

MEPTEC Report

A Quarterly Publication of The Microelectronics Packaging & Test Engineering Council

Volume 26, Number 3

FALL 2022

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A+

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The MEMS Industry Commercialization Report Card

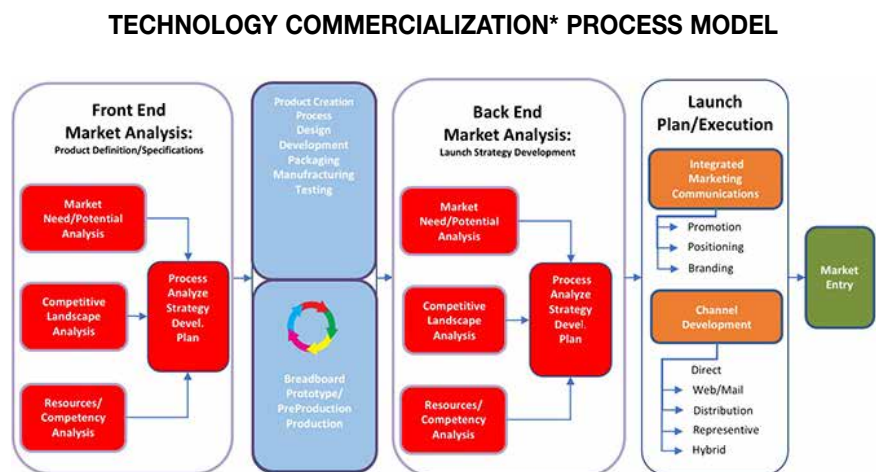
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Roger Grace Associates

Introduction/History/Evolution

The famous management guru, Peter Drucker, was said to have made the following remark: “what you cannot measure... you cannot manage”. And to his point rests the rationale for my creation of the *MEMS (Microelectromechanical Systems) Industry Commercialization Report Card* in 1998. During the famous *Hilton Head Conference* (also formerly known as the *Solid State Sensors Conference*) that I was asked by the conference technical chair to create a panel to address the topic “why are there not more MEMS millionaires”. I invited several of my colleagues in attendance to be on my panel and to have them share their opinions on this subject. It was a truly informative and illuminating session. Following that, I, as a technical marketer, decided to investigate this topic in detail and set out to determine some possible answers. My in-depth research uncovered several general articles on the topic of “technology commercialization”. Technology commercialization is defined as the process by which a product or service translates from an idea to the market as shown in Figure 1. I used the content of these articles to establish a list of criteria that appeared to be integral to commercialization success, including several which addressed the original question of MEMS millionaires. I modified these general criteria to develop the nine, and then added five additional criteria by 2002 to support my list. Now that the critical success factors have been established, what to do next?

Why a “Report Card” and “Grades”

Initially, I determined that there were nine critical success factors (CSFs) for MEMS commercialization, including several items reflecting on the original question of



* Def: Process or cycle of introducing a new product or production method to the market.

Roger Grace Associates supports its clients in front and back-end market analysis as well as in the product launch plan and execution.

Figure 1. The MEMS Commercialization Process illustrates the necessary steps to successfully bring MEMS-based products from concept to market. Market research is a critical part in the process appearing in the front-end to best define the product, competition and market needs and, in the back-end to optimize the communication strategy and plans in introducing the process/product to the market. (Courtesy: Roger Grace Associates)

financial success, and these were “Venture Capital Attraction”, “Profitability”, and “Creation of Wealth”. However, the question remained: what was the next step to make this information useful to the MEMS community? I decided that conducting a marketing study, using an initial email with a telephone follow-up would be the best approach. In creating the questionnaire, a format was selected which provided participants with the ability to grade the performance of these critical success factors in letter grades, from A to D. Additionally, it would ask participants to provide the rationale for their assigned grades and therefore create a research vehicle that were simultaneously qualitative and quantitative – a market researchers’ dream. We all know

that everyone loves grades – when we go to a restaurant, a hotel, when we select a physician, when we purchase something from Amazon – so why not with MEMS commercialization performance? What was needed was a unique and simplified approach to create a vehicle that could intimately and simply address the sentiments and attitudes of the MEMS community since none existed to this time, and since nature abhors a vacuum, the *Report Card* was born to address this deficiency and satisfy unmet needs of the MEMS community.

