. Gerzberg holds a Ph.D. in Electrical Engineering from Stanford University and an M.S. in Medical Electronics and a B.S. in Electrical Engineering from the Technion.

3.2.3 Entrepreneurs background

We have identified very strong entrepreneurial backgrounds (in many aspects) among the companies in our sample. This includes very strong educational background (M.S.c and PhD in electric engineering and related fields), extensive work experience background (work experience in multinational companies and in startups) and strong managerial experience. Moreover, most entrepreneurs recruited additional members to the core team with strong background in complementary areas of expertise.

In order to increase the company's founders' background, most startups in the sample were founded by several entrepreneurs (at least in 10 startups in the sample there was more than 1 entrepreneur).

For example: Firm9 semiconductors entrepreneur, Dr. Boaz Eitan, holds a B.Sc. in Physics and in Mathematics; a M.S.c and a Ph.D. in Physics, Physical limitation of Microelectronics components. Dr. Eitan worked in Intel for 3 year, in WSI for 13 years and was the founder of WSI R&D center in Israel. When he established Firm9, he hired additional members to the management team with strengths in operation, in finance in business development and in R&D.

Educational Background

All startups in our sample had at least 1 entrepreneur with an academic degree in electronic engineering; moreover only 1 entrepreneur didn't have such a background (two other entrepreneurs in this startup had some background in this field).

In 10 startups in the sample, at least one of the entrepreneurs had a Ph.D. in electric engineering (3 had at least a M.S.c degree and 2 had a B.S.c degree).

Only 2 entrepreneurs had business management or Economics degrees (in addition to the science/technology degree) and none had other degrees.

Only 1 entrepreneur didn't have any academic degree (he had two other entrepreneurs with him and he was in charge of marketing and management only – no technological/technical-aspects).

Work Experience

In 6 startups in the sample, at least 1 entrepreneur had, prior to founding the startup, work experience of at least 1 multinational company (for a minimum of 3 years). Out of these, 4 worked in those multinational companies both in Israel and in US.

In 5 startups in the sample, at least 1 entrepreneur had work experience prior to founding the startup in another startup company (in 1 case the entrepreneur had work experience both in an Israeli startup and in a US startup).

In 3 startups in the sample, at least 1 entrepreneur had work experience in one of the R&D units of the IDF (Israeli Defense Forces).

In 5 startups in the sample, none of the entrepreneurs had experience in any of the previous categories (Multinational, Startup and IDF-R&D unit). In 3 out of the 5, the entrepreneur held a Professor position in the academia and academic research experience in electronic engineering related topics, 1 had R&D experience from an Israeli Mid-Tech company and 1 had experience as a self employed subcontractor in semiconductors related fields.

Work Position Experience

All the startups in the sample had at least 1 entrepreneur with R&D experience; 4 of those had only academic R&D experience and R&D consulting experience.

At least 7 of the startups in the sample had at least 1 entrepreneur with managerial experience.

Two of the startups in the sample had 1 entrepreneur with entrepreneurial experience prior to founding the startup.

Strong core team

We identified very strong core teams (in terms of educational background, work experience background and variety among the management team capabilities) in the companies in our sample. We have identified, in 5 companies very strong core teams, in five companies strong core teams and in 5 companies weak (normal to startups) core teams.

* This category is not in Exhibit 6 due to the fact it is sensitive and subjective information.

