THE BEST MOTION SENSOR PROVIDER
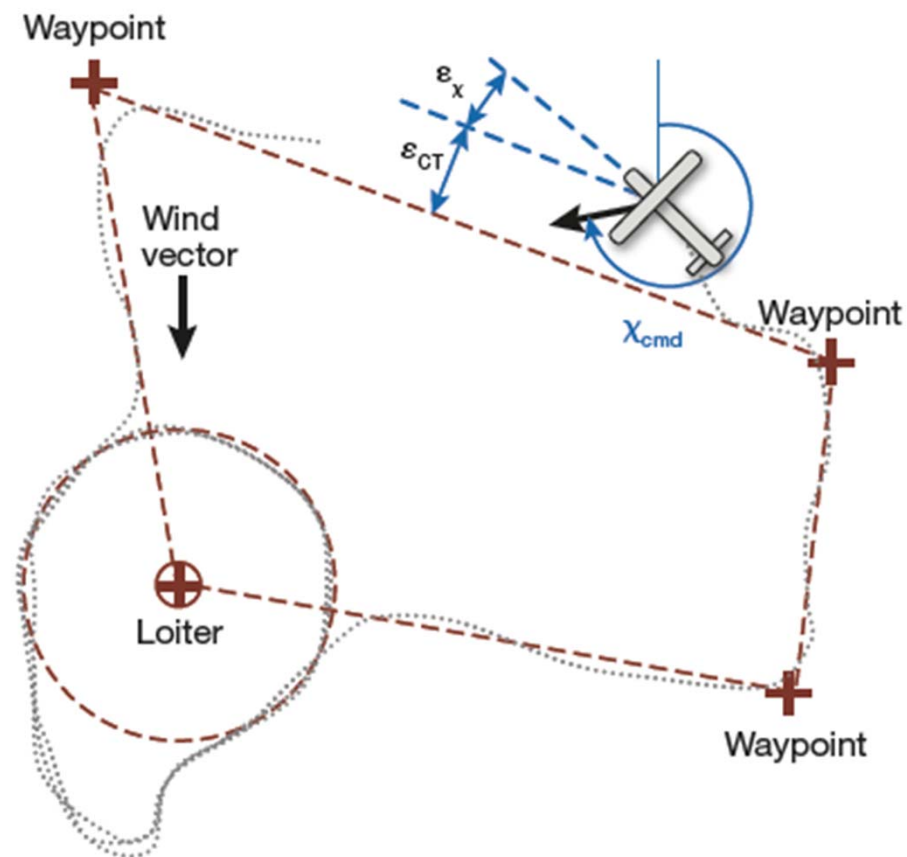
Magnetometer for Quadcopters

iSentek

sales@isentek.com
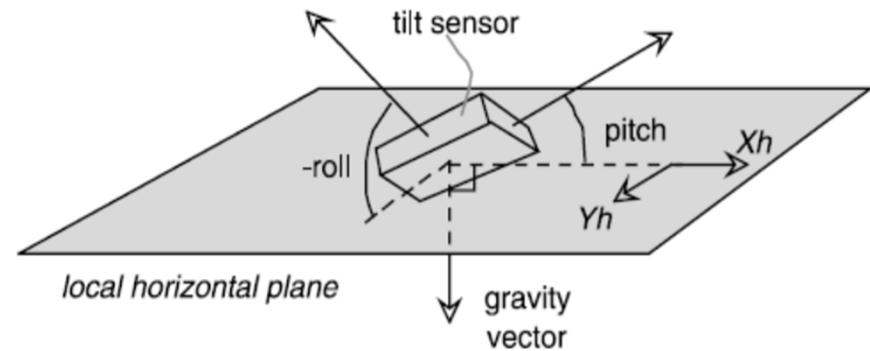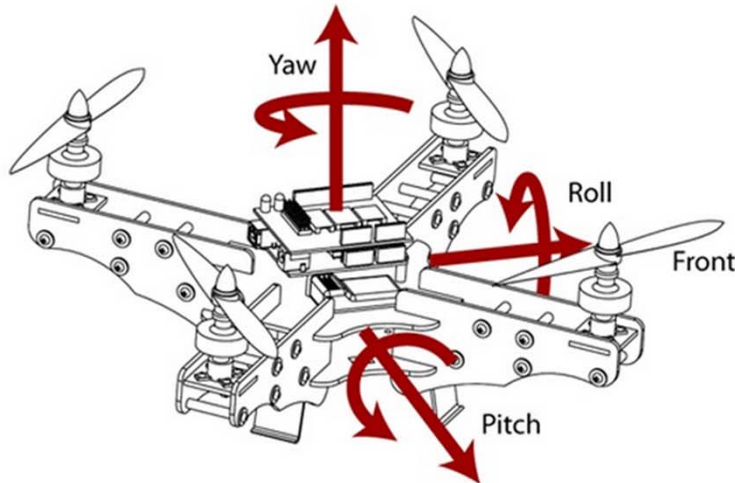
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Magnetometer Play Key Role in Autopilot