Motivation...Does Having a Report Card Matter?

My initial and ongoing intent has been to report to the MEMS community the sta-

tus of the efforts to overcome the barriers, a.k.a. critical success factors, in the creation of a successful MEMS industry and to help guide participants with valuable inputs as to how to better succeed based on past performance. This is truly a “lessons learned” opportunity and in the words of the famous philosopher George Santayana^[1], “those who forget the past are condemned to relive it”. It is noteworthy that MEMS were essentially discovered in the mid-1950s, along with semiconductors, both at Bell Labs. In 1998, I felt that it was long overdue to provide the MEMS community a different and simultaneously quantitative and qualitative approach to reporting on the progress of MEMS commercialization activities as a valuable alternative to the standard purely quantitative approach of sales volume and growth rate being reported on by several organizations. According to Gartner^[2], 2021 worldwide semiconductor revenue was US \$595.0 billion. Conversely, and according to IC Insights^[3], 2021 MEMS worldwide revenue was US \$15.9 billion. Why is there a 37.4:1 discrepancy in the revenue numbers? Looking to the semiconductor industry and its successful commercialisation is certainly a lessons-learned opportunity. After considerable research into the topic of technology commercialization, I concluded that the 14 *Report Card* subjects, a.k.a. critical success factors, were the best vehicles by which this can best be accomplished. The resulting reporting, and subsequent call to action recommendations, can be planned and executed to address subjects that appeared problematic.

Research Methodology

From its inception, the *Report Card* Study research process has embraced a hybrid approach using two popular market research vehicle concepts: The Delphi Process^[4] in addition to the Mass Observation Process (MOP)^[5] which gained popularity prior to WWII in the UK. Both approaches use inputs for a limited number of participants as compared to the popular opinion research vehicles (e.g. Harris, Gallup, Nielson Polls) which use a large number of interviews in an attempt to forecast/project an outcome within a certain degree of accuracy akin to what is used to forecast election results.

For the 2021 *Report Card* 42 completed questionnaires were received from a select list of 111 MEMS industry professionals

2021 MEMS INDUSTRY COMMERCIALIZATION REPORT CARD

SUBJECT / YEAR	98	99	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Δ
R&D	A	A	A	A	A	A-	A-	A-	A-	A-	B+	B	B	B+	B	B	B	B	B+	A-	A-	B+	B	B-	-1
Marketing	C-	C	C+	C+	C+	C	C	C+	C+	C+	C+	C	C	C+	C+	B-	B-	B	B	B	B	B-	B-	C+	-1
Market Research	C	B-	B-	B-	B	B	B+	B-	B	B	B	B+	A-	B	B-	B-	B-	C+	C+	B-	B-	B-	C+	C	-1
Design For Manufacturing	C+	B-	B	B	B	B	B	C+	B-	B	B+	A-	A-	B+	B-	B	B+	A-	A-	A-	B+	B	B	B-	-1
Established Infrastructure	C+	B	B+	A	A	A	A	A-	A-	A-	B+	B+	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	B+	B-	-2
Management Expertise	C	C	C+	C+	C+	C+	C+	B-	B-	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	-1
Venture Capital Attraction	C	B-	B+	A	C	C-	C	C+	C+	C	C	D	D+	D+	D+	D+	D	D	D+	C-	C-	C	C	C-	-1
Creation Of Wealth	C	B-	B+	A	C	C-	C-	C-	C-	C	C-	D+	C-	C+	C+	C+	B-	C+	C+	C+	C+	C+	C+	C	-1
Profitability	C-	C-	C-	C-	C-	C-	C-	C	C+	C	C-	D+	D	C-	C	C+	C+	C	C-	C-	C	C	C+	C	-1
Industry Roadmap	INC	B-	B	B+	A-	A	A	B	B-	C+	C-	C-	C	C	C	C+	B-	C+	C	C	C	C	C	C	0
Industry Association	INC	INC	INC	B	B+	B+	B	B	B	B+	B	B	A-	B+	B+	B+	B+	A-	B+	B-	B-	B-	B-	C+	-1
Standards	INC	INC	INC	INC	C	B-	B-	B-	C+	C	C	C	C+	C	C	C+	B-	C+	C-	C-	C-	C	C	C-	-1
Employment	INC	INC	INC	INC	INC	C	C	C+	C+	C+	C	C	C	C+	C+	C+	B-	B-	B	B	B	B	B	B	-1
Cluster Development	INC	INC	INC	INC	INC	B	B+	B+	B	B	C+	C+	C+	C	C+	C+	B-	C+	B-	C+	C+	C+	C+	C	-1
Overall Grade	C+	B-	B	B	B-	B	B	B-	B-	B-	C+	C+	B-	B-	B-	B-	B	B-	B-	B-	B-	B-	B-	C+	-1

