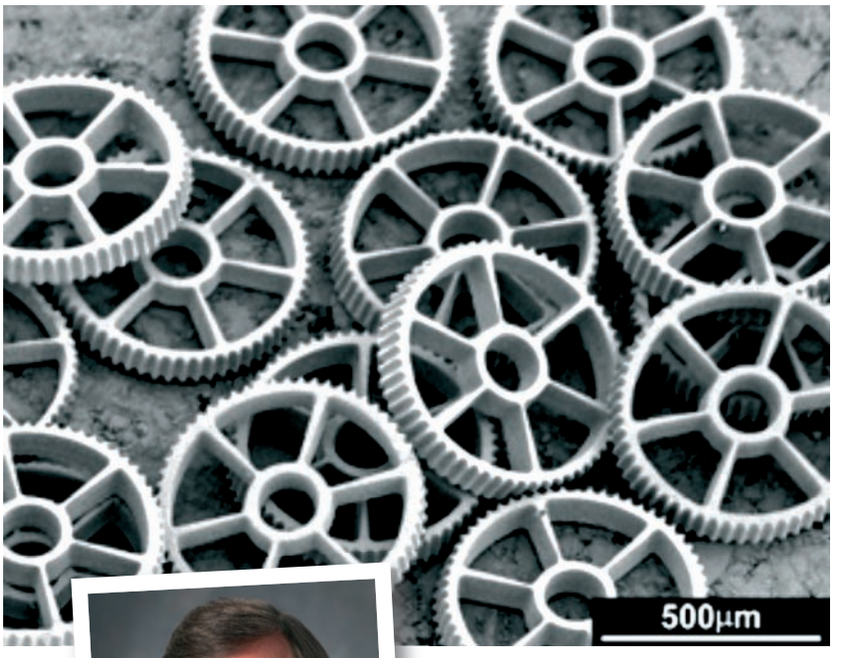
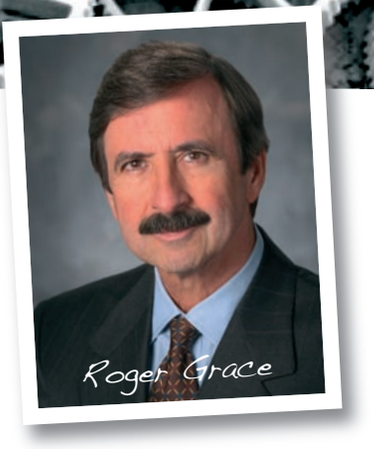
MEMS Commercialisation

FROM THE LAB...





<< ABOVE | Figure 2: Although Silicon is the dominant material for MEMS devices, other materials offer unique qualities for use in many applications. Here, micro gears measuring approximately 50 µm. in diameter are fabricated from WC-Co super hard alloy via batch mode micro discharging machining. Source: Wireless Integrated Microsystems and Sensors Centre (WIMSS), University of Michigan. >>

Introduction
This article will serve as a review of the MEMS commercialisation process as well as an introduction to the session which bears a similar name that I have organized, will chair and make a presentation at the MM/MEMS/Nano Live USA 2012 that will take place at the Donald Stephens Exhibition Centre in Rosemont, Illinois, from March 7-8, 2012.

The session and article title sums up, in my opinion, the extent of the MEMS commercialisation process and is given in Figure 1. This process and some of its elements have been graded in my annual MEMS Commercialisation Report Card issued since 1998 [1]. The updated 2011 Report Card grades will be debuted at the session in my presentation. The session as well as this article will focus on two of the 14 key factors for successful MEMS commercialisation. The first, 'Infrastructure' which includes software development tools, materials, process tools/equipment and most importantly wafer manufacturing, packaging and test foundries received a grade of C+ in 1988 and A- in 2010. The second, 'Marketing', both market research an integrated marketing communications received a grade of C- in 1988 and C in 2010 never achieving a grade higher than C+ during the 13-year reporting period. 'Applications pull' versus 'technology push' concepts must be adopted for successful commercialisation to be realised [2].

