Report

Date 11-May-2016

DENSO Driving Assist & Safety Eng. Div.3
Driving Assist & Safety Quality Assurance Div.

To TOYOTA MOTOR MANUFACTURING KENTUCKY

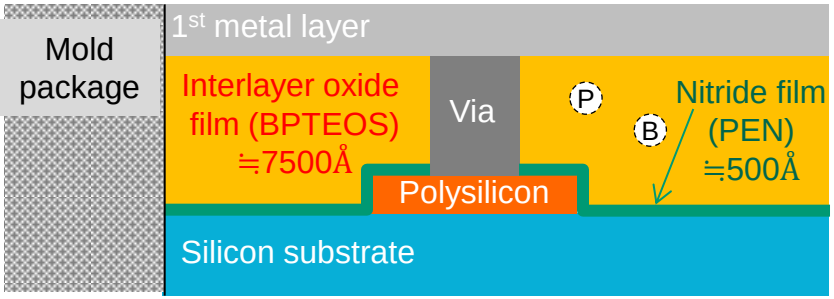
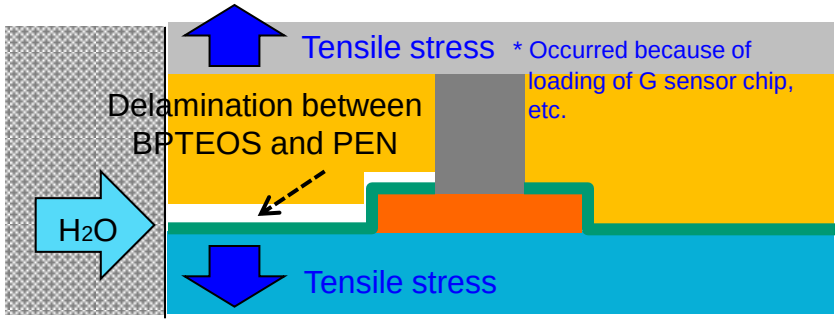
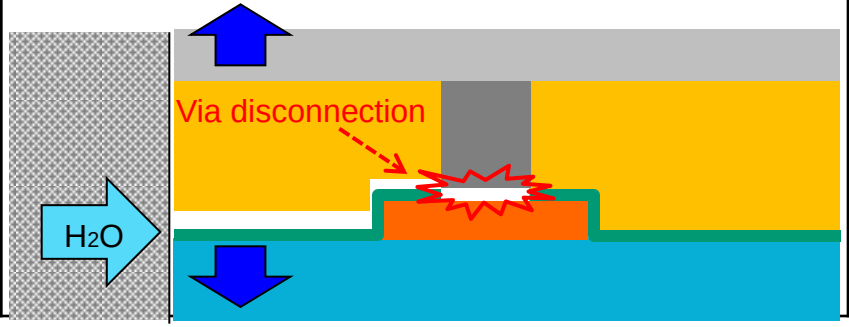
cc

Title Filed claim investigation result for Airbag sensor (DRAS Ⅱ)

We report the field claim investigation result for Airbag sensor.