Figure 2. The MEMS industry commercialization report card (Report Card) was created in 1998 and has been conducted annually. The 2021 aggregated grade was C+ which was a one grade decline from the previous six years of reporting. All but one of the 14 subjects experienced a decline of one grade with Infrastructure realizing a two-grade decline. The grade for Industry Roadmap remained at C. Standard deviation was 0.40. (Courtesy: Roger Grace Associates)

2021 MEMS COMMERCIALIZATION REPORT CARD

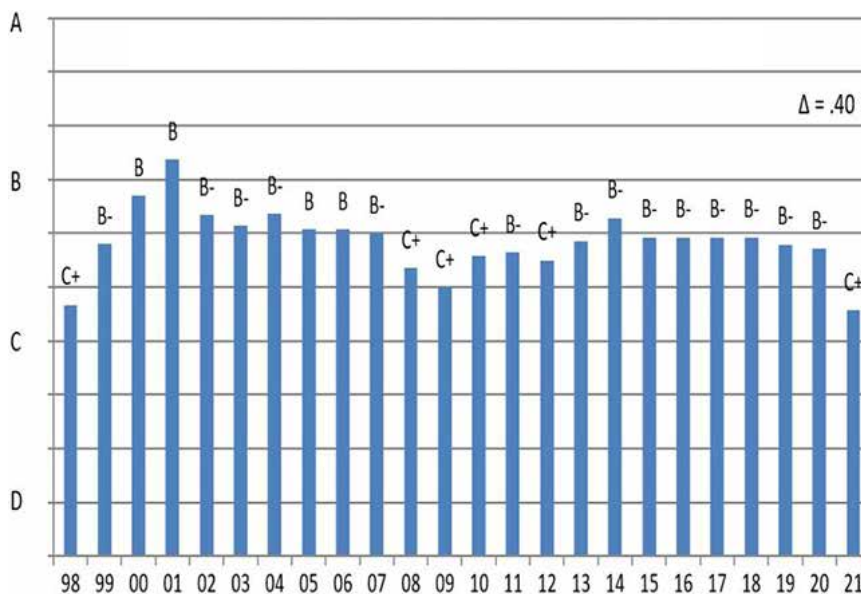


Figure 3. Since its inception in 1998, the MEMS Industry Commercialization Report Card consolidated grade has only received a grade lower than B- which occurred in 1998, 2008/2009 (as a result of the world economic recession, in its first year and in this year's 2021 study). (Courtesy: Roger Grace Associates)

in the Roger Grace Associates database, resulting in a 38% return rate. The emailed questionnaire required respondents to assign letter grades with pluses and minuses from

A to D to each of the 14 subjects as well as provide verbatim comments on subjects that they considered of unique importance. Most noteworthy was my effort to have

respondents address the issue of COVID's effects on their grades and what strategies that they were using to mitigate these effects. The typical respondent had an average of 25 years of experience in the MEMS industry and, as such, the *Report Card* represents a total of over 1,000 person years of cumulative MEMS experience. It should be noted that achieving a response rate of over 5 percent for this type of market study is virtually unheard of in the market research community. I believe that the 38% return rate demonstrates the continued commitment of the individuals in the study to support the MEMS community. Thus, the *Report Card* research was able to successfully assess the health of the MEMS community commercialization by simultaneously using both quantitative and qualitative research approaches.

