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MEMS Pressure Sensor Testing Solution and Challenges

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KYEC

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- Pressure Sensor Testing Solution Design
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- Conclusion

MEMS Pressure Sensor Testing

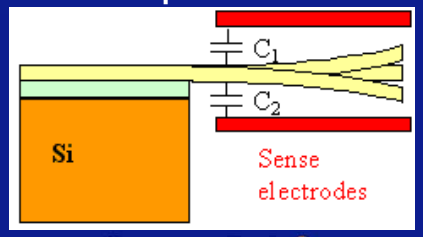
- MEMS for Pressure Sensing Technology
  - Capacitive

    Parallel plate structure with small displacement. Pressure cavity to create a variable capacitor.
  - Piezoelectric

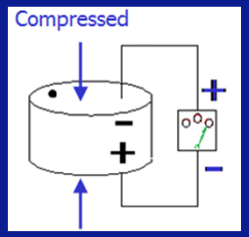
    Applying mechanical pressure to certain solid materials released an electrical charge.
  - Piezoresistive

    The change in electrical resistivity of a material when mechanical strain is applied.

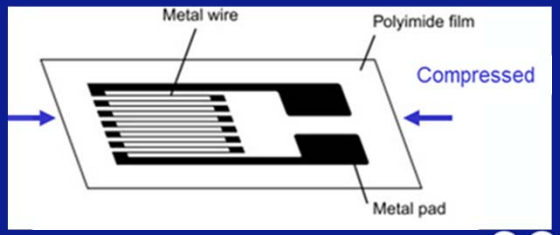
Capacitive



Piezoelectric



Piezoresistive



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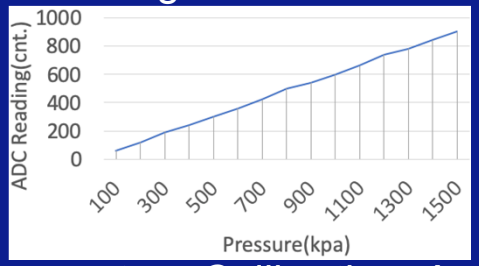
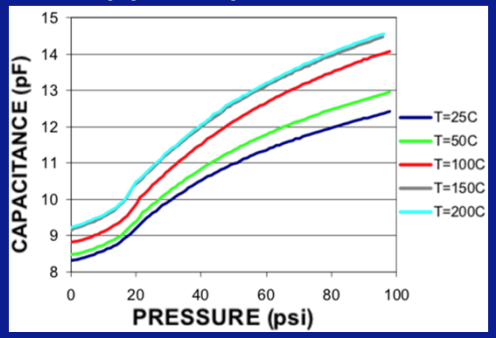
MEMS Pressure Sensor Testing

- Physical Stimulus for MEMS Pressure Sensor testing
  - Pressure Calibration: To get relationship between the applied pressure and electrical signal.



Pressure Rang (kpa)	Applications
110	Altitude measurement, barometric pressure
1400	Engine controls, water proof watches, diver's computers, tire pressure monitoring systems (TPMS)

  - Temperature Calibration: Applied pressure for various temperatures.



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Pressure Sensor Test Solution Design

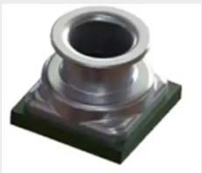
- Pressure Sensor Testing Challenges For MP
  - Pressure Range: 0~1400kpa, High pressure need more stronger chamber design.
  - Chamber Size: Parallel test Sites, Throughput.
  - Temperature Parameter: Temperature wait time, Temperature uniformity.
- Pressure Sensor Test Solution Concept
  - Multi-Chamber:

    Flexible configuration and quickly response for different temperature test conditions. Production line automation doesn't need multi-insertion and also reduce the use of manpower.
  - Testing Multiple Sites in Parallel:

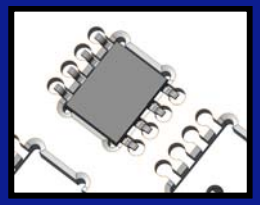
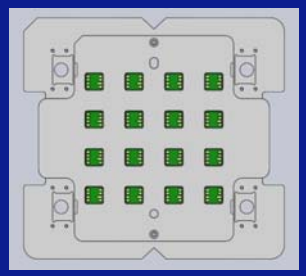
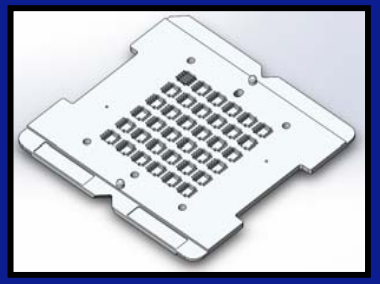
    Long temperature waiting time for temperature calibration. This is a trade-off between temperature stability and test time. Solution are designed to get the balance between device performance(quality) and throughput.

Pressure Sensor Test Solution Design

- Test Handler – Clamper
  - Pressure sensor package:

Package	QFN/LGA	Water resistant	SOP
Application	Altimeter, Barometer	Wearable Device	TPMS
			

  - Device Handing: Pick and place pad side and keep ware form the vent hole, we design the clamper to deal with various package.

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Pressure Sensor Test Solution Design

- Test Chamber - Temperature configuration/Test Flow
  - There are 4 chambers in line, that is more flexible. It's base on test condition and test flow.
  - 4 temperature: More temperature calibration data

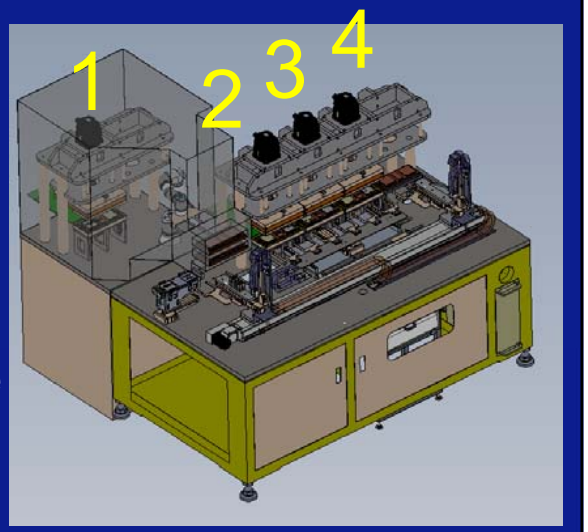
	Chamber 1	Chamber 2	Chamber 3	Chamber 4
Test Temperature	-20℃	25℃	65℃	125℃

  - 3 temperature+1 verify:

	Chamber 1	Chamber 2	Chamber 3	Chamber 4
Test Temperature	-20℃	25℃	65℃	25℃

  - 2 temperature+1 soaking+1 verify: Reduce waiting time

	Chamber 1	Chamber 2	Chamber 3	Chamber 4
Test Temperature	-20℃	Soaking	65℃	25℃



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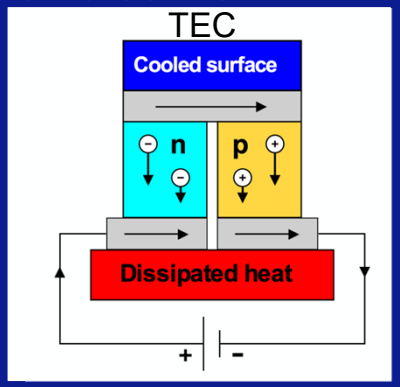
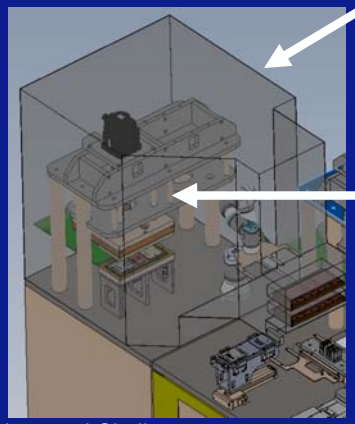
MEMS Pressure Stimulus - Temperature

- Pressure Chamber Temperature Control
  - Thermoelectric Cooler System
    - Water cooling system for hot side.
  - Closed loop control
    - Chamber has temperature reference sensors to feedback and monitor the actual temperature in test chamber.
  - Thermal Insulation for low temperature
    - Low temperature test chamber uses the thermal insulating material to minimizing heat loss and cooling chamber ambient air temperature.