Part Name : SENSOR, AIR BAG, FR
Part Number : 89173-06120

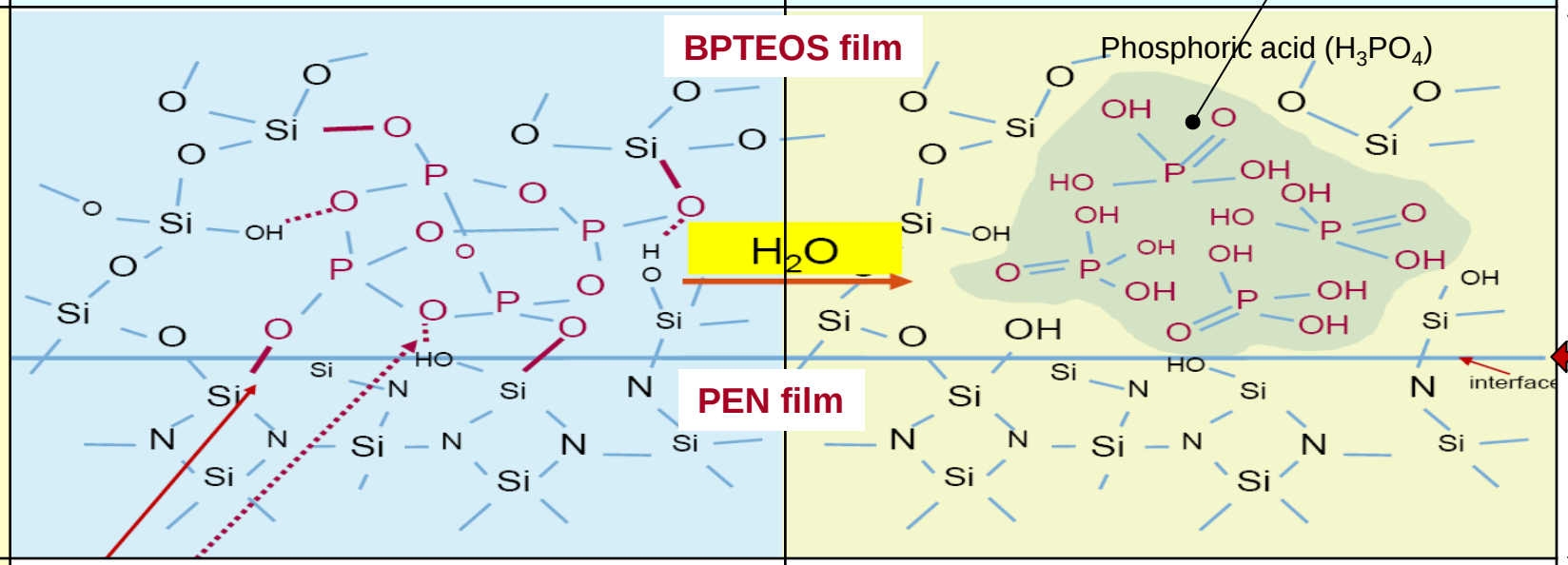
■Interlayer film delamination process

Process	Interlayer film condition	Description
Initial		Interlayer oxide film contains P(Phosphorus) and B(Boron). ・・・P and B protect the impurity ion in orde to acquire the transistor characteristics.
Absorp moisture ↓ Delamination occurs		When P concentration between BPTEOS and PEN increased, the interfacial bond strength decreased, and interlayer film was delaminated. ➔ Mechanism of bond strength decrease on the next page.
Via disconnection occurs		Via was disconnected because of tensile stress. (Delamination/disconnection occurred at chip edge with large internal stress.)

■Mechanism of bond strength decrease

$$P_2O_5 + 3H_2O \rightarrow 2H_3PO_4$$

Phosphorus oxide　Water　Phosphoric acid

	Before moisture absorption	After moisture absorption
Molecular structure model		
Remarks	- Si-O generate chemical bond strength to bond between P_2O_5 and SiN. (⟶) * Some of O-OH in oxide film contributes as hydrogen bond. (⇢) However, when P concentration is normal, SiO/SiN bond is dominant.	- Because of moisture, Si-O bond between P_2O_5 and SiN and hydrogen bond are broken and the bond strength decreases. [Phosphoric acid (H_3PO_4) is generated.] When P concentration is normal, SiO/SiN bond is dominant, so the bond strength decrease because of P_2O_5 moisture absorption has no influence.

・in case of normal P concentration ⇒ P area is small ⇒ bond strength > Tensile stress ⇒ No delamination

・in case of rich P concentration ⇒ P area is wide ⇒ bond strength < Tensile stress ⇒ Delamination

P concentration affects the interfacial bond strength.