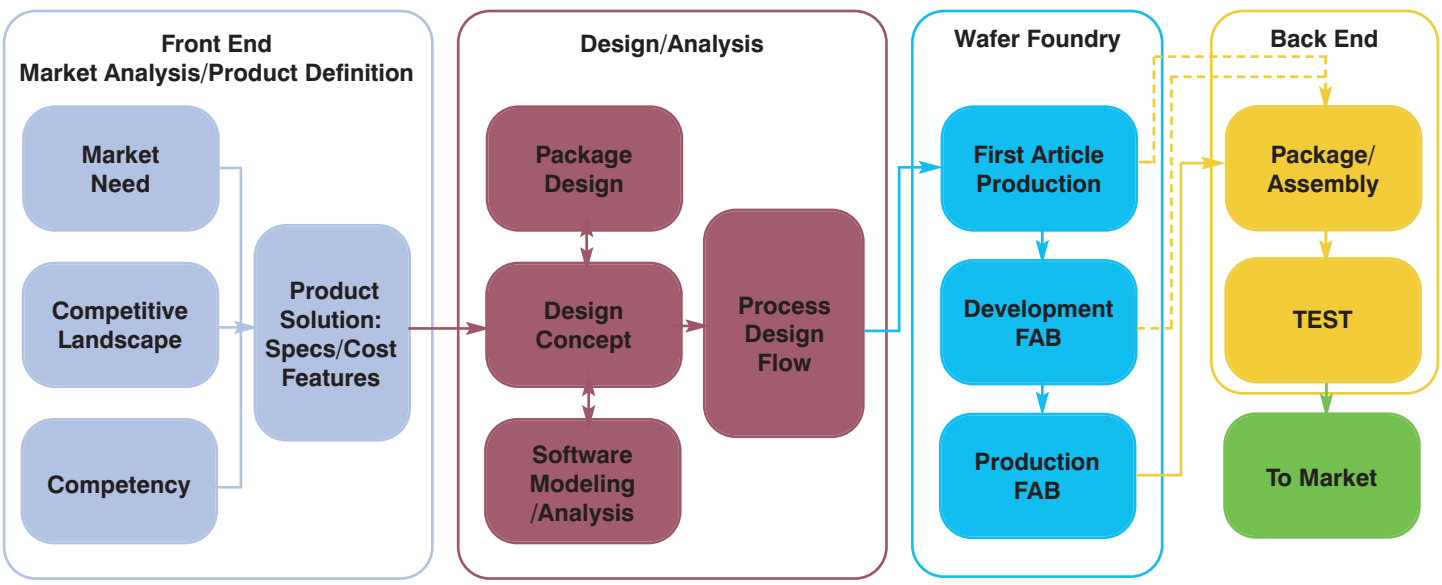
Market Research/Product Definition
Roger Grace Associates has been providing custom market research to MEMS companies since 1982. Based on the 30 years of experience, I conclude that the lack of proper market research for MEMS companies has been widespread and has been the basis for the lack of achieving significant sales success for many MEMS companies as well as the ultimate failure of numerous ones. At the beginning of the commercialisation process for MEMS (or anything for that matter), the product/service and market have to be fully defined through ample market research addressing the factors of user need analysis, competitive landscape and company core competencies. The results of this process which can be achieved using a number of marketing research tools including focus groups, web research and interviews (either in person, phone or via email/web) need to be introduced into the product definition process to support the product design and manufacturing/assembly and test strategies [3]. This market research process which drives the business strategic model will be addressed in my panel presentation.

Design and Manufacturing Process/Infrastructure

Product Definition/Modeling/Device Design
Following product definition is the product design as well as the processes by which the product (including the packaging and testing) will be created. The product could be designed in-house or via a number of independent design firms. Realising the design and simulating its performance requires adequate software tools. Here it is important that the MEMS/signal conditioning electronics/package interface has been modeled and analysed as a system, a.k.a. 'Co-design'. Mary Ann Maher of SoftMEMS will address this co-design concept as a session panel member.

