

# MEMS Stimulus Test Handling Challenges

Salland MEMS Conference

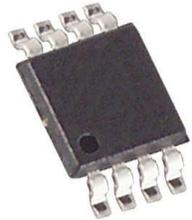
Nigel Beddoe - June 6th 2019



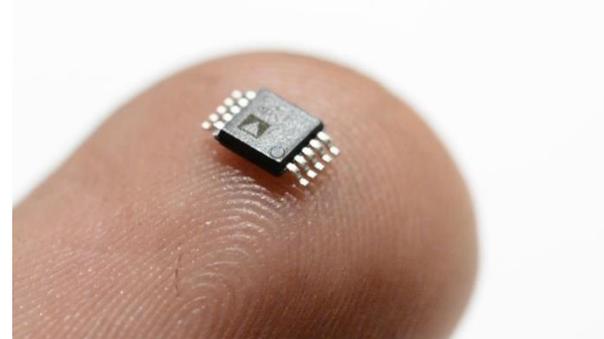
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# A brief overview of the history of change

- ❑ In the early days most of the MEMS packages were leaded and tested in singulated form on gravity handlers where the test site performed the stimulus.



SOIC 8L



MSOP 10L



# A brief overview of the history of change

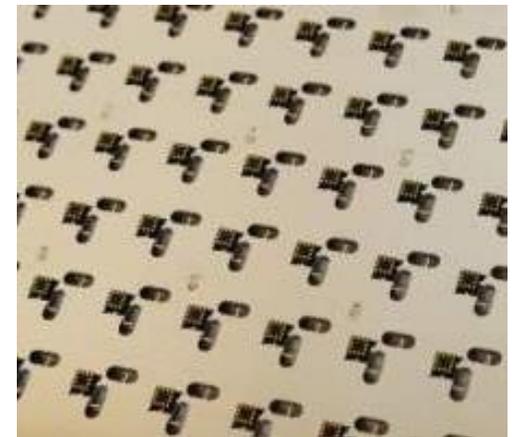
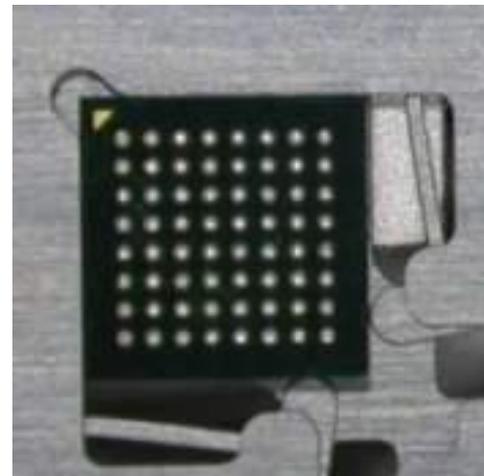
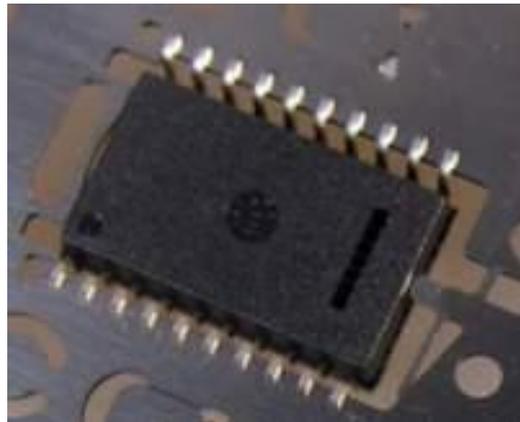
- ❑ Designers wanted smaller and thinner packages so the industry moved to the QFN package with the 5mm x 5mm being a “drop in” for the SOIC 8L, but the designers still wanted smaller.



- ❑ So now the challenge is back on the handler design as the packages were so small that standard handlers, gravity and P&P, could not handle these small packages, so something new was needed.

# A brief overview of the history of change

- ❑ Everyone thought that testing in strip format was the solution as there were several strip handlers on the market but a lot of these did not have any stimulus modules. In addition it was discovered that MEMS packages do not handle mechanical stress very well so the stored calibration values were found to be incorrect after the singulation of the devices from the strip.
- ❑ One solution was to put the units in a carrier that could hold the units in place.