Results

The results are in, and the grades for the 2021 microelectromechanical systems (MEMS) Industry Commercialization Report Card (*Report Card*) Study were tabulated. And, not surprisingly, the final grade declined from B- to C+, breaking a string of the previous six years (see Figure 2).

The C+ grade had previously occurred only once in the years 2008 and 2009, and as a direct result of the worldwide financial recession. A C+ grade was also given for the initial year of the *Report Card* in 1998 (see Figure 3). More importantly, and as a result of a closer examination of the numerical results, the actual numerical, not grade score, in 2021 was the lowest in the history of the study.

Additionally, all but one of the 14 "subjects", Industry Roadmap, declined one grade. Infrastructure declined two grades, and was certainly expected as a result of the severe detrimental effect of COVID on the supply chain. The apparent maturity of the MEMS industry to maintain its B- grade for the past six years, has been previously reported in *Fierce Sensors*^[6], has been severely upended by economic and societal changes brought about dramatically by COVID in 2020, 2021 and now being projected into 2022 as a result of the Omicron and other variants.

And just briefly, a high-level sample of some of the more significant results:

Marketing – a major reduction in travel and attendance at industry events has torpedoed marketing and sales programs.

SENSOR-BASED SYSTEM SOLUTIONS

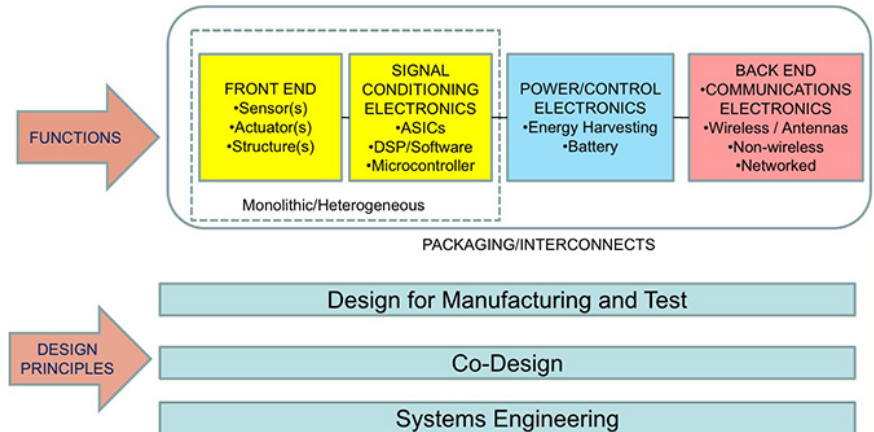


Figure 4. MEMS are to be considered product/solution enablers and not a solution unto themselves. They typically exist in the front-end of a product/system and work in conjunction with other electronic functions including signal processing, power, communications. Interconnects and packaging are a key and integral part of the system solution. (Courtesy: Roger Grace Associates)

Infrastructure – the supply chain problems have been severe and organizations are attempting to develop local suppliers for critical parts.

R&D – the inability of researchers to collaborate in our labs and the travel bans have seriously kept graduate students at home has seriously derailed the progress on ongoing projects.

Selected Verbatims

Over 125 verbatims were submitted as a rationale for the grades that the participants provided. Out of those, a small number of the most poignant were selected to appear here. I believe they truly capture the sentiments of the audience on the topic. For brevity, I have not addressed every topic here, nor included all of the verbatims for each of the subjects provided. A full list of the verbatims is provided in the Final Report^[7].