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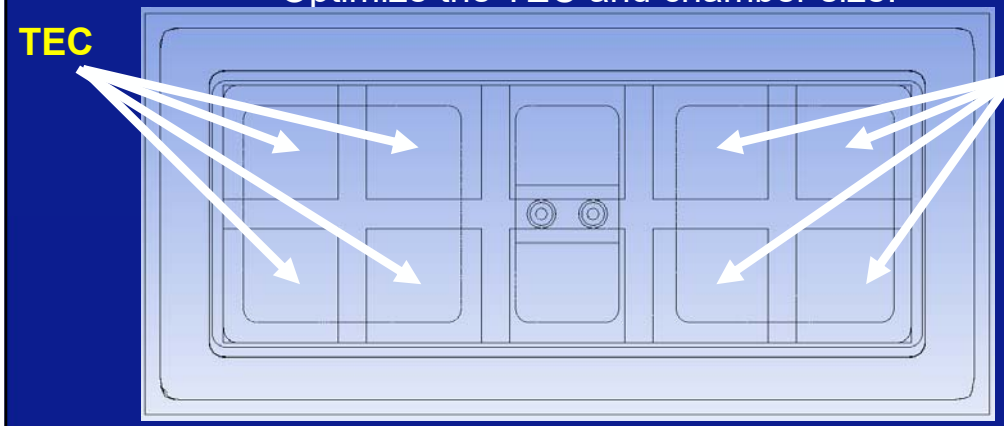
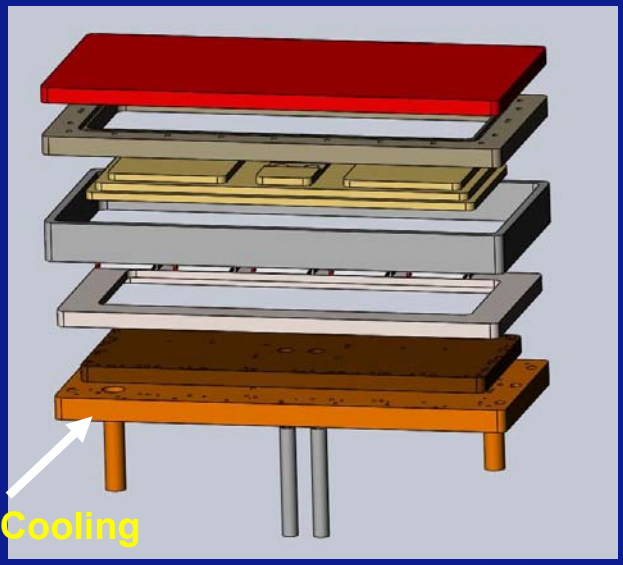
MEMS Pressure Stimulus - Temperature

- Chamber Temperature Control
  - Chamber temperature uniformity
    - 10 TEC(Thermoelectric Cooler) modules all cooperate to improve temperature uniformity.
    - Water cooling system for hot side.
    - Optimize the TEC and chamber size.





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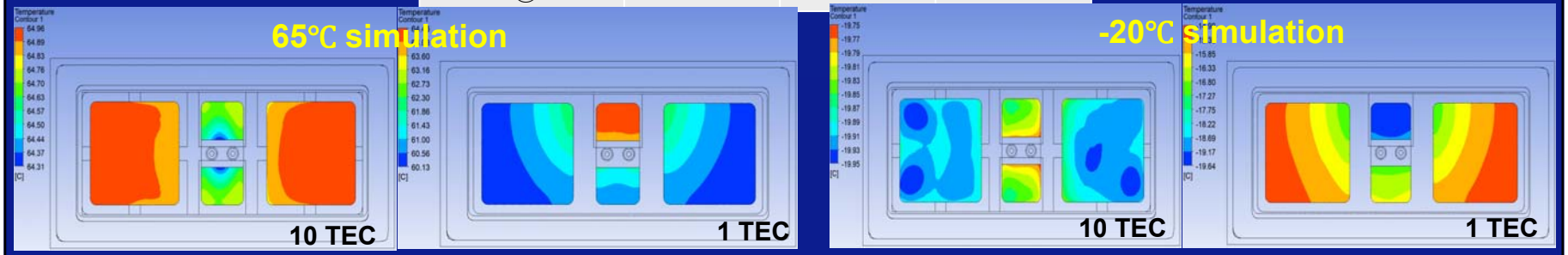
MEMS Pressure Stimulus - Temperature