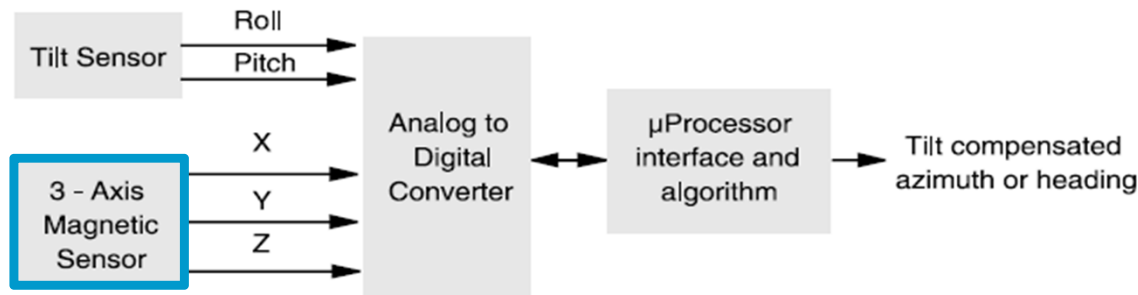# What does Magnetometer Do in Quadcopters?

- Quadcopters use three angles as: Yaw, Pitch and Roll to define attitude parameters.

- These three parameters are derived from Magnetometer.

- The auto-calibration function of gyroscope is achieved via Magnetometer's real time data.

2

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e-Compass System in Quadcopters

- The e-Compass system includes at least one 3-axis magnetometer and one accelerometer.
- The accelerometer is used for magnetometer's tilt compensation function. Without tilt compensation, the heading error can be larger than 10 degree.

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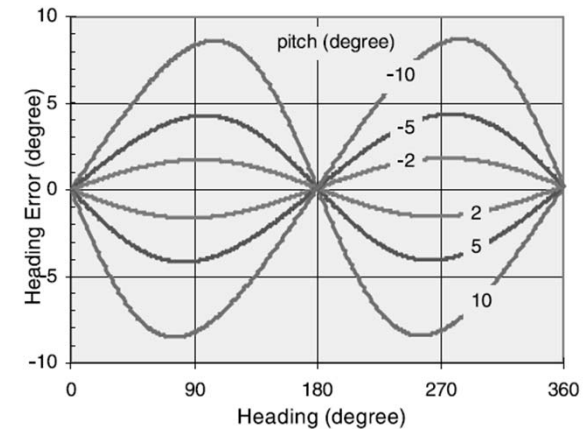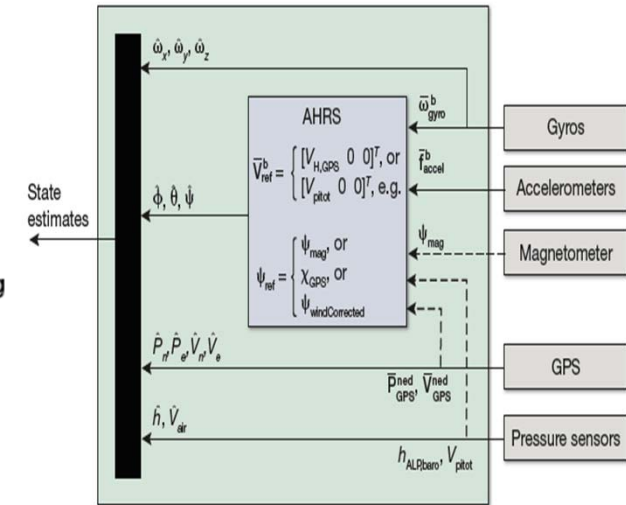
Main Parameters that Affect Heading Accuracy

- **A/D Converter's resolution**

- **Error from magnetometer**
  - Noise
  - Linearity

- **Magnetic interferences**

- Temperature drift
  - iSentek AMR magnetometers achieve small temperature drift

- Error from the tilted angel of magnetometer
  - Can be fixed through accelerometer's data and algorithms

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A/D Converter's Resolution

- If we want the A/D converter contributes only <0.1°to the heading error:
  - 0.1°=arcTan(Yh/Xh), Yh/Xh=1/573
    => A/D Converter's resolution needs to be larger than 9-bit

- Assuming the geomagnetic field in X/Y-axis is ~200mG and the magnetic field of operation environment is ~3000mG:
  - 3000mG/200mG=15 => A/D Converter's resolution needs to be larger than 4-bit

- In total the A/D Converter's resolution needs to be larger than 9+4 = 13bit

- **IST8307 uses 14bit A/D Converter**

- **HMC58xxx uses 12bit A/D Converter**

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Noise of Magnetometers

Product	Noise*	Induced Heading Error
IST8307/IST8310	**X-axis < 0.10 uT**	**0.29°**
	Y-axis < 0.16 uT	**0.46°**
	Z-axis < 0.24 uT	**0.69°**
HMC58xxx	**X-axis < 0.21 uT**	**0.60°**
	Y-axis < 0.18 uT	**0.52°**
	Z-axis < 0.24 uT	**0.69°**

*Experimental results

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Linearity of Magnetometers

Product	Dynamic Range	Linearity*		Induced Heading Error
IST8307/ IST8310	+/- 2G	X-axis < 0.17 %FS		~0.30°
		Y-axis < 0.22 %FS		~0.36°
		Z-axis < 0.31 %FS		~0.77°
HMC58xxx	+/- 2G	X-axis < 0.19 %FS		~0.49°
		Y-axis < 0.22 %FS		~0.50°
		Z-axis <0.23 %FS		~0.52°
Product	**Dynamic Range**	**Linearity***		**Induced Heading Error[1]**
IST8307/ IST8310	+/- 8G	X-axis < 1.38 %FS		2.50°
		Y-axis < 0.94 %FS		1.75°
		Z-axis < 0.82 %FS		1.36°
HMC58xxx	+/- 8G	X-axis < 6.73 %FS		12.2°
		Y-axis < 6.97 %FS		12.8°
		Z-axis < 4.99 %FS		8.22°

