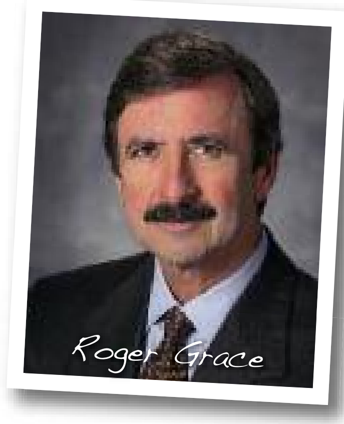
Technology Clusters and Their Role in the Commercialisation of Micro and Nano Systems

words | ROGER H. GRACE, PRESIDENT, ROGER GRACE ASSOCIATES



In my annual MEMS Commercialization Report Card which was presented at the MM/MEMS/Nano Live USA 2012, I presented 14 critical success factors for MEMS commercialisation [1]. One of these factors was MEMS cluster development. Since I began tracking this topic starting with the 2003 Report Card, which was facilitated as a result of a strategic marketing research study that I conducted on technology clusters for the State of Michigan's Economic Development Corporation , the grades have varied between C+to B+ with the 2011 grade being C (Figure 1).v I believe that these mediocre grades provided by the market research participants have recently existed due to the lack of newly formed clusters in the past couple of years and not based on the continuing level of support of existing clusters.

The concept of clusters has existed for centuries. As early as 500 B.C. the Greek city-state of Miletus existed as a cluster in manufacturing wool products [2]. Industrial clusters have existed since the very beginning of the industrial revolution. Technology clusters first become prominent in the Route 128 area of Boston in the early 1940's to support the U.S. military involvement in W.W.II. Silicon Valley saw its first technology cluster develop to support the meteoric growth of the semiconductor industry in the early 1960s [3].

The informal creation and development of these clusters has been a major catalyst in the successful economic development of these regions and the technology (ies) produced within.

Clusters are defined as "geographical concentrations of firms, supplies and related industries and specialized institutions that occur in a particular field in a nation, state, city (or region) [4]. Cluster formation has been proven to provide organisations within the cluster with competitive advantages in the market as a result of enhanced cost-efficiencies and faster product/service time-to-market. I have taken some of Prof. Porter's concepts and have created my own successful cluster model specific to micro and nanotechnology.

Benefits

The benefits that emanate from clusters for their participants are many. Michael Porter, the Harvard Business School professor has written much on how clusters create competitive advantage for its participants. This emanates from the ability of the cluster participants to share information on both a formal (but more importantly informal) basis. The relationship of the intellectual property (IP) core, especially the technical university provides a major source of highly trained technologists to support existing or "spun out" organisations.

The cluster also provides clean room and other technology/manufacturing facilities with their well trained operators for capital limited organisations to utilise on an "as-needed" basis thus eliminating large overhead.

Necessary Elements

Micro and Nanosystems clusters require similar ingredients as other clusters, i.e., intellectual property creation (not only as ideas and patents i.e. 'hard' but also through people's experience and know-how i.e. 'soft'), funding sources, and service infrastructure. I equate this to a three-legged stool. All of these elements need to exist at sufficient levels for the creation of a successful cluster…or the "stool" collapses.

Intellectual Property Creation – Most high technology clusters have formed around centres of intellectual property, either through federally funded laboratories and/or through research universities. "Intellectual Property" is defined here in a more general and all-inclusive sense that goes beyond patents. General knowledge and experience of design and processes is of great value and can be transferred with less encumbrance than that associated with patents. People who have worked for these institutions who are gifted with great ideas and an entrepreneurial spirit "spin out" of these engagements and seek

Figure 1

The MEMS Commercialization Report Card market research project was initiated in 1998. Based on a Delphi Research process with approximately 75 of the world's leading MEMS industry experts as the research universe, it reports yearly and assesses the status of MEMS critical success factors. Cluster development is one of the 14 factors, first being reported on in 2003. The 2011 grade was C. Source: Roger Grace Associates.

Figure 2

The Lurie Nanomanufacturing Facility (in the photo background) on the University of Michigan's Ann Arbor Campus provides state-of-the art research and development facilities to a broad spectrum of users…both academic and industrial and is a major provider of development resources for the Michigan Cluster. It supports the University's Wireless Integrated Microsystems and Sensing Center (WIMSS) a world renowned organisation in MEMS device and systems design and development. Source: University of Michigan.


