RECENT STUDIES ON ACCERELATING STRUCTURE FABRICATION
(Evaluation of diffusion-bonded junction of DDS3D2.)

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Evaluation of diffusion-bonded junction of DDS3D2.

(1) Measurement principles and results.
   ① Liquid penetrant testing.
   ② Fluorescent penetrant testing.
   ③ Immersion ultrasonic testing.
   ④ Micro-observation.

(2) Calculation of shrinkage of void based on the theoretical formula by Kuczynski.

(3) Conclusion
First apply the penetrant liquid. You can coat either by a brush or a spray.

Liquid penetrant testing
Wait for a moment until the liquid permeates the coat. Next wipe the surface clean.

Then spread the developing solution.

The permeating liquid, which is standing the coat, comes out to the surface through the developing solution by the capillary action.

Before the test, the surface must be made clean.
The appearance of the cutting face of DDS3D2
Result of Liquid Penetrant Testing  
(cutting face of DDS3D2)
Result of Liquid Penetrant Testing (outside of the structure)
Result of fluorescent penetrant testing
(There was only one defect observed between #138cell and #139cell)
Immersion ultrasonic testing
Result of immersion ultrasonic testing
(Where defect was detected in fluorescent penetrant testing)
normal image  defect candidate(1 2 3)
Typical patterns obtained by immersion ultrasonic testing
The micro-observation of well-bonded junction (#149 & #150)
The micro-observation of defective part

(138 & 139)

outside

center

inside
connecting part between #138 and #139 (fluorescent penetrant testing; there is defect)

connecting part between #149 and #150 (fluorescent penetrant testing; there is not defect)

Result of SEM
Calculating results based on the theoretical formula by Kuczyński.

**Basic Formula**

\[ r^3 = r_0^3 - \frac{6 \rho s^3 D}{k T} \]

\[ D = D_0 \exp \left( - \frac{E}{RT} \right) \]

- \( r_0 \): Initial radius of spherical cavity
- \( r \): Radius of spherical cavity
- \( k \): Boltzmann factor
- \( T \): Temperature
- \( \gamma \): Surface tension
- \( \delta \): Interatomic distance
- \( D \): Diffusion coefficient
- \( D_0 \): Frequency factor
- \( Q \): Activation energy
- \( R \): Gas constant

\[ \gamma = 1.72 \text{ (J/m}^2) \]

\[ \delta = 2.55 \times 10^{-10} \text{ (m)} \]

\[ D_0 = 6.20 \times 10^{-6} \text{ (m}^2/\text{sec)} \]

\[ E = 2.08 \times 10^4 \text{ (J/mol)} \]

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There is a graph showing the relationship between the burning time and the ratio of \( r/r_0 \) (× 100%) during the heat treatment.

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**Reference**

3. Conclusion

(1) Defects were observed in
   1 junction out of 200 (Fluorescent penetrant testing)
   3 junction out of 30 (Immersion ultrasonic testing)

(2) In order to make the bonding reliable, we should study the cleanliness in the fabrication area, improve the quality of cells, or something obt's