Development of SCC Resistant Canister for Spent Fuel Storage and Transport

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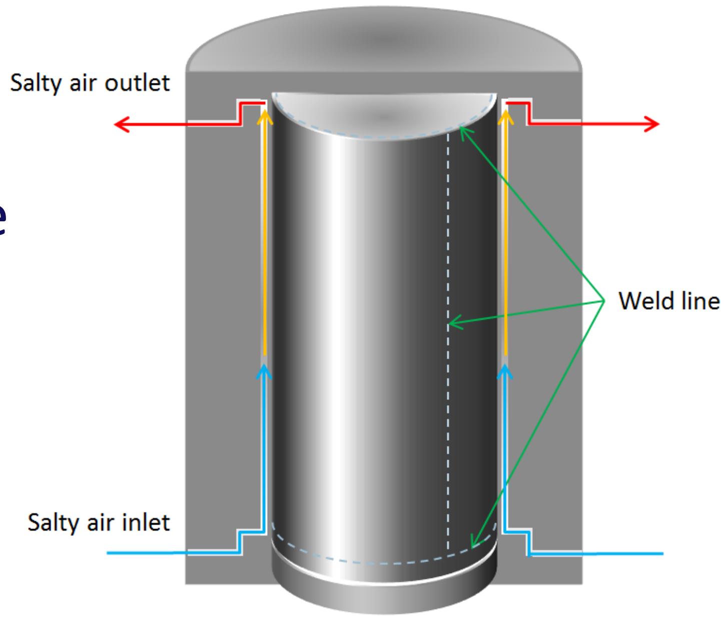
Outline

- Introduction and background of SCC
- Technical issue for practical use of concrete cask in Japan
- Solution of the issue
- Conclusion

Introduction and background of SCC

- Interim storage facility (ISF) will be likely to be built at coastal area.
- The salty air contacts to the canister surface directly due to the natural convection of the cooling air.
- Salty particles in the cooling air adhere to the surface of the canister might be possible to induce the SCC and lose its containment function in the worst case.



It is one of the main reasons that the concrete cask is not used in Japan

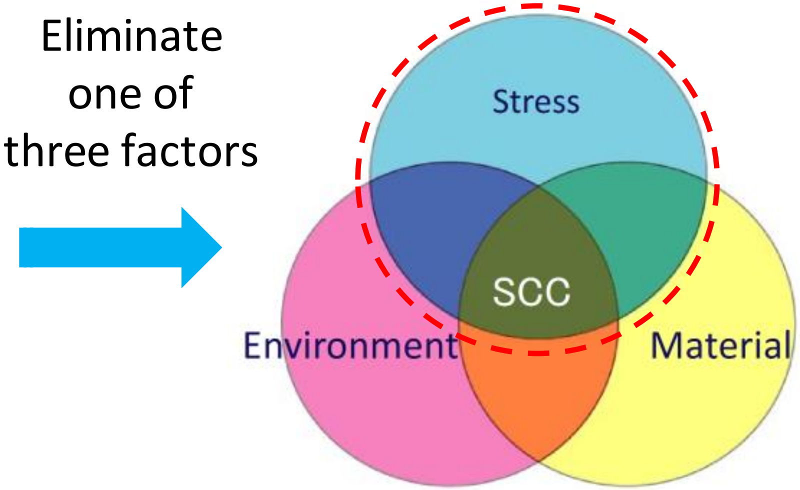
Technical Issue practical use of Concrete Cask in Japan

How to prevent SCC?

- Three factors are necessary to induce SCC.
- Measures for one or two of the three factors must be taken,i.e. mitigation of tensile residual stress, corrosion resistance material, and environment control.

To make a canister surface tensile residual stress compressive, as a preventive maintenance against SCC

Eliminate one of three factors



Solution of the issue

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Specifications for SCC resistant canister

- Material
  - ➢ Austenite stainless steel :

    UNS S30403(Type 304L), UNS S31603 (Type 316L)

- Welding
  - ➢ Laser weld

- Surface treatment (to make surface stress compressive)
  - ➢ Completion of fabrication at factory :

    Zirconia Peening on whole surface
  - ➢ After lid welding at Nuclear Power Station(NPS) :

    Burnishing on Lid Weld and Heat Affected Zone(HAZ)

Solution of the issue

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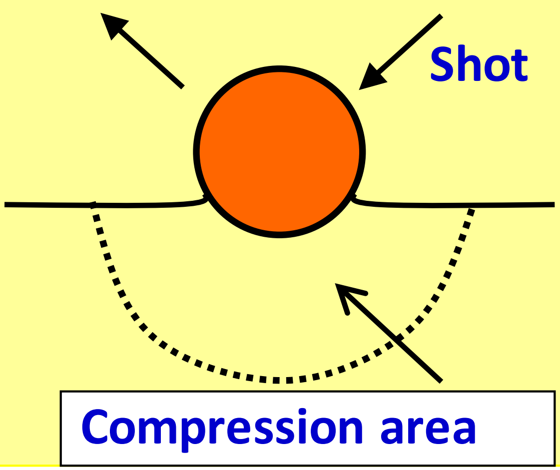
Zirconia Peening