General

- People do not want to buy a MEMS. Customers want to buy a device that (does a specific function) like redirecting light. They want to know speed, wavelength dependence of the device, and how many resolvable spots (diffraction limit).
- The "novelty" of MEMS is gone. MEMS is part of a general system solution (Figure 4). Just as ICs are not just a tube replacement in many ways, MEMS is still suffering from a problem of perception.

R&D

- R&D was tough indeed, effects of COVID linger on but are getting better.
- The impact of COVID in 2021 continued to plagued R&D and most companies were focused in manufacturing, operational efficiencies and supply chains. All three of these focus areas were impacted significantly from the COVID pandemic (from starting wafers to materials, chemicals, gases and equipment were all negatively impacted from disruptions in the global economy).

- Many companies reduced R&D budgets in preparation for ongoing uncertainty from the pandemic, shattered supply chains and declining economic conditions.

Marketing

- Restrictions in travelling, more web-based communication, less visits in fairs and exhibitions and smaller marketing budgets. As a result, we have successfully adopted new marketing communications strategies to replace those that were negatively affected by the effects of COVID – webinars, direct mail, websites, social media and YouTube have been cost effect. What we still need to do is determine their ROI (Return on Investment)
- Dealing with COVID has been a mess. Online conferences are not very efficient (as in-person ones).
- The return of face-to-face meetings has enabled showcasing R&D, marketing, mar-

ket research and new employment in the MEMS industry again.

Established Infrastructure

- Like many other industries, the MEMS industry is currently plagued by supply chain problems and cost explosions in raw materials and logistics.
- Not surprisingly the biggest issue this year is supply. And MEMS appears to have taken this about the hardest among all componentry, including comm and SoC chips, hence my low grades.
- Supply chain problems, delivery from China is problematic. Problems with supply of exotic/special materials.
- One of the biggest negatives in the last year is the lack of MEMS production fab capacity, the difficulty in purchasing new fab tools. This has hit smaller foundry customers hard, driving up commercialization timelines.

Venture Capital Attraction

- Our company, Exo Imaging, raised \$220M in a Series C for our pMUT-based ultrasound imager. At least another 20 companies raised significant amounts for Series A, B, C and D Series. Most notable were wearables companies which is one of the most active sectors for investors.
- Interest increased partly because of increased medical interests, COVID, e-automotive and battery applications, slowly interest in agriculture and food processing applications.
- VC's are very active given the shortage of supply and demand for future growth.
- There is a real uptick worldwide in startup funding where I would classify MEMS again as a "software startup enabler".

Profitability

- COVID reduced work force costs and marketing travels, and as such, increased profits.
- Profitability has been affected by COVID. Need to pay premium to get supply of raw materials, equipment parts, etc. Wages cost increasing with resources shortages.
- Disruption in supply chain along with increased lead times for most semiconductors are the primary reason for my lowering the profitability grade. However, unit prices

have increased 8-10% for most semiconductors including commodity memory (just an example). However, it is unclear if profitability is increasing.

- It is difficult to determine if pricing increases are a result of the economic uncertainty, availability of wafers, chemicals, materials, equipment or the global supply chain disruptions that are affecting every industry.

Newly adopted business strategies employed to mitigate the effects of COVID should be critically assessed for deployment in 2022 and beyond.

What Can Be Done to Mitigate the Negative Effects?

I offer the following recommendations to help mitigate the negative effects:

Infrastructure/Supply Chain

- Develop, wherever possible, alternative materials and systems resources capabilities within your supply chain.
- Prioritize purchasing from "local" sources. Minimize purchasing from "non favorable" sources.
- Seek and qualify additional suppliers and include in supply chain.
- Develop "flexible" designs, where ever possible, and switch out components to mitigate impact of extended deliveries.
- Attempt to create in-house vertical integration strategy.
- Proactively partner with key suppliers.

Marketing

- Conduct a thorough and critical assessment of ROI of all of the strategies and tactics embraced during the pandemic, knowing that things will never be back to pre-pandemic scenario – and adopt, "the new normal".