Wafer Foundries
MEMS wafer foundries come in all shapes and sizes and conveniently segmented into development and/or production foundries or a hybrid of these two. Their primary purpose is to convert the product and process designs into

TO THE FAB... TO THE MARKET



<< Figure 1: The successful MEMS Commercialisation process is driven by market research activities to define the product/market and through a complex assemblage of design/manufacturing/assembly/packaging and testing infrastructure. It concludes with the 'applications pull' of an integrated marketing communications process to bring the product to market. Source: Roger Grace Associates. >>

hardware from an evaluation/breadboard or small scale to full production levels. Many development foundry services to the merchant market include universities/institutes. They provide this service through extensive in-house facilities, including the University of California Berkeley, Stanford, University of Michigan and Cornell. Although Silicon wafer processing is the prime activity of these facilities, some also explore alternative material approaches as will be the topic of the session keynote by Professor Yogesh Gianchandani of the University of Michigan's Wireless Integrated Microsystems and Sensors Centre (WIMSS) (Figure 2). Also institutes/laboratories including Fraunhofer, VTT, CSEM and Sandia National Laboratories play heavily in this area. Sandia will make a presentation on its SUMMiT V process which is a truly unique and powerful tool to create 'three dimensional' MEMS structures (Figure 3).

Two very interesting participants in this area are MEMSCAP which hosts a multi-user MEMS process (MUMPS) capability and MEMS and Nano Exchange which provides in-house design, process and small volume manufacturing resources. In the area of MEMS production wafer foundries, the choices are many amongst the more than 65 Silicon wafer foundries worldwide. 20 years ago, MEMS foundries were not so 'in fashion' as they are today. Their proliferation has been driven by the 'lessons learned' from the semiconductor industry in its 'fabless' and 'fablite' models. Most of the MEMS startups in the past 20 years have been fabless since the VC community prefers to invest in intellectual capital and not capital equipment. The 'sweet spot' of foundries i.e. what they do well and want to support varies dramatically from foundry to foundry. Selection criteria for organisations wishing to engage foundry partners also varies dramatically and is specific to the product and process required to manufacture. SVTC, major MEMS foundry service will be represented on the session panel and will present its perspective on barriers to the commercialisation of MEMS most specifically to the transition of MEMS development from the lab to high volume production.

Equipment/Tool Support

If one were to track the progress of the commercialisation contributions of tool suppliers since the 1988 beginnings of my MEMS Commercialisation Report Card to the infrastructure topic, one would find that tool/equipment suppliers have been a major positive force in this area. Where once MEMS tools were outgrowths of semiconductor tools, today's MEMS tool suppliers have developed an extraordinary spectrum of tools including lithography aligners, wafer bonders, wafer cleaning systems and plasma etchers to name a few. Additionally, these suppliers provide a spectrum of these tools to support all levels of production, from hand operated single wafer systems used for development activities to cassette-to-cassette systems for large scale production. Plasma-Therm, a leading supplier of MEMS and semiconductor deposition and etching equipment (Figure 4) will be represented on the session panel and will address barriers to the commercialisation of MEMS from a tool supplier perspective.

Back End

Packaging and test are acknowledged as major cost and performance factors in the creation of a MEMS device. To meet the need of the industry, a number of MEMS

***<< RIGHT | Figure 3:* MEMS micro grippers capable of extending off-chip into a full arch to capture micro scale objects. A foldable scissor-hinge structure enables large radial extension. Designed by University of Utah College of Engineering students Austin Welborn and Brian Baker, and Professor Ian Harvey. SEM Microphotograph: Kathryn Ecsedy. Fabricated at Sandia National Laboratories using the SUMMiT VTM process as part of the University Alliance Design Competition. >>**

packaging suppliers have been created. Another very interesting aspect of MEMS packaging is quickly emerging that of wafer level packaging, chip stacking and Through-Silicon-Vias (TSV). Currently a number of MEMS foundries are offering this capability with wafer 'capping' being a mainstay of MEMS for many years. Once the MEMS device has been manufactured and electronically tested, it needs to be tested in the physical environment similar to that in which it is required to operate and over its operating temperature range. Companies supplying large volume MEMS to applications including automotive and consumer have refined assembly, packaging and test functions to an art form, including MEMSIC who designs and manufactures MEMS accelerometers and electronic compasses and who will make a presentation on these topics during the session. And what to do if you do not have in-house test capability? Go to a foundry that does.