Figure 3
The IMTEK campus in Freiburg Germany was founded in 1995 and provides research and development resources to the Microtech Sudwest/Baden-Wurttemberg Technology Cluster. The University and its courses and research direction are focused on the commercialisation of micro systems. It is one of the 12 higher education institutes, 18 research institutes and is part of the 350-member cluster. Source: IMTECH/Microtech Sudwest/Baden-Wurttemberg.

opportunities for greater fame and fortune. These people wish to not move themselves and their family but rather to take advantage of the business and social infrastructure within which they have developed. Therefore, they set up their businesses in close proximity to their former employer. Without the people and their talents and treasures, there can be no creation of new businesses, which are the basis of the cluster.

Funding Sources – The world of capital formation has no physical boundaries. Investment firms are always seeking the best risk/reward tradeoff opportunities. However, there is a human tendency to want to work as close to home to maximise work efficiency. Therefore, there is a tendency for investment firms to have offices in close proximity to cluster areas. A case in point – Silicon Valley and Boston. In the case of the earlier cluster, Boston, investments were made out of New York City, the U.S. financial capital. The second phase was to set up offices in the Boston areas and for Boston-based financial institutions to create venture arms. In the case of Silicon Valley, again earlier investors came from the outside, e.g. Boston and New York, before a significant financial infrastructure was set up locally in Northern California [2]. Funding sources need not be physically located with a cluster but it certainly helps matters if they do. Also, although the "informal" clusters of Route 128 and Silicon Valley have received no direct federal funds (other than military contracts from the Department of Defense), most microsystems clusters received either direct investments in research and/or facilities or favorable tax considerations from their local governments.

Infrastructure – A critical requirement to achieve competitive advantage is the existence of a human resources, plant, equipment and services infrastructure. The availability of these resources can reduce time to market and product development costs. The local availability of well-trained legal, financial and business professionals in addition to technicians, machine operators, designers and a broad spectrum of consultants is critical. In the case of capital intensive industries like the semiconductor and microsystems industries, the availability of research and development facilities and prototyping facilities is of significant importance. Typically, new companies tend to be "fabless" and need the support of a well-run and fully equipped development manufacturing/foundry facility. Large-scale production facilities are typically not absolutely necessary. The close proximity of technicians, service personnel, applications engineers and raw materials, e.g., gases and chemicals, is critical to support these facilities. These requirements have been somewhat mitigated as a result of the recent popularity of microsystems foundries.

Case Studies

Many Micro and Nanosystems clusters have been formed in Europe, North America and Asia. Micro and Nanosystems clusters require many of the same ingredients as other technology based clusters. We will focus our comments here on several of the more successful "clusters" that have been established. I believe that the increasing popularity of the funding of these new entities and continued funding of earlier formed clusters is due to the past success of the clusters to create jobs and the resulting creation of new businesses in the region which translated into tax revenues for the region and country.

- Dortmund, Germany. The first micro systems cluster, created in 1989 was fueled by intellectual property from the Technical University at Dortmund and funded by the regional German government. This cluster exists to this day being most successful in its support developing major microsystems players including Steag Microparts (acquired by Boeringer Mannheim in 2004) who has developed nebulizers for asthma patients, and H.L. Planar (acquired by Measurement Specialties in 2005)who has a broad portfolio of MST technologies and is currently in large volume production of tilt sensors for automotive applications. Dortmund is also the location of IVAM, which was founded in 1995 and is a leading microsystems development trade organisation that supports this cluster as well as other organisations having currently over 300 members in over 20 countries. IVAM provides a communications bridge between suppliers and users of high tech products and services in need of education and guidance in the fields of microtechnology, nanotechnology and advanced materials.

- University of Washington Microfabrication Facility (State of Washington). Originally founded in 1997 under the Washington Technology Center (WTC) and transferred to the University of Washington in 2011, the MFF has had 55 companies and 31 research groups associated with it and using its fabrication facilities. Its mission plan is to nurture the creation and retention of jobs in Washington- based companies by increasing the effectiveness and abilities of those companies to adapt and deploy technology that leverages the investment made in research at the state universities, i.e. University of Washington, Washington State, Eastern, Western and Central Washington Universities. Companies served to date include Micronics, Microvision, Combimatrix, Lumera (now part of Gigoptix), Trace Detect, Therus, EOSpace, Ionographics, Silicon Designs, Blue View Technologies, New Light Industries, MesoSystems, and Neah Power. These and other companies represent the creation of over 400 new jobs. To date, $1.6M US has been invested by the state of Washington, and the facility has extended its reach of clients to many US- and Canadian–based organisations. The goal of its multi-phased development program has been to formulate and create a network of interested parties including companies, academic institutions, and government agencies who are committed to exploring technology development and commercialisation of micro and nano technology.