- Chamber Temperature Control
  - Chamber temperature uniformity simulation and result

	Max Temp.	Min Temp.	Diff.
10 TEC@65℃	64.96	64.31	0.65
1 TEC@65℃	64.46	60.13	4.33
10 TEC@-20℃	-19.75	-19.95	0.25
1 TEC@-20℃	-14.9	-19.64	4.74



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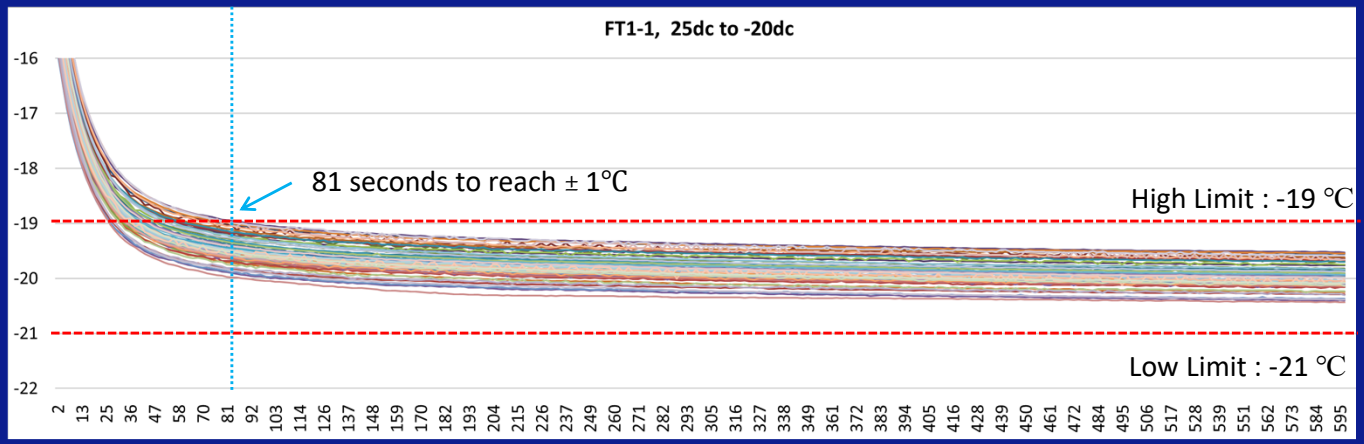
MEMS Pressure Stimulus - Temperature

- Chamber Temperature Control
  - Chamber temperature uniformity result
    - 128 sites for one chamber.
    - IC temperature uniformity result: -20 ℃ +/- 1℃, Stability Time: 81 Sec.



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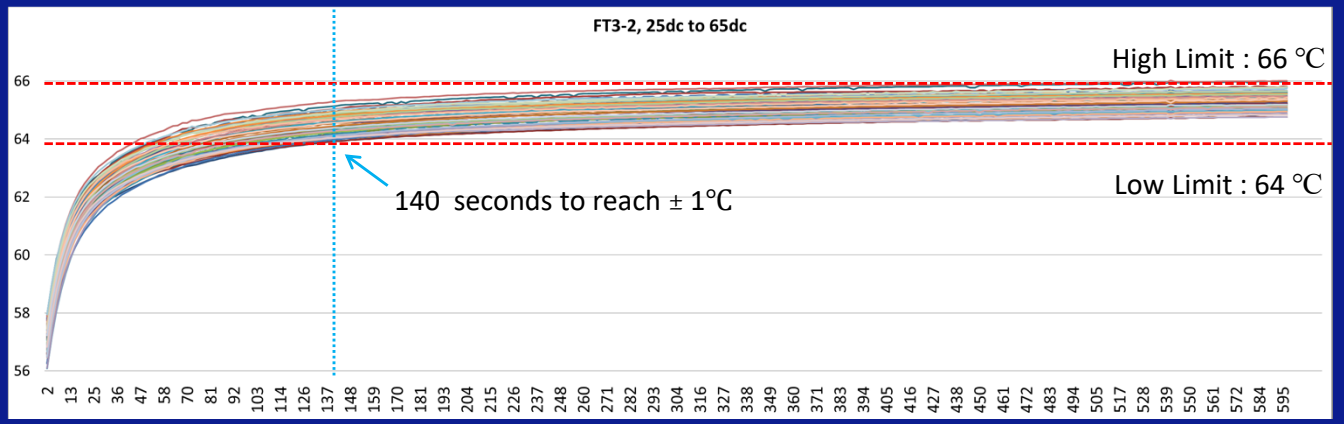
MEMS Pressure Stimulus - Temperature