[1] If the magnetometer operates at in around +/- 4~8 Gauss
(15~20 times higher magnetic field than geomagnetic field)

*Experimental results

Hysteresis of Magnetometers

Product	Dynamic Range	Hysteresis*	Induced Heading Error
IST8307/ IST8310	+/- 2G	X-axis < 0.16 %FS	1.72°
		Y-axis < 0.13 %FS	1.52°
		Z-axis < 0.45 %FS	4.93°
HMC58xxx	+/- 2G	X-axis < 0.11 %FS	1.72°
		Y-axis < 0.21 %FS	3.44°
		Z-axis < 0.23 %FS	3.44°
Product	Dynamic Range	Hysteresis*	Induced Heading Error
IST8307/ IST8310	+/- 8G	X-axis < 0.12 %FS	4.94°
		Y-axis < 0.07 %FS	3.00°
		Z-axis < 0.21 %FS	9.59°
HMC58xxx	+/- 8G	X-axis < 0.17 %FS	10.2°
		Y-axis < 0.09 %FS	5.14°
		Z-axis < 0.13 %FS	6.84°

*Experimental results

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Temperature Drift of Magnetometers
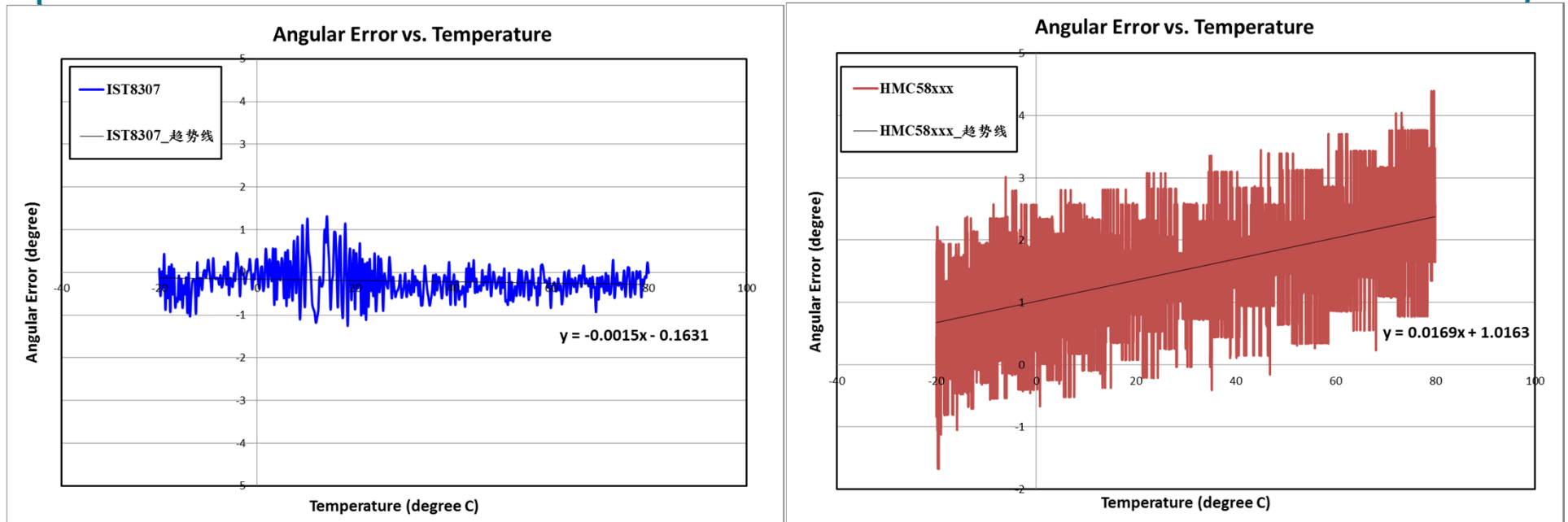
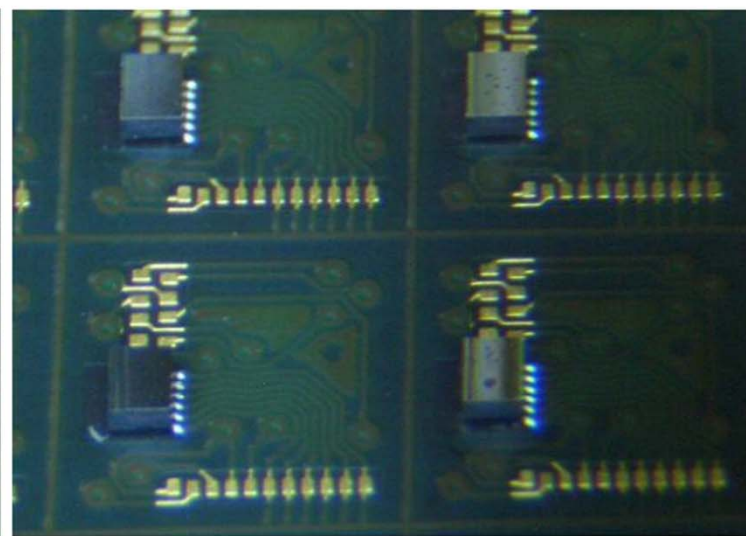| Product	Contributed Angular Error (-20~80 °C)
IST8307/IST8310	± 1.2°
HMC58xxx	-1.7~4.3°