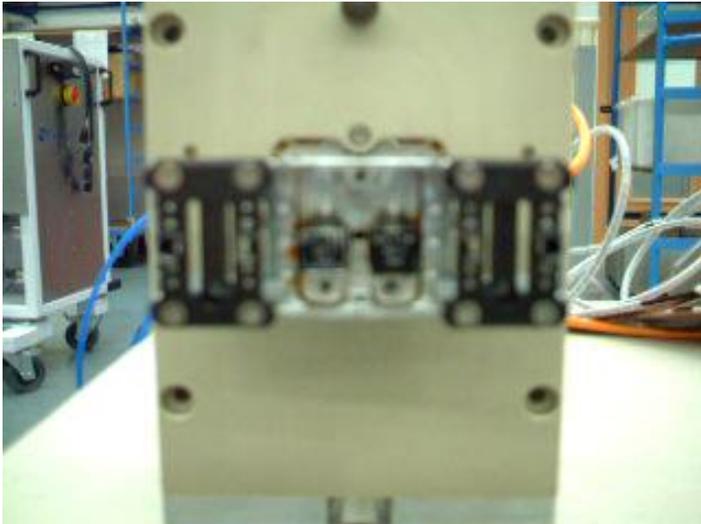
# A brief overview of the history of change

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- ❑ Now there was a solution for handling the small packages which were still >1mm and so the attention turned towards the stimulus and accuracy requirements.
- ❑ Accelerometers were the biggest volume and the standard package was the 2mm x 2mm QFN and the volume driven by the mobility megatrend. Remember the early iPhones ?
- ❑ Then came the eCompass magnetometer, followed by the barometric sensor and of course the microphones and gyroscopes in the smartphones....
- ❑ However the designers were continuing to design smaller and smaller solutions based on “more than Moore” and the end customer were requesting higher accuracy levels across all MEMS for their products and finally new solutions for sensors, besides mobility, continued to grow the market.

# The solutions

- ❑ Based on these early requirements an abundance of different stimulus were available across various different handler types.



- ❑ But the specifications for the accuracy of these devices were reaching the limit of this type of stimulus with the exception of Hi G airbag sensors.

# Accuracy Trends

- ❑ Accelerometers started out with high guardbands on angular accuracy although for the G levels the design of the structures meant that the linearity of the sensor could be extrapolated up to 10G although the units themselves were only tested at 1G.
  - 1.5 degrees – 1degree – 0.5 degree – 0.1 degree --- 0.05 degree
- ❑ The same applied to Gyroscopes and eCompass with location accuracy being the driver behind these new requirements.
- ❑ Barometric sensors used to have an accuracy of meters when they first came out but now they can measure down to an accuracy of 25cm.
- ❑ Microphones used to have a 55dB SNR level and even up to 63dB SNR there was no actual SNR test but as we move to the future (now at 70dB SNR) the SNR must be tested and the future mobile sets require 75dB SNR.