- Chamber Temperature Control
  - Chamber temperature uniformity result
    - 128 sites for one chamber.
    - IC temperature uniformity result: 65 +/- 1℃, Stability Time: 140 Sec.



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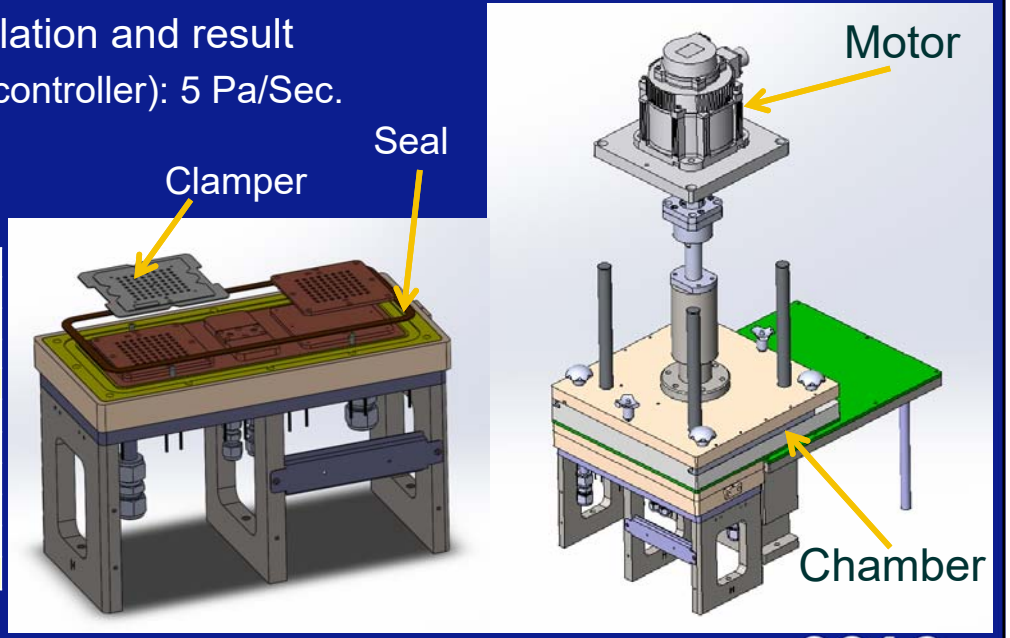
MEMS Pressure Stimulus - Pressure

- Chamber Pressure Control
  - Powerful structure and motor for High Pressure
  - Chamber pressure stability simulation and result
    - Pressure chamber leakage (off controller): 5 Pa/Sec.

SLOPE(Pa/sec)	Indicator:PACE1000	
MAX	2.97	
MIN	0.21	
STD	0.42	
AVG	2.36	Criteria < 5 Pa
Pressure(1 mins)	Indicator:PACE1000	
MAX	10139.7	
MIN	10000.1	
STD	41.03938558	
MAX-MIN	139.6	Criteria < 300 Pa