HMC58xxx Reliability Issue (1/5)
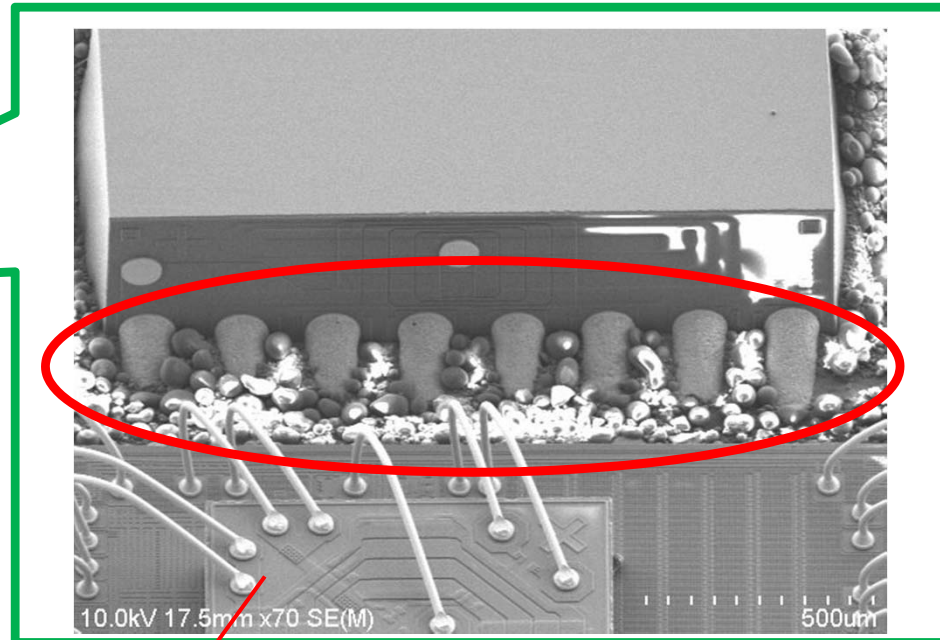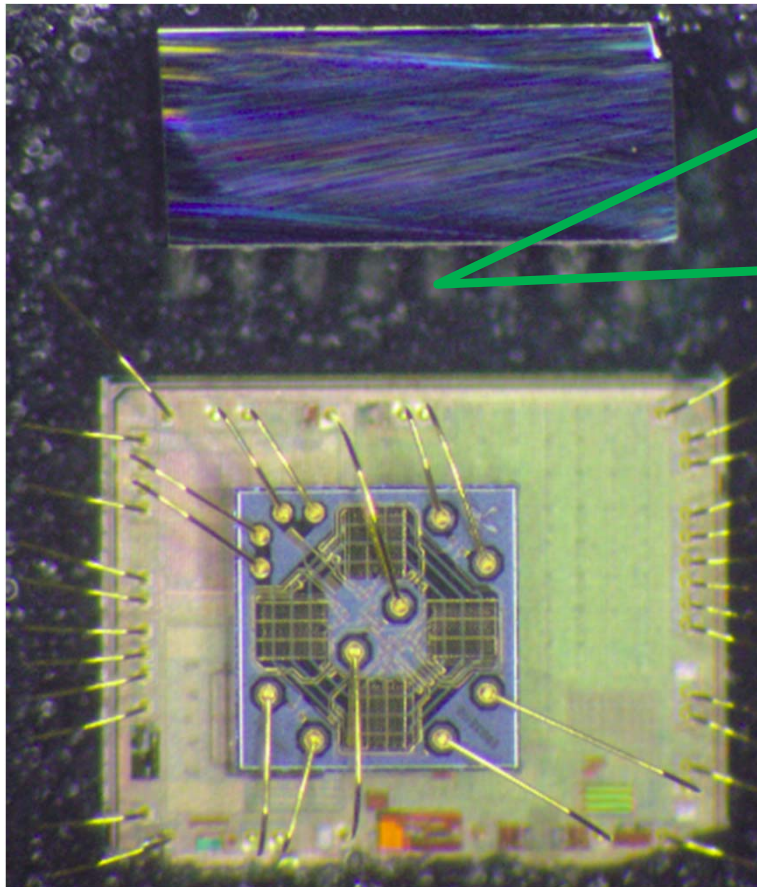
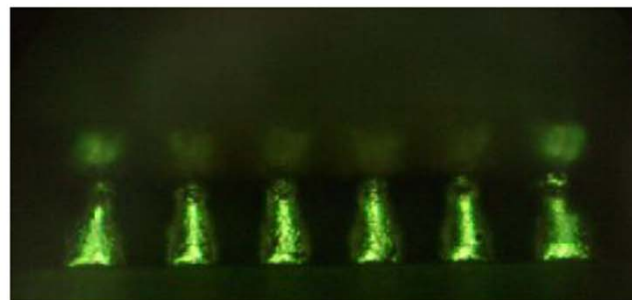The vertical architecture of z-axis of HMC58xxx leads to 10~15% failure after reflow process