# Accuracy Trends

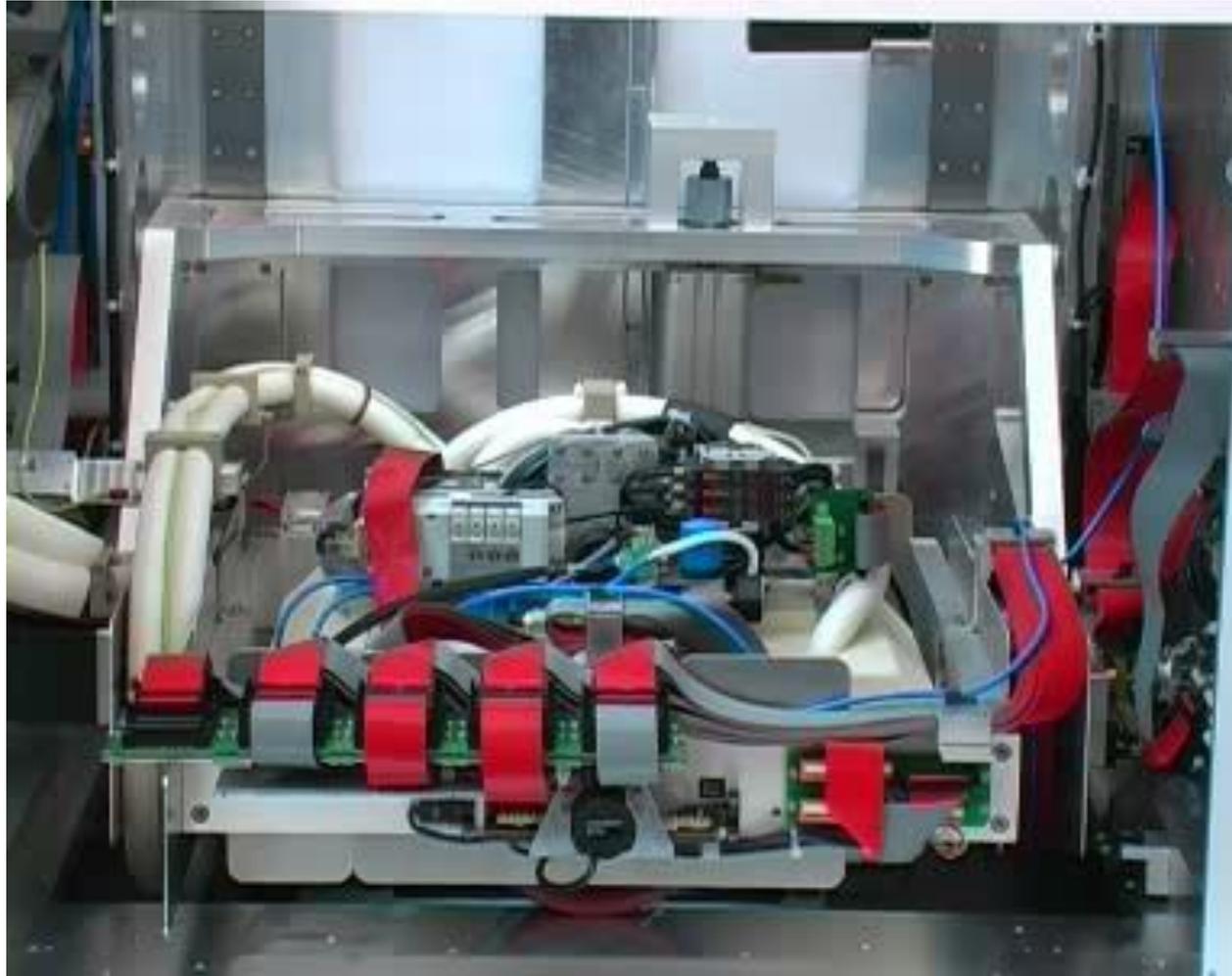
- ❑ So we at the handler companies had to develop stimulus solutions that not only could meet the accuracy requirements years into the future but also do it in high parallelism, due to the ASP's dropping by large percentages every year, and handle the ever shrinking packages.



- ❑ Game controller accelerometer test on a 1.2mm x 1.7mm LGA package at a 256 site parallelism

# Accuracy Trends

- ❑ Even the handphone requirements for the screen rotation feature is getting more and more difficult to test due to the phone manufacturers latest requirements.