- State of Michigan. The criterion of intellectual property in the cluster is aptly satisfied with the excellent work on micro and nanosystems at the University of Michigan (through its Wireless Integrated Microsystems and Sensors Center) and Michigan State, Michigan Tech and Wayne State University. ISSYS was the first commercial Microtechnology company to be founded out of University of Michigan. Other notable startups include Handylab (bioMEMS), Sensicore (bioMEMS), ePack (MEMS packaging) and Tessera (RF MEMS). Intellectual property for all of the new startups was licensed from the University of Michigan. R&D fabrication for the companies has primarily been supported by the University of Michigan through its former laboratories and through recently completed Laurie Nanomanufacturing Facility at its Ann Arbor campus (Figure 2). Wayne State University in Detroit also has a significant research and development facility at its Smart Sensors and Integrated Microsystems Center and has spawned a number of startups in this field focusing primarily on biomed applications. These companies include Visca LLC, Visca Energy and Medical Engineering Partners.

- Microtech Sudwest/Baden-Wurttemberg/Freiburg Germany. The Microtech Sudwest Cluster (MST BW) has IMTEK and its Department of Microsystems Engineering under the direction of Prof. Roland Zengerle which was founded in 1995 as a core source for IP. The cluster is comprised of 350 members including 12 higher education institutes with 40 microsystems professorships and 18 other research institutes boasting over 1200 scientific employees. (Figure 3). Its industrial members include Bosch, Daimler and Roche Diagnosis with 57% (200) of the participants being SMEs and 7% (25) being startups. Roughly one in seven patents granted worldwide in the microsystems field comes from this cluster region. In January 2010, the German Federal Ministry of Education and Research (BMBF) selected MST BW as one of five winners of the highly prestigious Leading Edge Cluster Competition resulting in an 80 million Euros grant award.

- Minatec-Grenoble France. The cluster was officially created in 2006 with its framework agreement established in 2002 when I first visited there and met with the Minatec Director Jean-Claude Gilbert (and who currently holds this position). During my most recent visit in March 2011, the fields that were literally inhabited by cows during my first visit have turned into a gigantic complex of three research organisations i.e. CEA-Leti, CEA-INAC and FMNT, three research universities and 20 companies all on the sprawling 20-hectare campus that provides over 70,000 square meters of workspace and over 10,000 square meters of cleanrooms. (Figure 4). The cluster has 2400 researchers, 1200 students and 600 industrial and technology transfer specialists. It has an operating budget exceeding 300 million Euros. Some of the many companies spun out of this cluster include STMicroelectronics, Tronics, Memscap, E2v, Sofradir, Ulis, MicroOled, Movea and the newcomer, ISORG.

Numerous other micro and nanosystems clusters include:
- Silicon Valley, Northern California
- Greater Boston, Massachusetts
- 4 Corner States (New Mexico, Arizona, Colorado, Nevada) (US)
- Albany, New York (US)
- Edmonton, Canada
- Enchede, The Netherlands
- Flanders, Belgium
- Goethenburg, Sweden
- Neuchatel, Switzerland
- Northwest (Liverpool/Manchester), UK
- Seoul, Korea (Kyunggi Technopack)
- Hinshu , Taiwan

Summary/Conclusions

Micro and nanosystems clusters have proven themselves to be effective facilitators to the successful commercialisation of these technologies. They literally have created hundreds of companies worldwide and thousands of high skill and high paying jobs. Their economic development growth and enhanced competitive advantage objectives have more than been met. We foresee the continuation of support for both existing micro and nanosystems clusters in the future and the creation of yet additional clusters to help facilitate the successful commercialisation of these technologies worldwide.

Figure 4

The MINATEC campus in Grenoble France was established in 2002 and spans over 20 hectare and is home to three universities and 20 companies. It is one of the top technology clusters in Europe. It provides over 70,000 square meters of workspace and 10,000 square meters of clean rooms to MEMS, IC, Photonic and Biomed research and development activities. Source: MINATEC.

References

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3. A. Saxenian, Regional Advantage: Culture and Competition in Silicon Valley and Route 128. Harvard Business School Press, 1994.
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Roger Grace will organise and chair a session on MEMS Commercialisation on 1 October 2012 at the Sensors Tech Forum in Anaheim California. Included in the session will be his presentation on "The MEMS 2011 Commercialization Report Card" providing extended coverage of the topic of MEMS and Nanotechnology Clusters. www.sensorstechforum.com