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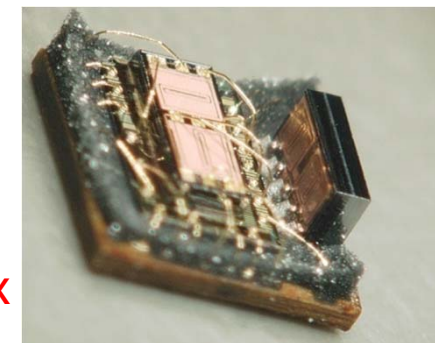
HMC58xxx Reliability Issue (2/5)

Solder Joint

Acceptance

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HMC58xxx Reliability Issue (3/5)

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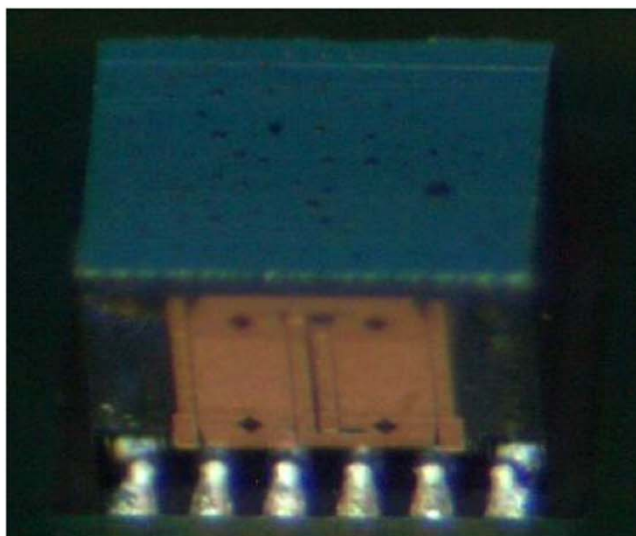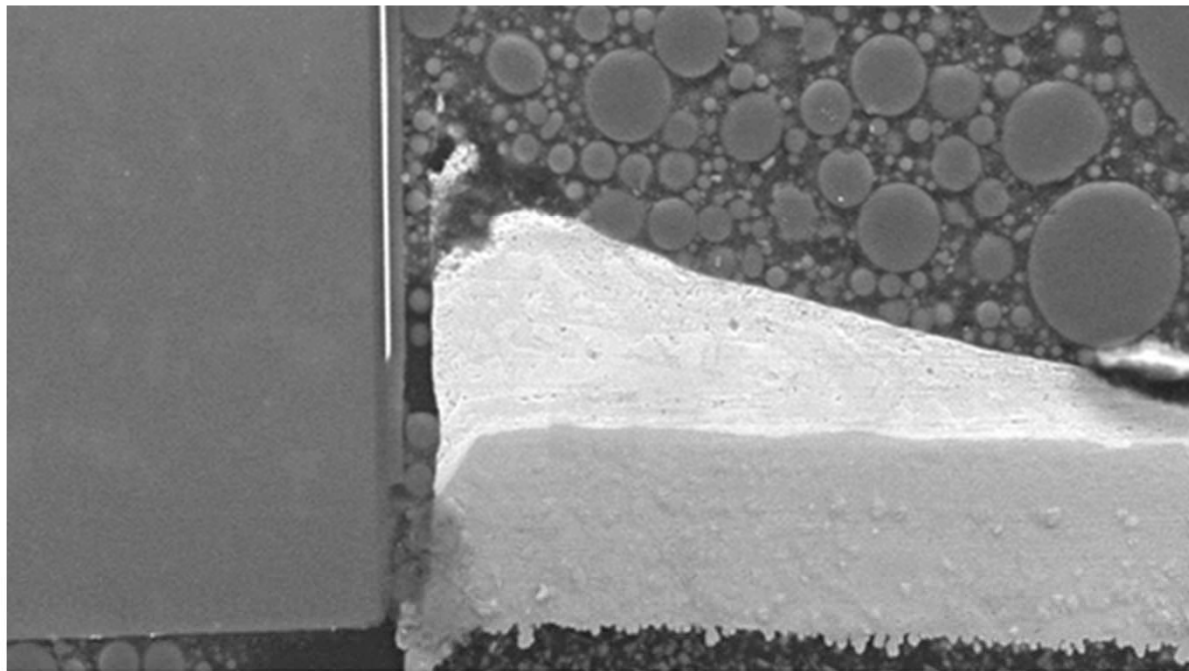
HMC58xxx Reliability Issue (4/5)