5. Cause and countermeasure

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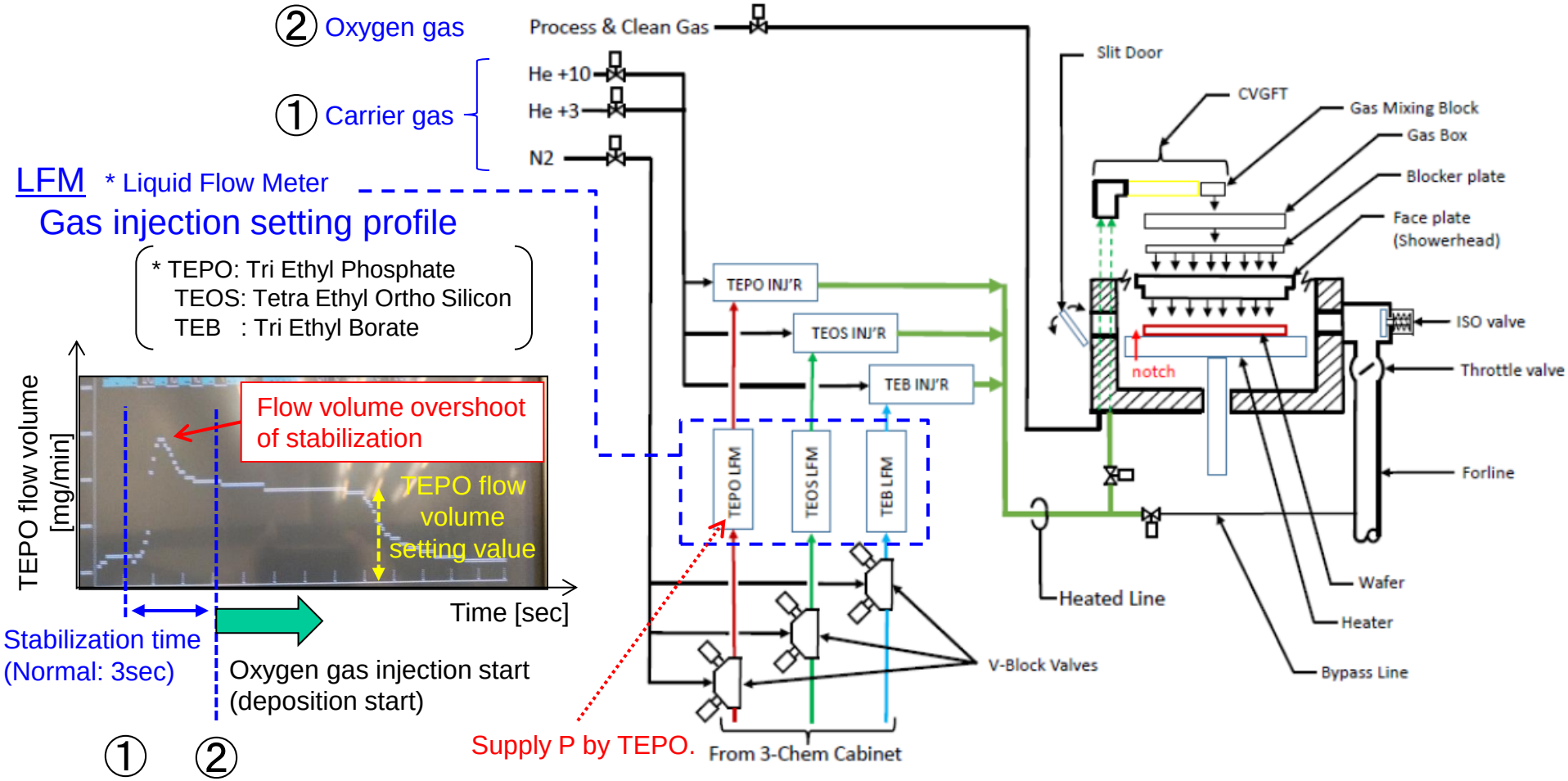
■BPTEOS deposition device overview