Exhibit 6: Entrepreneurs background

	Company	Number of founders	Education	Work experience	Work position
1	Firm2	2	2 – tech PhD	2 – A	2 – P, R
2	FIRM13	3	2 – tech MSc	2 – SC 1 – SU(I) + IDF	2 – RD 1 – M+I(I+A)+E(I+A)
3	Firm15	2	1 – tech PhD	1 – HC(I), MNE(A)	1 – RD
4	Firm4	1	1 – tech BSc	1 – MNE(I+A) + SC(I)	1 – D(I+A)
5	Firm7	2	1-tech PhD 1-Tech BSc + MBA	1 – A 1 – HC(A)	1 – P+R 1 – O+M+F
6	Firm10	3	3 – tech PhD	3 – IDF + A 1 – SU(I)	3 – P+R 1 – RD
7	Firm11	6	6 – tech PhD	6 – MNE(I+A)	6 – RD+M
8	Firm5	2	1 – tech PhD 1 – tech BSc	2 – MNE(I+A) + SU(I)	2 – RD+M
9	Firm12	3	3 – tech BSc 1 - MBA	1 – IDF 1 – HC(I)	2 – RD
10	Firm6	2	2 – tech PhD	2 – SU(I) 1 - A	2 – RD+M 1- P+R
11	Firm9	1	1 – tech PhD	1 – MNE(I+A)+SU (I+A)	1 – RD+M+E
12	Firm1	1	1 tech MSc	1 - HC(A)	1 – RD
13	Firm8	2	2 – tech MSc	2 – MNE(I)	2 – RD+M
14	Firm3	1	1 – tech MSc	1 – SC + S	1 – RD+D
15	Firm14	1	1 – tech PhD	1 - A	1 – P+R

Education: Tech - Technology/Science degree (in these cases it was always related to electric engineering degrees; MBA - Business Management and Economic degrees; O - Other academic degrees.

Work experience: A – Academia; SU(I/A) - Startup (Israel/Aboard); MNE(I/A) - Multinational (Israel/Aboard); Other work experience: HC(I/A) - Hi-tech company (Israel/Aboard); SC - Subcontracting company; S - Self employed; IDF -Israel Defense Force).

Work Position: RD - R&D; D - Technical development; R - academic research; SM - S&M; M – management; F- Finance and Accounting; O – Operation; I - Investment and Business development; E – Entrepreneur; P - Professor.

3.2.4 Triggers and reasons for foundation

We find that most of the entrepreneurs in our sample were scientists/engineers who developed the initial concept during previous work positions. These entrepreneurs were usually triggered to establish their startup by three main factors: the rapid growth of the communication and semiconductor industries and the readiness of the market to accept their technology; the easiness of raising capital in Israel during the 90's; and the hype in the Nasdaq, which made the chance to go public high and enrichment dreams realistic.

Despite the above, we deeply believe that in this sector more entrepreneurs were driven by technology vision than the enrichment dreams (compared with software and Internet startups).

For example: two entrepreneurs who developed the company's main concept long before establishing the firm established Firm5. In 1998, they felt the cellular market will be ready to adopt their technology in a few years and as a result they established the startup and began developing their technology.

In 12 startups in the sample the leading entrepreneur was responsible for developing and bringing the initial concept of the company's product/technology. In 3 cases the leading entrepreneur decided to establish a company in a specific field and looked for an idea (in 1 of these cases the idea came without an additional entrepreneur).

In 2 startups the foundation was part of a spin-off from another company. Two startups were founded in a technology incubator and we believe that without the Incubator program they couldn't have been established (both startup are in niche markets). One startup was directly established by an INBAL VC fund. In 7 other startups, we believe that Yozma program and the growth of the Israeli VC industry were crucial. At least 7 startups were established due to very good products market conditions (heavy capital expenditure and high demand for technology products) and financial market conditions (NASDAQ), in the 90's.

At least 4 startups were established after the entrepreneur was confronted with an unsolved problem during previous work experience and developed a concept for solving this problem.

Exhibit 7: Trigger for foundation.

	Company	Nasdaq	Personal readiness	Yozma	Incubator	Problem solving	Spin off	Idea
1	Firm2	No	No	No	Yes	No	No	Yes
2	FIRM13	Yes	Yes	No	No	No	DSPG	No
3	Firm15	No	Yes	No	No	No	No	Yes
4	Firm4	No	Yes	Indirect	No	No	No	Yes
5	Firm7	Yes	Yes	Indirect	No	No	No	No
6	Firm10	Yes	Yes	Indirect	No	No	No	Yes
7	Firm11	Yes	Yes	No	No	No	No	Yes
8	Firm5	Yes	Yes	Indirect	No	No	No	Yes
9	Firm12	No	Yes	No	No	No	No	Yes
10	Firm6	Yes	Yes	Indirect	No	Yes	Zoran	Yes
11	Firm9	No	Yes	No	No	Yes	No	Yes
12	Firm1		No	Yes	No	Yes	No	No
13	Firm8	Yes	Yes	Indirect	No	No	No	Yes
14	Firm3	No	Yes	Indirect	Yes	Yes	No	Yes
15	Firm14	No	Yes	No	No	No	No	Yes