- SEM check: Result showed RDL happened crack around UBM edge.
- Root cause analysis: Stress too large that to make RDL layer crack during assembly process.
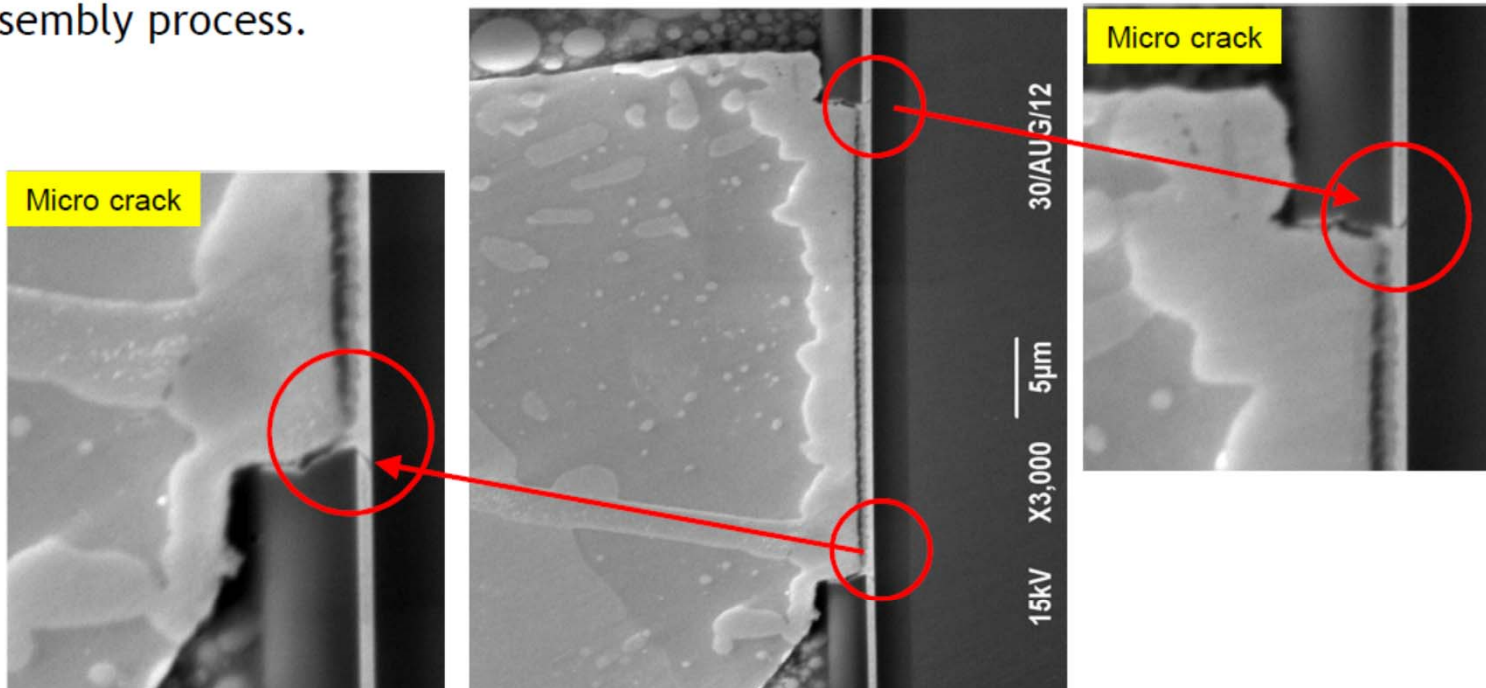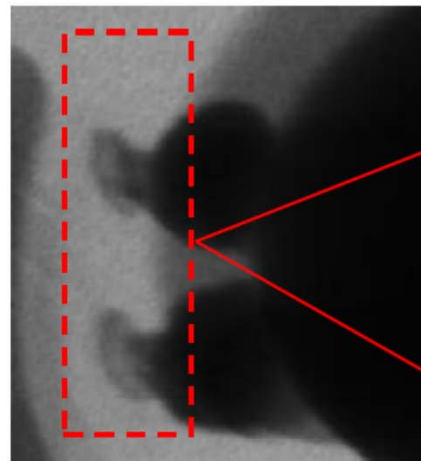

- Plan to do: will to study the root cause of large stress and improvement action
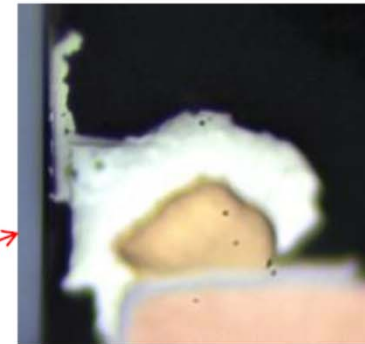
HMC58xxx Reliability Issue (5/5)