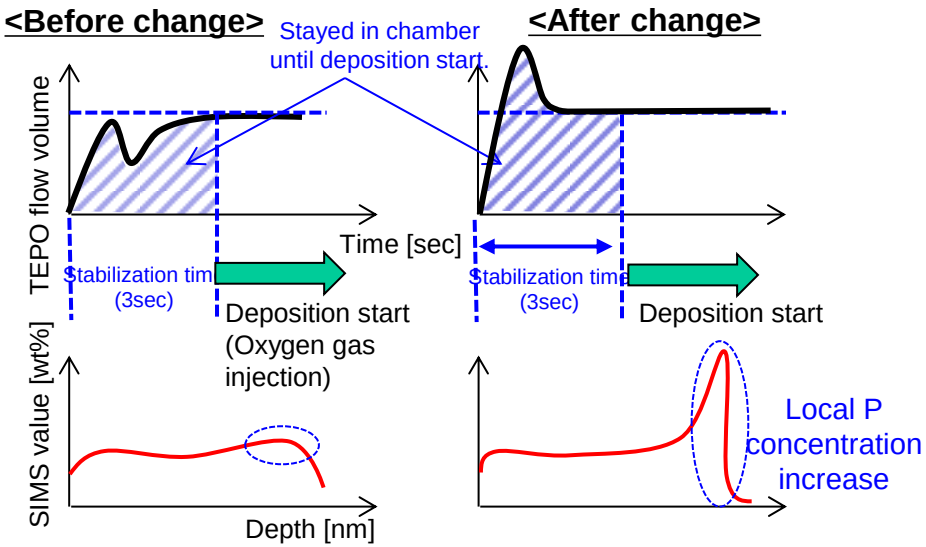
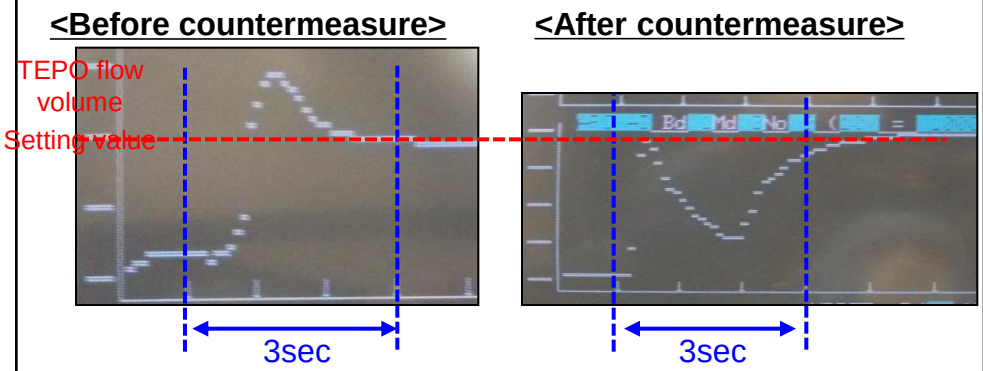
* Machine below: FF09 (A, B, C, D) and FF10 (A, B, C, D)



Confirmed that the process change of TEPO flow setting was happened. → Next page

■Cause and countermeasure

<Occurrence cause: Flow volume profile change>

Cause	Countermeasure (1)
- Machine error occurred because of TEPO flow volume variation. Maintenance engineer changed the flow volume profile in order to control the variation. (Changed to an overshoot waveform to make the flow volume stable early.) * At this moment, no knowledge that overshoot causes local concentration increase. ➔ At the time of deposition start, P concentration in chamber (shadowed area below) increased, and P concentration of interface between BPTEOS and PEN films (soon after deposition start) increased.  	- Changed the flow volume profile not to overshoot. ('14/12/17~) 

Changed the flow volume profile to limit the peak of P concentration of interface between BPTEOS and PEN films.