3.2.5 Foundation and capital raising

In our chip design sample, we identified that most of the companies had a long maturation process between getting the initial idea and founding the company. In general we can say that usually the "appearance" of the idea and the commercialization as a company is a long evolutionary process, which requires much experience and a slow maturation processes. Due to these characteristics it seems that seed and first round capital raising are easier because the technology is strong and the hardest rounds are the second and the third when the question is market demand rather than technology demand.

We saw that a relatively high portion of the companies in the sample had US and Asian VCs and strategic investors. This can be explained by the fact that the demand of this sector comes from semiconductor companies (manufactures). Finally, we discovered that the companies in the sample have relatively high valuation compared with other sectors of Israeli startups.

The process of transforming the idea into a company

In ten companies in our sample the entrepreneur went through a long process of maturation between the time the initial idea was identified by him and the actual foundation of the company. In 4 of these cases the idea came from the academia, in another 4, the idea came from the founder while he was working in another hi-tech company and in 1 case the idea came while he was self employed as a subcontractor in the semiconductor field.

In 2 other companies the idea matured in an established company, which made a spin-off.
Only in 3 cases the process of transforming the idea into a company was quite short.

The duration of the pre-seed/seed capital raising

In 6 cases the process of raising pre-seed/seed capital was fast (1-4 weeks). In 2 of these cases the seed came from the entrepreneurs.
In 5 cases the process of raising pre-seed/seed capital took a normal period of time (2-4 months).
In 4 cases the process was slow (more then half a year), 3 of them were founded prior to 1993 (the 1st phase of the Israeli VC sector and the beginning of Yozma program) and one was founded in 1994. There is only one company that was established prior to 1993 that underwent a fast process of raising seed capital and its success in this fast capital raising is related to the fact it was a spin-off of an existing company.

First institutional round

In 2 cases the duration between seed capital raising to the first institutional capital raise was very fast (less then half a year). In both cases the companies are regarded as potential "Gorillas" (very successful startups).
In 6 cases the duration between seed capital raising to the first institutional capital raise was normal (1-1.5 years).
In 7 cases the duration between seed capital raising to the first institutional capital raise was slow (above 2 years).

Latter stages of capital raising and Exits

Three companies didn't have second rounds (1 due to a fast exit), and 11 didn't have third round (4 due to a fast exit). Seven had an exit: 1 as the last means before closure (for $2.25 million), 4 were successfully acquired and 4 had gone through a successful IPO (2 of those were later acquired).

Total capital Raised and Last valuation

Seven companies raised less the $10 million in their entire private placement rounds, 5 companies raised between $10-$20 million in all their private placement rounds and 3 companies raised more then $20 million in their entire private placement rounds. Four companies had last valuation of less than $10 million, 4 companies had last valuation of between $20-$60 million, 2 companies had last valuation of between $100-$200 million, 3 companies had last valuation of between $400-$600 million, and 2 companies had last

valuation above $1.5 billion (DSPC that was acquired for $1.6 billion and Galileo that was acquired for $2.7 billion).

Exhibit 8: How fast did the startups grow in means of capital raising rounds.

Phase of foundation*	Idea –foundation	Foundation – (pre) seed	Seed - first	First - Second	Second - third	Foundation - Exit
Phase1	Long	2-4 months	NA			
Phase1	Long	0.5 year	2.5 year	1 year	0.5 year	5 years
Phase1	Long	1-4 weeks	1 year	1 year		4 years
Phase1	Spin off	1-4 weeks	3 years	2 years	2 years	
Phase2	Long	2-4 months	2 years			
Phase2	Short	2-4 months	1 year	1 year		4 years
Phase2	Long	2-4 months	2 years	1 year		
Phase2	Long	2-4 months	1 year	1 years	1 year	
Phase3	Long	1-4 weeks	5 months	1 year		
Phase3	Long	No seed	1.5 years	1 year		
Phase3	Long	No seed	2 months	1.5 years		
Pre-phase1	Short	0.5 year	3 years			4 years
Pre-phase1	Short	1 year	2 years	5-7 years		12 years
Pre-phase1	Spin off	1-4 weeks	NA	NA		3 years
Pre-phase1	Long	1 year	1 year	1 year	1 year	5 years

* According to the phases of the Israeli VC industry that were classified in the VC report.