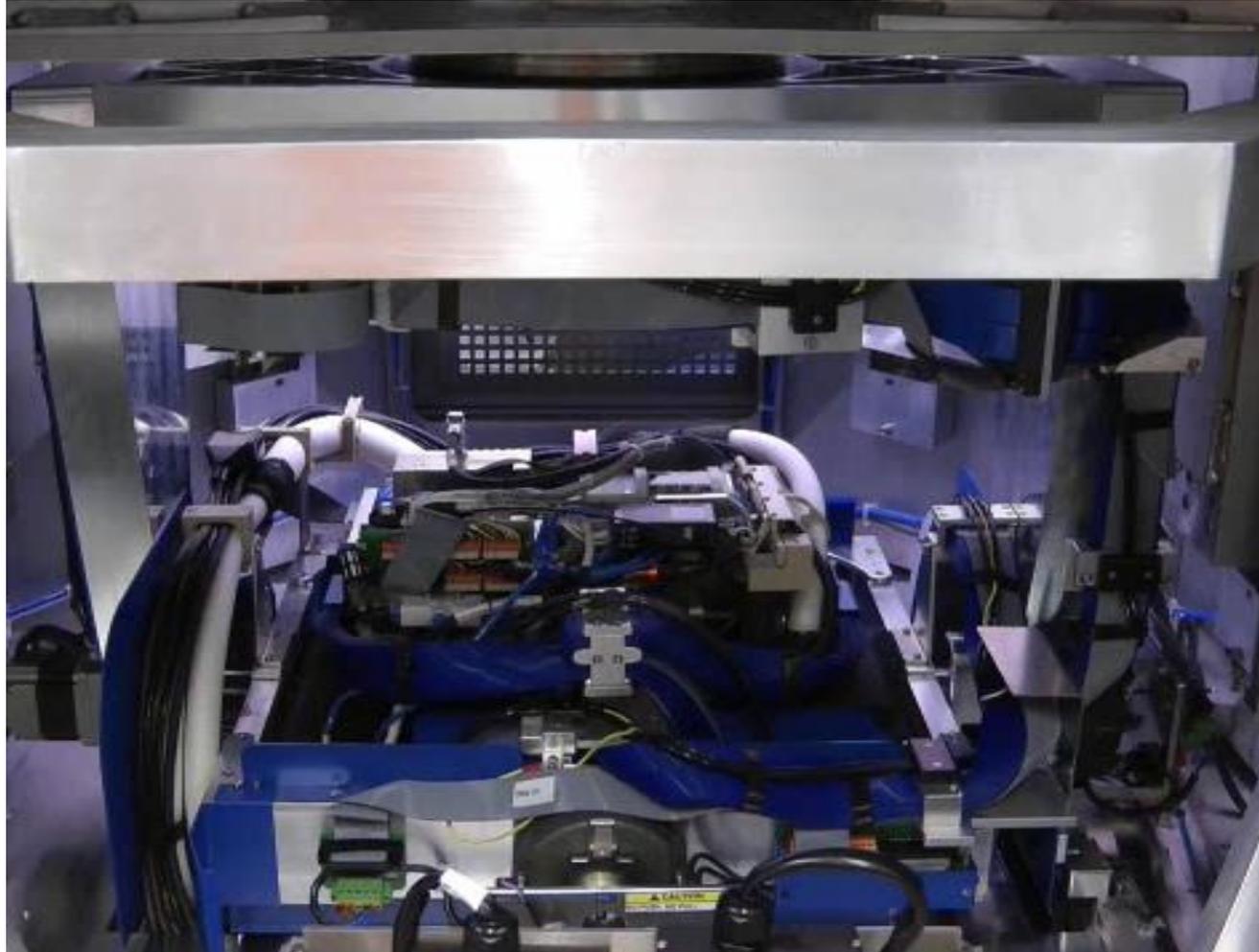
# Accuracy Trends

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- ❑ In addition to these smaller packages and accuracy requirements the IC designers were asked by the end customers to put two or more sensors into one package and so the combo sensors period started.
- ❑ 6DOF inertial with 3DOF accelerometer and 3DOF Gyroscope and some even went on to develop a 9DOF with magnetometer but this was not adopted by the mobility companies as they wanted to place the magnetometer away from the inertial sensors.
- ❑ Environmental sensors moved from separate solution to a single Barometric, Humidity Gas sensor at full temperature range. The automotive temp requirements brought a new challenge to the handler companies as now we had to achieve these accuracy levels at +125C and -40C.