- **UBM peeling**: Z-die bonding to closer Au stud bump.
- Shift back 10um in case any collision between solder & Au stud bump.
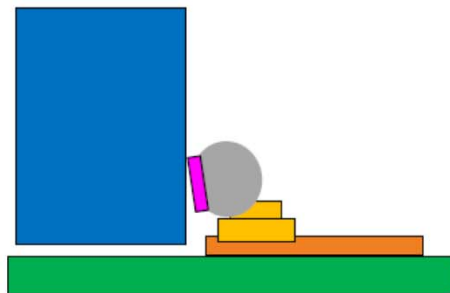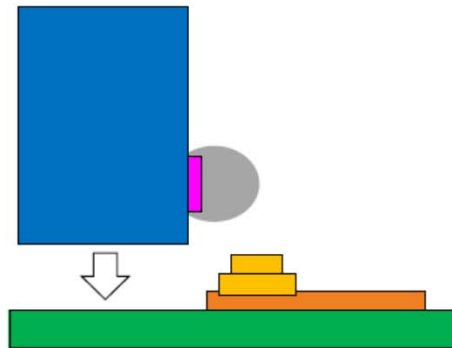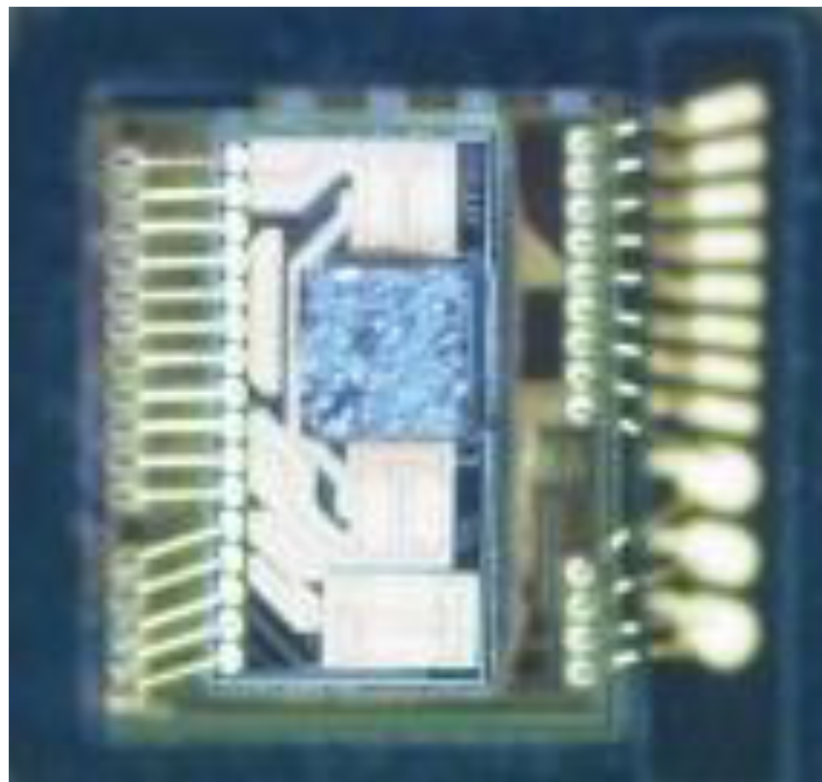

Solder hit stud bump: UBM peeling

Transparent joint

UBM peeling

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IST8307/IST8310: High Reliability

IST8307/IST8310: planar design, allows unlimited times of reflow, high reliability.

15

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Magnetometers for Quadcopters

	iSentek	H公司
Model	**IST8307/IST8310**	**HMC58xxx**
Package Size	**1.6 x 1.6 x 1** **3.0 x 3.0 x 1**	**3 x 3 x 0.9**
Operating current (uA)	**200uA@7.5Hz**	**100uA@7.5Hz** ✅
Linearity (+/- 8G, %FS)	**< 1.38** ✅	**< 7.0**
RMS Noise (uT) — X-axis	**< 0.10** ✅	**< 0.21**
RMS Noise (uT) — Y-axis	**< 0.15** ✅	**< 0.18**
RMS Noise (uT) — Z-axis	**< 0.24**	**< 0.24**
Hysteresis (+/- 8G, %FS) — X-axis	**< 0.12** ✅	**< 0.17**
Hysteresis (+/- 8G, %FS) — Y-axis	**< 0.07** ✅	**< 0.09**
Hysteresis (+/- 8G, %FS) — Z-axis	**< 0.21**	**< 0.13** ✅
Reliability	高 ✅	低
Temperature Stability (-20~80 ℃ Angular Error)	**± 1.2** ✅	**-1.7~4.3**
Dynamic Range (uT)	**X&Y-axis: +/-1600** ✅ **Z-axis: +/-2500** ✅	**+/-800**
Resolution (bit)	**14** ✅	**12**
Sensitivity (uT/LSB)	**0.3** ✅	**0.4**

*Data from experiments and H-company's product's datasheet

16

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IST8310 Product Features

Anti-magnetic interference

- Single chip 3-axis magnetic sensor
- I2C slave, Fast mode up to 400kHz
- Compact form factor, LGA12, 3.0x3.0 package
- Wide dynamic range of +/-16 gauss(X,Y-axis) and +/-25 gauss(Z-axis)
- 14 bits data output
- **Ultra-low noise of < 0.1uT(X-axis), < 0.2uT(Y-axis), < 0.3uT(Z-axis)**
- **Ultra-low hysteresis(<0.1%FS)**
- **Ultra-low sensitivity temperature drift(+/-0.016%/K)**
- **Ultra-low offset temperature drift(0.024uT/K)**
- Built-in high precision temperature compensation circuit
- Built-in Self-test function