Exhibit 9: capital rising by rounds prior to Exit (M$)

Phase of foundation	Total	Seed + First*	Second	Third	M&A	IPO	Last** Valuation
Phase1	3	3			Yes	No	$22.25M
Phase1	27	1	11	15	No	No	$48M
Phase1	2-3	1	1-2		No	No	<$10M
Phase1	10-15	3	7	NA	Yes	No	$365M
Phase2	7	2	5		Yes	No	$2.25M
Phase2	11	3	8	2	No	No	$42M
Phase2	14	3	11		No	No	$56M
Phase2	1.4	1.4			No	No	<$10M
Phase2	2.2	0.5	0.7	1	No	No	<$10M
Phase3	70	5	20	45	No	No	$200M
Phase3	58 (+60)	11	47		No	No	$400M
Pre-phase1	11	0.5	1.5	10	Yes	Yes	$1.6B
Pre-phase1	3	0.5	2.5		No	Yes	$162M
Pre-phase1	16.5	22.5	4	10	Yes	Yes	$2.7B
Pre-phase1	5-10	0.5	NA	NA	No	Yes	$607M

* We include here capital from pre-seed round, seed round, first round, and OCS grants in the same period

** In public companies we took valuation to 30.8.01, in private companies that had private placement after March 2000 we took the private placement valuation and in the rest we estimated their valuation.

Type of capital sources the companies used prior to Exit

Almost all of the companies raised capital from Israeli business angels and from Israeli VCs and most of the companies also raised capital from one or more of the following; US VCs, Japanese investors or strategic investors.

The authorized enterprise is considered to be the best government incentive for hi-tech companies to establish their facilities in Israel.

Surprisingly, there is no differentiation between companies established in different phases of the Israeli VC industry, considering the issue of raising capital from US VC and strategic investors.

In 3 companies there was no use of Business Angels, 2 of those companies used personal capital of the entrepreneurs instead and in 1 company the pre-seed/seed capital came from a VC.

Although most interviewees had a lot of complaints regarding government policy towards hi-tech in general, 9 companies took different kinds of OCS grants. During the years of phase3 of the Israeli VC industry none of the startup took OCS grant and prior to phase1 all startup took OCS grants. This may point to the fact that VC money is complementary to OCS money.

All interviewees had only good things to say about the particular program of Authorized manufacture (tax credit course) and 14 companies used it.

Eight companies raised capital from Yozma funds (this is reasonable in regard to Yozma funds portion in the total VC capital managed in the Israeli industry), and 3 out of them raised only from Yozma funds (in Israel). Eleven companies raised capital from other Israeli VCs, and 6 out of them, raised only from a non Yozma VC (in Israel). Eight companies raised capital from US VCs, out of these three were co-investments with Yozma funds. Only in one company US VCs invested without an Israeli VC. Japanese institutional investors invested in 3 companies and none of the companies had investments from a European institutional investor. In 6 companies, among the investors there were also strategic investors.

Exhibit 10: sources and amounts of capital raised (in million dollars)