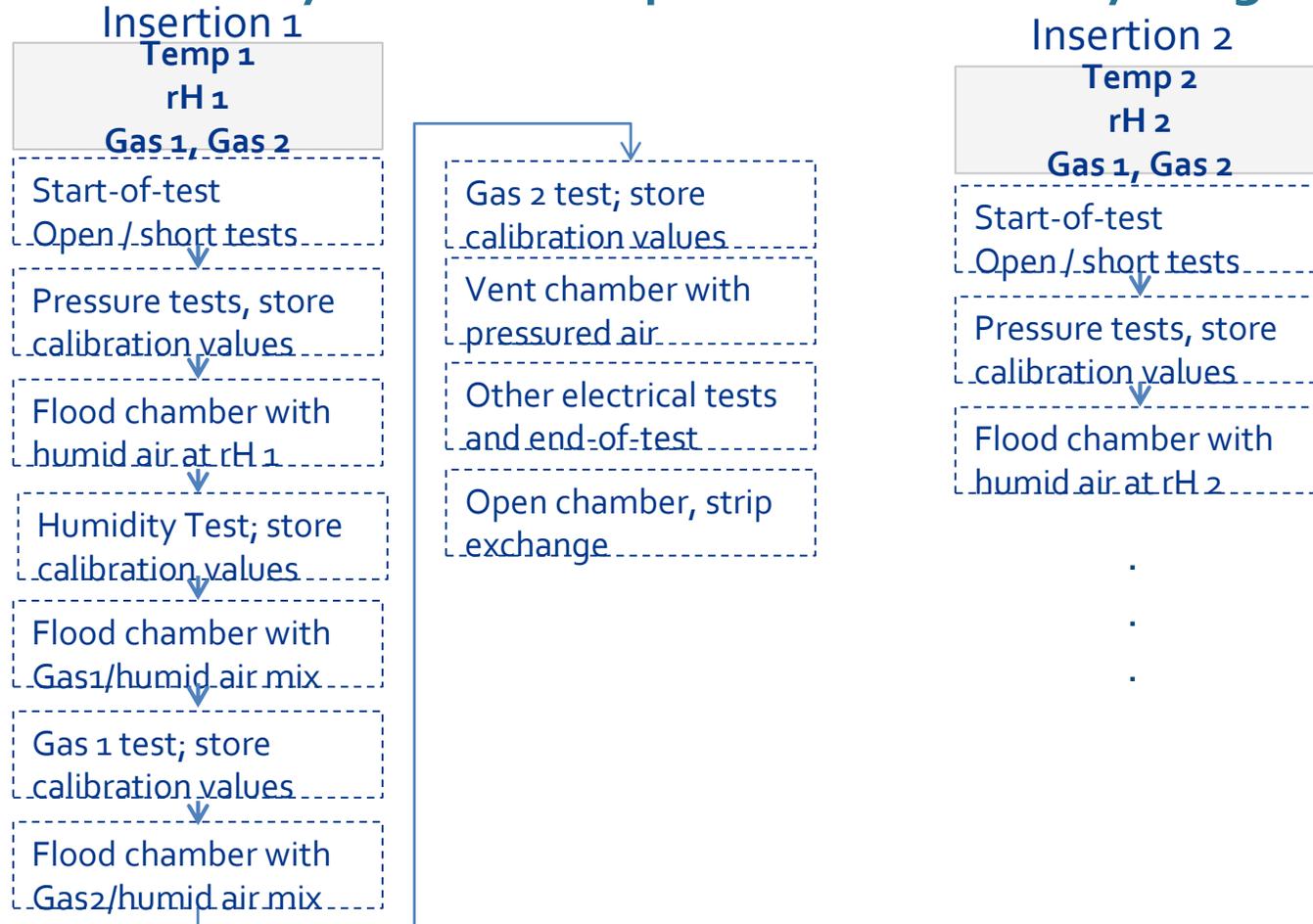
# Accuracy Trends

- ❑ Again we were able to overcome these challenges on both the inertial and environmental sensors