- Continue to do what works...do not overreact or overcorrect.
- New social media approaches adopted have promise for the future:
 - Webinars
 - Social Media, e.g. LinkedIn, Twitter, Facebook
 - YouTube
 - Enhanced websites
 - Direct mail, e.g. Constant Contact
 - Hybrid conferences
- Many publications have ceased to exist in printed form creating opportunities for facilitating access for submitted editorial in electronics versions, thus a new opportunity – *carpe diem*.
- The pull-back of resources expected in entering the economic downturn will provide enhanced opportunities to "pull out all the stops" and NOT reduce spending on MARCOM, but rather increase it. *Carpe diem*.
- Plans need to be viewed as living, breathing and highly malleable vehicle that need to change in a timely fashion to accommodate quickly changing industry dynamics.

Prognostications

It is interesting to note that while a great deal of the research which formed the basis of the *Report Card* was conducted in Q-1 and Q-2 2021, I believe that the verbatims contributed are especially still applicable after over 30 plus months of the pandemic, as are the recommendations.

With the ongoing presence of COVID throughout 2022, it is highly likely that the *Report Card* for 2022 could be similarly affected as it was for 2021 by these lingering effects. Exacerbating this is another possibly more daunting issue on the future 2022 *Report Card* grades... the resulting business uncertainty due to the effects of the quickly emerging global economic slowdown driven by increased interest rates, inflation and massive layoffs in the technology sector. I would expect that some of the same challenges posed by COVID in 2020 and 2021 will also exist for 2022. Newly adopted business strategies employed to mitigate the effects of COVID should be critically assessed for deployment in 2022 and beyond.

Summary/Conclusions

The final grade for the 2021 *Report Card* declined to C+ with a standard

deviation from 1998 to 2021 of 0.40. All subjects declined in at least one grade with the exception of Industry Roadmap which remained the same. Infrastructure declined two grades and highly driven by the significantly negative and prolonged impact of supply chain disruptions resulting from COVID. This outcome was projected to occur in the last year's *Fierce Electronics* coverage of the 2020 *Report Card*^[6] and referenced in my *Forecast 2022* articles^{[8][9]}.

I am hopeful that the continued undertaking and subsequent publication of the results of this unique industry annual market study will continue to provide valuable guidance and actionable information to the MEMS (and other high tech) industry community to support its commercialization efforts. It should be used as a valuable tool in their efforts to successfully overcome the existing barriers to commercialization in addition to continue to act as a critical input to help formulate strategies and tactics for its accomplishment. Organizations should use this information to help them pivot in the market and to create and execute new strategies to become successful in the "new normal", con-

sidering future health and economic uncertainties. And yes, to answer the above posed question, the *Report Card* matters!

Due to the limited space allocated to this article, the sharing of the more information including significant and critical "verbatim" and recommendations to overcome barriers was not possible. However, the extensive *Report Card Final Report* is available on the Roger Grace Associates website (www.rgrace.com) and provides a more detailed assessment. ♦

Acknowledgements

The author wishes to thank all the individuals who participated in this research study for their kind, valuable and continued contribution to the betterment of the MEMS commercialization community.

References

- [1] G. Santayana, *The Life of Reason: Five Volumes in One*, 1905-06
- [2] www.gartner.com
- [3] www.icinsights.com
- [4] A. Twin; Delphi Method; Investopedia; May 27, 2022; www.investopedia.com

[5] www.massobs.org.uk

[6] R. Grace; MEMS Industry Commercialization Report Card 2020; Fierce Electronics; October 27, 2020; www.rgrace.com

[7] R. Grace, Final Report: The MEMS Industry Commercialization Report Card Study for 2021, June 2022, www.rgrace.com

[8] R. Grace; Industry Insiders Share Their Sensors/MEMS Industry Forecasts for 2022 Including the Impact of COVID; Fierce Electronics; January 18, 2022; www.rgrace.com

[9] R. Grace; Forecast 2022 for Sensors/MEMS: Focus on the Impact of COVID 19 on the Commercialization Process Global Supply Chain; NASA Tech Briefs; June 2022; www.rgrace.com

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