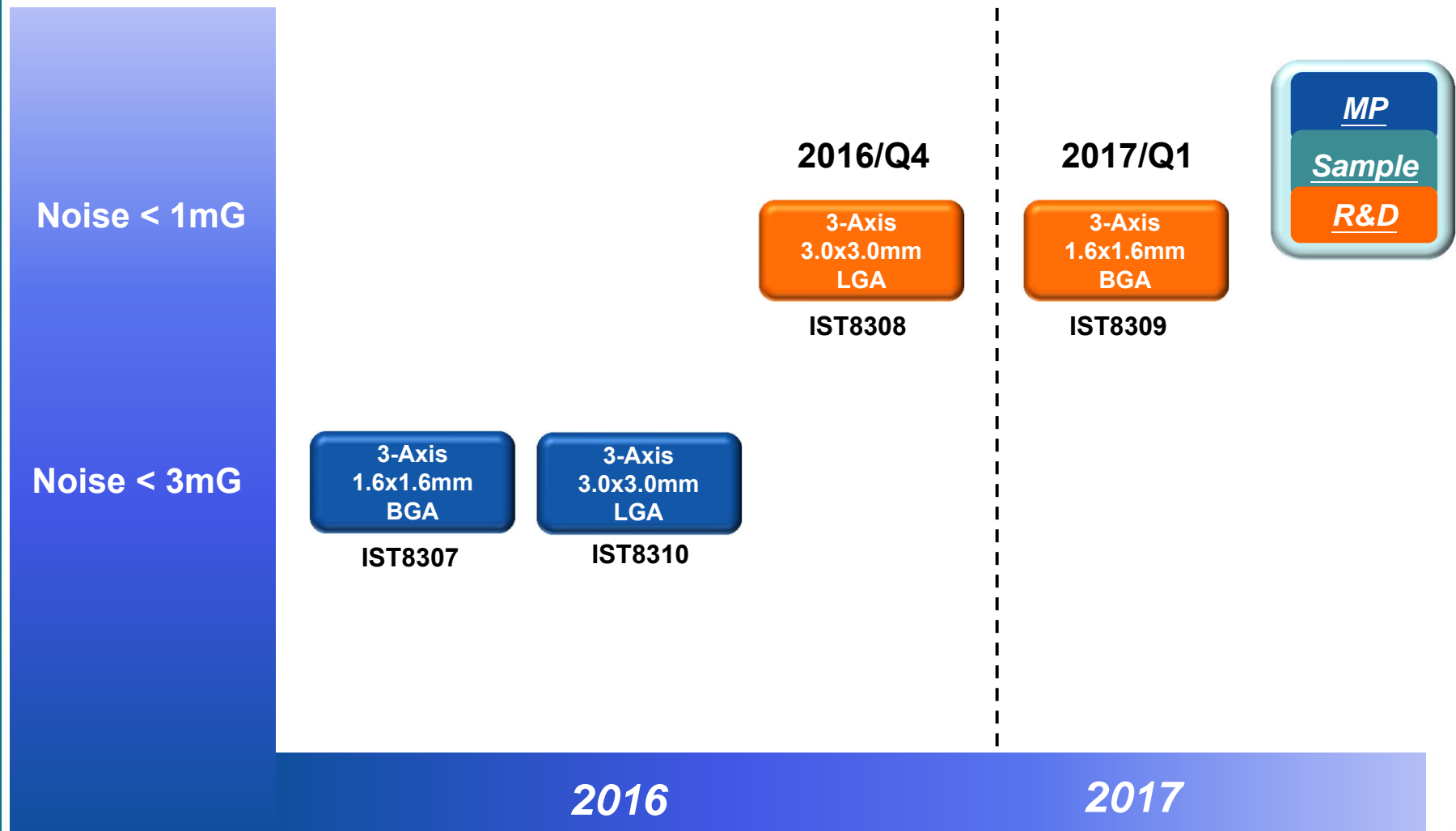## Applications

- Quadcopter/Drone
- GPS/pedestrian Navigation
- Digital Compass
- Augmented Reality
- Virtual Reality
- Industrial Application
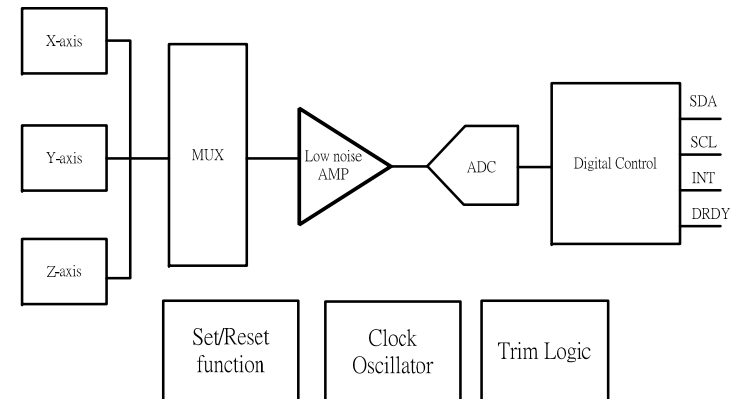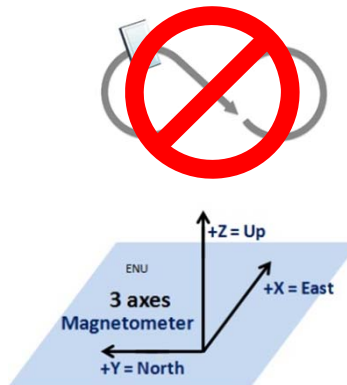
Operating temperature:	-40°C to +85°C
Supply voltage:	DVDD 1.72V~3.6V AVDD 1.72V~3.6V
Current consumption:	80uA@10Hz
Sensitivity:	0.3uT/LSB
Measurement range:	+/-16 gauss(X,Y-axis) +/-25 gauss(Z-axis)
Serial interface:	I2C bus
Package:	LGA12, 3.0x3.0

iSentek Magnetometers for Quadcopters

Customer Approvals

Thank You