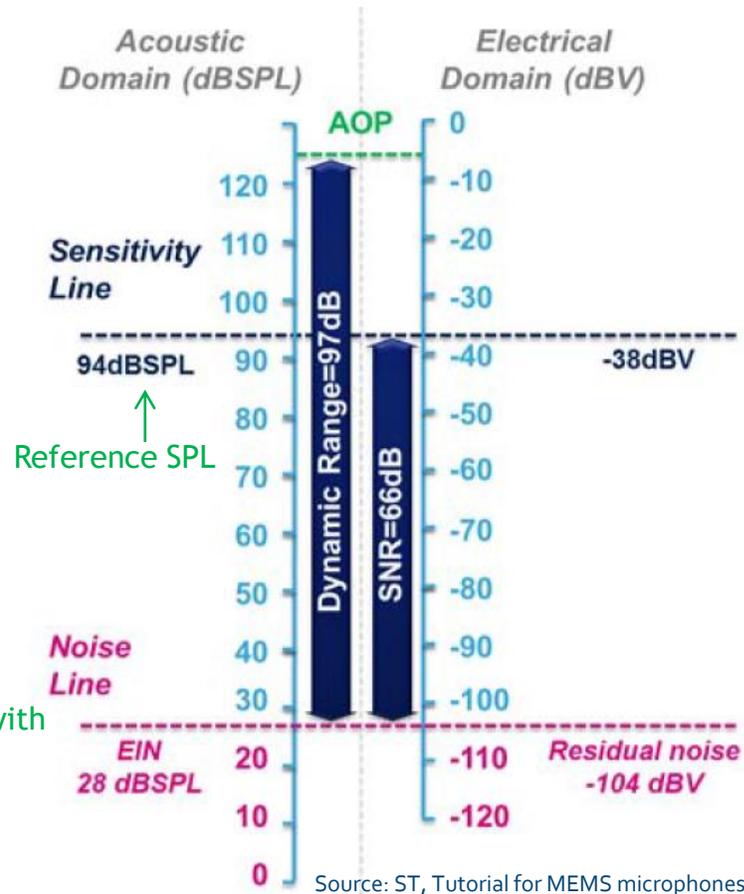
# Accuracy Trends

- From the customer requiring three complete test cells to test the barometric at temperature and then the humidity on a different system and the gas on another one or two systems it was possible to do everything in a single insertion



# Accuracy Trends

- Probably the toughest challenge for the handler solutions was to produce a system that could test microphone SNR levels in a standard test floor with an ambient noise level of 75db to 80dB.



- Whilst testing SNR levels accurately for a 66dB SNR microphone was achievable the new announcement that the upper requirement would be 75dB meant the system noise needed to be  $< 19$ dB and work in a production floor environment.

- Freq. 20Hz-20kHz\**
- Max. SPL 140dB\**
- SNR 75dB (+)*
- THD  $< 0.1\%$  @ 1kHz, 94dB SPL\**
- Single Platform*
- Full Port Down Process*
- High Parallelism*

# Future Trends & Challenges

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- ❑ We are currently testing a 0.8mm x 0.8mm MEMS package in a parallelism of 256 sites but are really at the extreme of being able to both handle and stimulate the devices to the accuracy levels being demanded.
- ❑ IC designers, however, are still continuing to develop smaller MEMS packages but without considering how will these devices be tested in a high volume, 24/7 production facility. We should be brought into these design reviews before the package size is decided to determine if the particular stimulus can handle the smaller package size.
- ❑ Based on today's available technologies with motors, encoders and other stimulus mechanical requirements we are also reaching the limit on testing accuracy specification limits, again, these limitations need to be considered in the design phase.
- ❑ Probably only the high end microphones are going in the opposite direction for package size when it comes to high end SNR as they move from 2 x 2 to 4 x 5mm.

# Future Trends & Challenges

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- ❑ We are also seeing more and more enquiries about MEMS without packaging i.e. WLCSP and so this becomes a really big challenge especially in handling these fragile die level packages.
  
- ❑ With the growth of wearables and home health monitoring the accuracy challenges become more apparent as it is our lives and health we are now dealing with. This makes the need for the IC design, packaging, final test and end application companies to come together for all future developments.

# Summary

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- ❑ During each change phase, whether it is package size shrinking or accuracy specifications increasing, we have been able to overcome the inevitable roadblocks with new designs.
- ❑ As more and more sensor types evolve, or are created, the current technology allows us to be able to test these products at the highest accuracy and parallelism.
- ❑ However, if the IC designers keep on developing new designs following “more than Moore” we will soon reach the limits of today’s technology for MEMS test. Whilst BIST on ASIC can resolve the handling process roadblocks this is still not yet possible across all MEMS devices.
- ❑ A new design process needs to be established whereby the IC designers should consult with the Wafer Fabs, Assembly packaging companies, the Testing companies, and, not forgetting the handler and stimulus companies, before a design is created that is not able to be tested whilst stimulated.

**And now**

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# QUESTION TIME

# Thank You



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