Phase of foundation	Angels	OCS	Tax credit	Yozma VCs	Other IL VCs	US VCs	Other VCs	Strategic investors
Phase1	No	No	Yes	Yes	No	No	No	No
Phase1	Yes	No	Yes	No	Yes	Yes	No	Intel, GE
Phase1	Yes	Yes	Yes	Yes	No	Yes	Japanese	Sony
Phase1	Yes	Yes	Yes	Yes	Yes	No	No	No
Phase2	No	No	Yes	No	Yes	Yes	No	No
Phase2	Yes	No	Yes	No	Yes	No	No	No
Phase2	Yes	Yes	No	Yes	Yes	No	No	No
Phase2	Yes	Yes	Yes	Yes	Yes	No	No	No
Phase2	Yes	Yes	Yes	No	Yes	Yes	No	Microsoft
Phase3	No	No	Yes	Yes	Yes	No	No	Infinion
Phase3	Yes	No	Yes	No	No	Yes	No	Del
Pre-phase1	Yes	Yes	Yes	No	Yes	Yes	Japanese	Intel
Pre-phase1	Yes	Yes	Yes	Yes	No	Yes	No	No
Pre-phase1	Yes	Yes	Yes	No	Yes	No	No	No
Pre-phase1	Yes	Yes	Yes	Yes	Yes	Yes	Japanese	No

3.2.6 Indication of success

Exhibit 11: indications of success

Company	Valuation	Number of employees	Sales01E	Sales00A	Earnings00A
Firm1	Less then $10M	4	$10M	$8M	Losses
Firm2	Less then $10M	10	0	0	Losses
Firm3	Less then $10M	15	$2M	$1.5M	NA
Firm4	$2.25M (E8/01)	30	$1M	$4M	Losses
Firm5	$56M (P7/00)	35	0	0	Losses
Firm6	$48M (P4/01)	55	NA	NA	NA
Firm7	$42M (P2/00)	60	$5M	0	Losses
Firm8	$22.23M (E8/01)	60	NA	NA	NA
Firm9	$400M (P4/01)	65	$20M	$5M	$10M (E01)
Firm10	$465M (E7/99)	100	$60M (99)	$20M (98)	NA
Firm11	$200M (P7/01)	130	0	0	Losses
Firm12	$160M (T9/01)	140	$50M	$93M	$12.5M
FIRM13	$1.6B (E10/99)	300	$170M (99)	$131M (98)	$40M (99)
Firm14	$600M (T9/01)	300	$80M	$68M	$-20M
Firm15	$2.7B (E11/00)	410	$100M (00)	$80M (99)	$33M (00)

Valuation: E – Exit (M&A), T – Traded, P – Private placement.

3.2.7 Homan resources

The human resources required in the chip design sector are of high quality personnel with engineering degrees (at least B.S.c) and with work experience. For this reason the supply of human resources in this sector is strict in the short term (training courses of 3-4 month are definitely not enough in the chip design sector). Moreover, because of the universities' policy in Israel of restricting the number of students studying towards engineering degrees the supply is also strict in the mid-term. This situation causes shortage of human resources in periods of fast growth in the sector.

In the late 80's and early 90's there was no shortage in human resources in this sector and all companies in our sample, which already existed, didn't report any specific problems in recruitment of new employees. In the mid 90's the situation became more complicated and later on even problematic. In the years 1996-2000, there was a shortage of human resources in the industry for two reasons, the high growth of the chip design sector and transition of engineers to Internet companies. In this period, only startups with very strong indications of potential future success didn't have problems in recruiting new employees. Usually in the first years, companies made use of personal/business networking in order to find new employees. The most successful networking in means of finding new employees, are related to an entrepreneur previously (or currently) working as a professor in the university and previously working in a multinational semiconductor company in a high position. For example, most of ITRAM employees are former students of one of the founders. Most of Firm11 employees were previously employees in Intel Corporation and Qualcomm (the origin of Firm11 entrepreneurs). Startups that didn't have strong networking or strong indications of potential future success had many difficulties in finding new employees.

Today after the Internet "bubble" blew, it is much easier for companies in the sector to find new employees.

3.2.8 Business model and company strategy

We tried to categorize the business model and strategy through three main aspects. First, a distinction is made between companies that develop specific product/s to those that develop technology applications and to those that develop new technologies and standards of technologies. Second, whether the company's development became more focused or less focus or didn't change. Third, what kind of marketing model did the companies use: direct sales, OEMs or strategic and marketing alliances.

In our sample, 5 companies developed a specific product/s, 6 developed technology applications and 4 developed new radical technologies or new technology standards.