Countermeasure (2)

Perform 100% monitoring of peak ratio for TEPO flow volume setting value in flow volume profile. (Sept. 1, 2015 ~)

Control item: TEPO flow volume setting value x Peak ratio
Control interval: 100% monitoring
Control value: 1.2 or less
* In the case of over 1.2 --- Machine stops. (Scrap the product.)
After adjusting the machine, check with SIMS result, and then flow.

<TEPO flow volume setting value x Peak ratio >

Actual measured value (Peak)

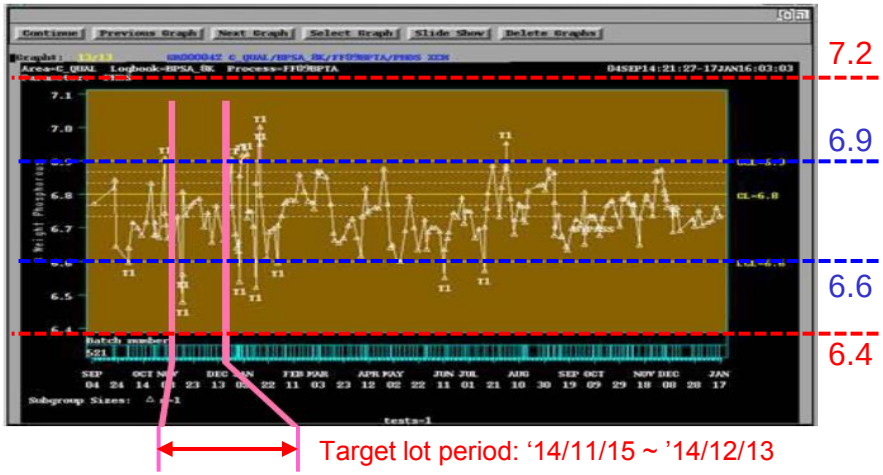
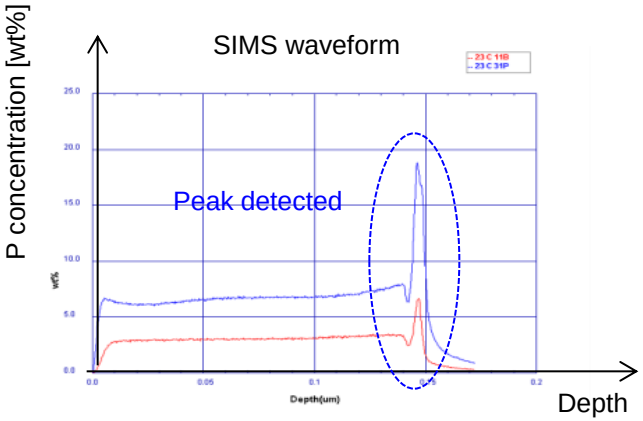
TEPO flow volume setting value

* The above is the waveform of ratio ≒1.5. (Created intentionally.)

Perform 100% monitoring to see that flow volume profile is not overshoot.

<Flow-out cause: Phosphorus concentration control by X-ray fluorescence>

* SIMS --- Secondary Ion Mass Spectroscopy

Cause	Countermeasure
- P concetration has been controlled by X-ray fluorescence. In this method, only average value of P concentration in deposition direction can be obtained, and local P concentration increase cannot be detected. * No knowledge that increase of local P concentration causes delamination. Process control width: 6.6 ~ 6.9wt% (Product spec: 6.4 ~ 7.2wt%) **<X-ray fluorescence P concentration near target lot>**  ➔ During the target lot period, P concentration (average value) increase was not detected. * Correlation between P concentration (average) by X-ray fluorescence and P concentration (local) by SIMS is weak.	- Introduce SIMS to control local P concentration. ('14/12/17～) (Continue concentration control by X-ray fluorescence.) Control item: P concentration peak Control value: MAX 9.2% Control interval: 2/week or after every maintenance * Chamber A: 1/D (under special control) Measuring position: Center of wafer (Set as a result of investigation of distribution in wafer surface) 

Introduced SIMS control for workmanship control of P concentration peak value.