***<< ABOVE | Figure 4:* Through the use of specialized and highly automated cassette-to-cassette processing equipment similar to the Versaline cluster platform, MEMS manufacturers and foundries are able to create high throughput processes producing low cost and robust MEMS devices. Etching and deposition processes are the key to many of today's MEMS designs. Source: Plasma-Therm >>.**

Integrated Marketing Communications

We end the commercialization process with the promotion, distribution and selling of the product/service vis-à-vis marketing, especially integrated marketing communications… and thus we have come full circle since marketing is where we started the process [2]. Many tools are available to the MEMS marketer in the integrated marketing communications program including advertising in print/electronic publications, trade show appearances, email blasts, webinars and social media. The judicious use of a number of these marketing 'tools' and the proper funding and execution of these can lead to extraordinary results. I will make a presentation in the panel discussion "MEMS Marketing: Oxymoron or Opportunity" that will address both the market research and integrated marketing communications processes and provides case studies to support my position [3].

Summary

A robust infrastructure currently exists and is expected to further develop to support the design, analysis, manufacture and test of MEMS devices. The major challenge for MEMS developers to achieve successful commercialization is to maximize one's options, establish selection criteria and choose the right partner. Choosing the right partner is also appropriate for MEMS infrastructure suppliers. Additionally, thorough market research activities need to be conducted as the first step in the process and an integrated marketing communications program planned, properly resourced and executed to successfully drive the product into the market through an 'applications pull' approach.

Where to Learn More

Roger Grace has organized and will chair and will present in an inaugural MEMS session at the MM/MEMS/Nano Live USA 2012 Conference in Rosemont, Illinois, on March 8, 2012 as part of this March 7-8, 2012 conference. Four presenters will address major commercialization issues including MEMS manufacturing/assembly/test and wafer processing. In addition, I will debut my 2011 MEMS Commercialization Report Card. The session panel discussion topic is "Barriers to the Successful Commercialization of MEMS" from an industry infrastructure perspective. This will be addressed by panelists representing software, foundry and equipment suppliers and by me in marketing.
www.micromanu.com/x/mm-live-us/mmlive.html.
Mr. Grace has also organised, will chair and present at a session of the Smart Systems Integration Conference to take place in Zurich, Switzerland, from March 21-22, 2012. In his session "Smart System Integration in the US" on March 22, the panel will address barriers to the commercialization of MEMS/smart systems.
www.mesago.de/en/SSI/home/htm.

Roger Grace is President of Roger Grace Associates of Naples, Florida, a marketing consulting firm which he founded in 1982, specializing in the commercialization of MEMS. His firm provides business development, custom market research, market strategy and integrated marketing communications services to high tech clients worldwide. He has published over 20 articles in industry publications, organized and chaired over 50 MEMS technical sessions and conferences and is frequently quoted in the technical and business press as a MEMS industry guru. He was a visiting lecturer in the School of Engineering at the University of California Berkeley from 1990 to 2003. He holds BSEE and MSEE (as a Raytheon Company Fellow) degrees from Northeastern University where he was awarded the "Engineering Alumni Engineer of the Year Award" in 2004. **rgrace@rgrace. com,www.rgrace.com**

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[1] R. Grace, MEMS: Lessons for Nano, Mechanical Engineering Magazine, August 2008, pp. 25-29. (www.rgrace.com)

[2] R. McKenna, Marketing is Everything, Harvard Business Review, January/February, 1991, pp. 1-10.

[3] R. Grace, MEMS Marketing: Oxymoron or Opportunity, Proceeding of the MEMS Technology Summit 2010, Stanford California, October 10, 2010. (www.rgrace.com)