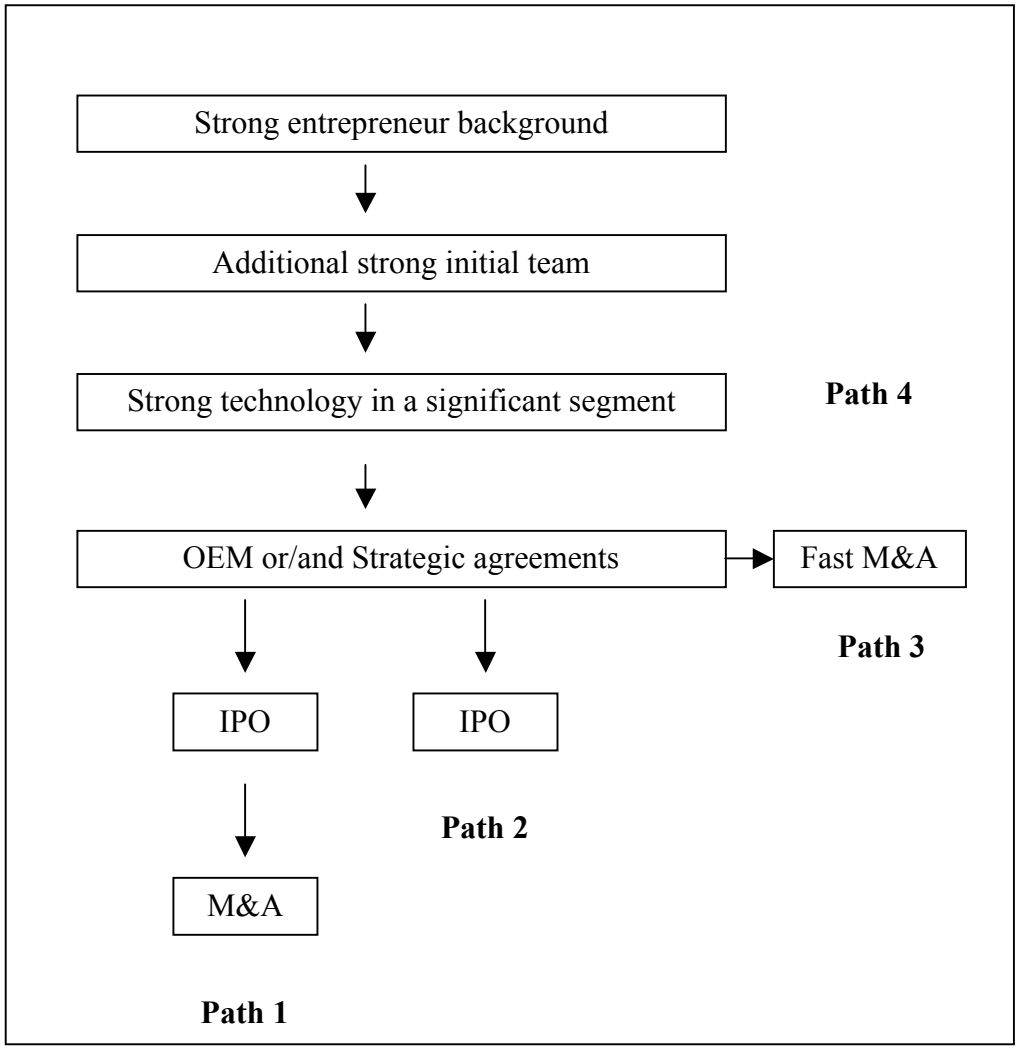
Six companies became more focused in their development as they grew, 3 companies broadened their developments and the rest didn't have any change in this respect.

Five companies used direct sales, 6 companies used OEM agreements and 8 used strategic and marketing alliances.

We have recognized that usually the companies that developed a specific product were less successful and tended to use direct sales. The companies that developed new technologies were the most successful and tended to use both OEMs and strategic agreements. The companies that developed technology applications were more successful when they used both OEM agreements and strategic alliances rather then only using strategic alliances.

3.2.9 Growth profile

Exhibit 12: The optimal growth profile for Israeli startups in the chip design sector



Explanation of the optimal growth model

Path 1: companies with all characteristics of optimal profile of growth, which underwent successful IPO and were later acquired by a large multinational company (2 companies in our sample).