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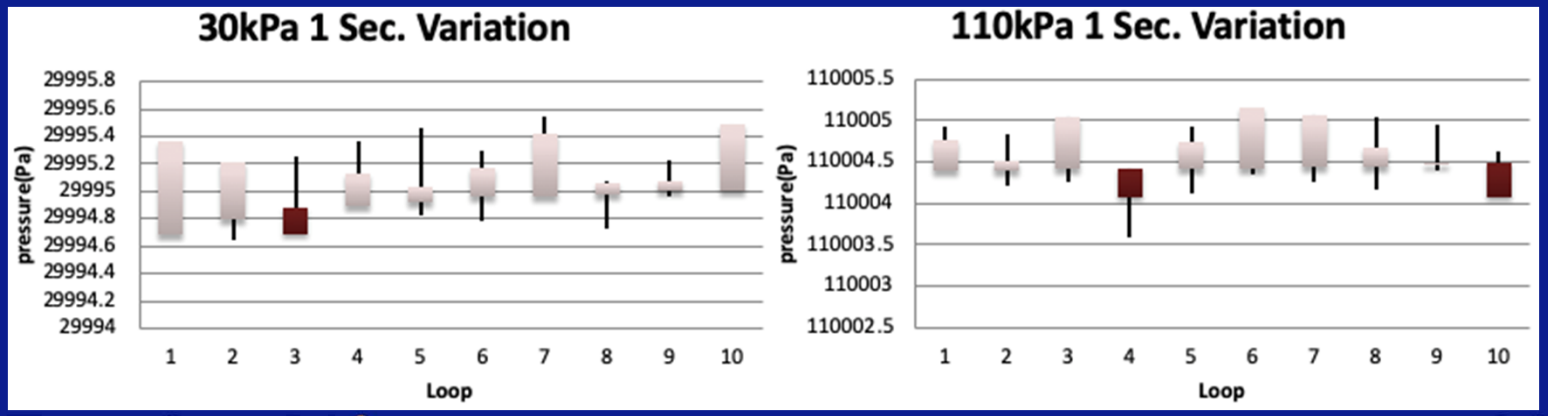
MEMS Pressure Stimulus - Pressure

- Chamber Pressure Control
  - Powerful structure and motor for High Pressure
  - Chamber pressure stability simulation and result
    - Pressure chamber leakage (off controller): 5 Pa/Sec.
    - Pressure stability (Max-Min): <1 Pa/Sec.



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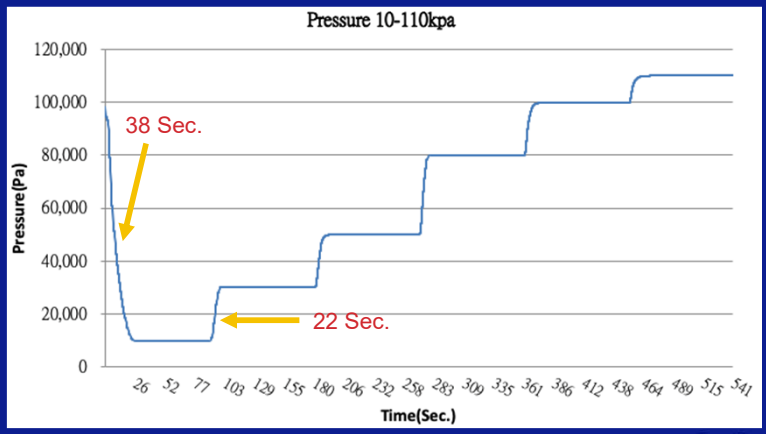
MEMS Pressure Stimulus - Pressure

- Chamber Pressure Control
  - Powerful structure and motor for High Pressure
  - Chamber pressure stability simulation and result
    - Pressure chamber leakage (off controller): 5 Pa/Sec.
    - Pressure stability (Max-Min): <1 Pa/Sec.
    - Pressure stable time: Average 23 Sec.

Pressure(Pa)	Stable Time(Sec.)
Atm.->10k	38
10k->30k	22
30k->50k	20
50->80k	15
10->100k	24
100k->110k	20



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Conclusion

- MEMS pressure sensor testing challenges
  - There are various package type for different applications. How to handle DUTs at MP handler? The effect of temperature on thermal conductivity is different from materials. HW(kit, socket…) designs also impact the heat conduction.
  - Temperature stable time is march long than pressure. We try to use a soaking station to improve the temperature stable time and MP efficiency. More smarter temperature control policy to reduce the temperature stable time.
  - The key point of pressure is chamber designs. Chamber structure needs to strong enough to handle high pressure. And pressure leakage is related to pressure noise.
  - This concept and structure of airtight chamber is also available for humidity and gas sensor. But we have to care about corrosion and concentration of combined gas.

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