Path 2: companies with all characteristics of optimal profile of growth, which had gone trough a successful IPO (2 companies in our sample).

Path 3: companies with all characteristics of optimal profile of growth, which were acquired by a large multinational company in the beginning of their marketing and strategy alliances efforts (1 company in our sample).

Path 4: companies that seems to have all characteristics of optimal profile of growth but are only in an initial phase of marketing and strategic agreements (2-5 companies in our sample).

In path 1 we will usually find very successful companies. In contrast, in path 2 we find success stories (the companies, which were strong enough to stay independent in the long-term) or moderate success (the companies, which were good enough to go through a successful IPO in flow periods but were not attractive enough to be acquired in slowdown periods).
In path 3 we usually find successful companies that had a very strong technology but a shortage of managerial capabilities, or successful companies that had a very strong technology but were established late compared with their competitors and were not strong enough when the consolidation in their market began.
In path 4 we find companies that have the potential to continue to any of the other paths but it is still too early to tell which one.

Reasons for not being included in the optimal growth model (in the sample)

1. Weak entrepreneurial background: 4-6 companies in our sample had a lack of capabilities due to weak entrepreneurial background.
2. Niche segment: 3-4 companies in our sample where located in niche segments and as a result were not able to go through a successful IPO (are not in IPOable markets) and were not attractive enough to be acquired. Companies in niche segments can be successful in other countries where manufacturing and engineers are cheaper and are located closer to the customers.

3. Unproven technologies (or weak technology) or technologies that are not accepted by the customer due to other reasons: 2-4 companies in our sample concentrated on technologies that are not accepted, yet, by the costumers. Some of these technologies are still unproven.
4. Marketing model, which is based on direct sales: 3-4 companies in our sample are basing their marketing models on direct sales. The direct sales model is not effective for young startup companies in the semiconductor sector.

4. Conclusions and Policy implications

4.1 Conclusions and policy implications for Israel

The chip design sector is a very important sector in the global economy, and therefore it is important for a country that has ambitions to be among the leading hi-tech societies, to have a strong chip design sector.

This situation requires a proactive government policy in order to promote this sector, through different means such as investments in national semiconductor facilities, effective and clear government policy and even direct support.

In order to build an effective government policy the government must use a clear model of the factors of success and the competitive environment.

This declaration is suitable for all sectors but is reinforced in the chip design sector where the competition is very aggressive and as a result many high potential startups, which made small mistakes in their development, failed.

Our model (see paragraph 3.2.8) is only a primary model and is very general but we do believe it is an optional one in the direction of beginning to build a model for better understanding of the preconditions of any success of startups in the sector.

This model may need change when implemented in other countries due to different competitive advantages and disadvantages.

- Appendixes

5.1 Glossary

Fabless (without fab) refers to the business methodology of outsourcing the manufacturing of silicon wafers, which hundreds of semiconductor companies have adopted. Fabless companies focus on the design, development and marketing of their products and form alliances with silicon wafer manufacturers, or foundries.

Foundry is a service organization that caters to the processing and manufacturing of silicon wafers. A *pure-play foundry* is a company that focuses 100 percent of its efforts on this service and offers no end products. These companies typically develop and own the process technology or partner with another company for it. Some companies offer 100 percent wafer manufacturing services and others offer foundry services to supplement their company's own requirements.

Wafer is short for silicon wafer, which is a thin disk of purified crystalline semiconductor that is cut after processing into individual chips. Today's leading foundries provide 8-inch wafers.

Fab is short for fabrication facility or silicon wafer manufacturing plant. This term is typically used to describe an individual facility, rather than a company.

Fab-lite is a new term recently coined by the industry referring to integrated device manufacturers or vertically integrated companies with a strategy bent toward utilizing a fabless approach.

Integrated Device Manufacturer **(IDM)** is a class of Semiconductor Company that owns an internal silicon wafer fab or, as the name indicates, the fabrication of wafers is integrated into its business. However, even IDMs may do some outsourcing.

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