	Glass Beads		Zirconia
Bulk specific gravity	2.2	<	6.0
Hardness (Hv)	570	<	1300

→ **Deep Compression area**



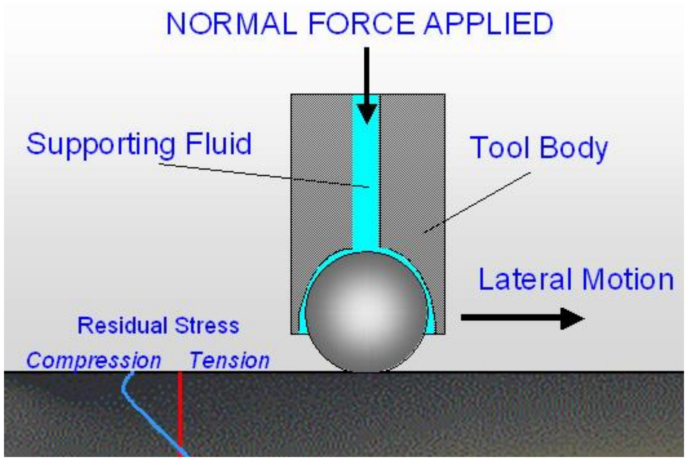
Change in the surface layer by peening

- Shape change
- Compressive residual stress
- Metallurgical structure
- Hardness

Solution of the issue

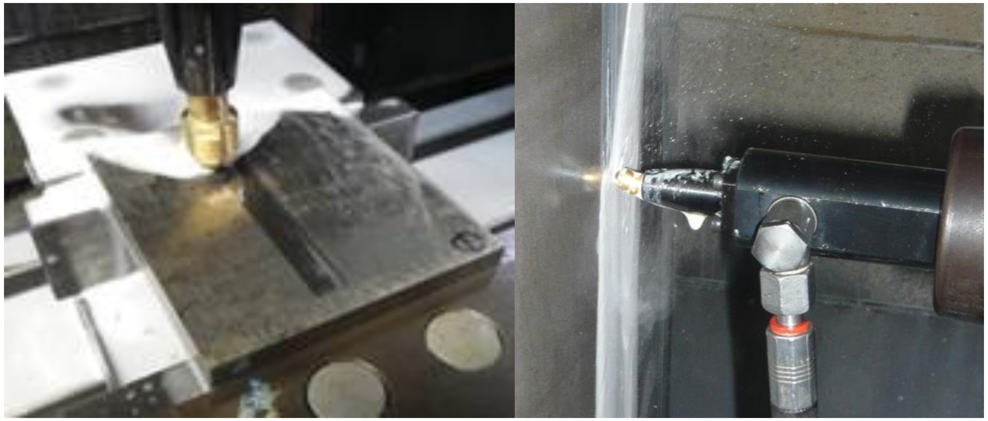
Burnishing

- Post-weld surface enhancement processing via low plasticity burnishing(LPB) can be used to introduce deep compression into tensile fusion welds thereby mitigating SCC.



Burnishing tool schematic

Ball burnishing tool

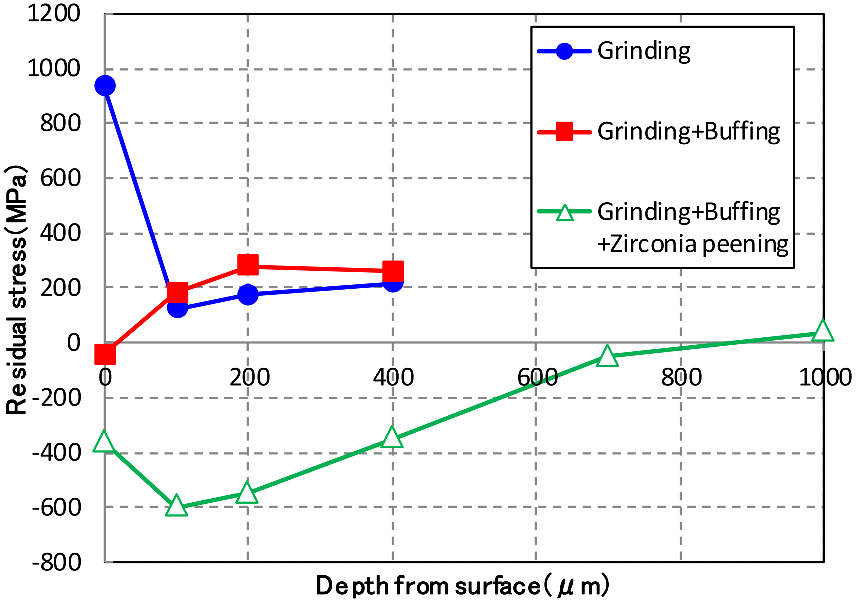


Compressive residual stress

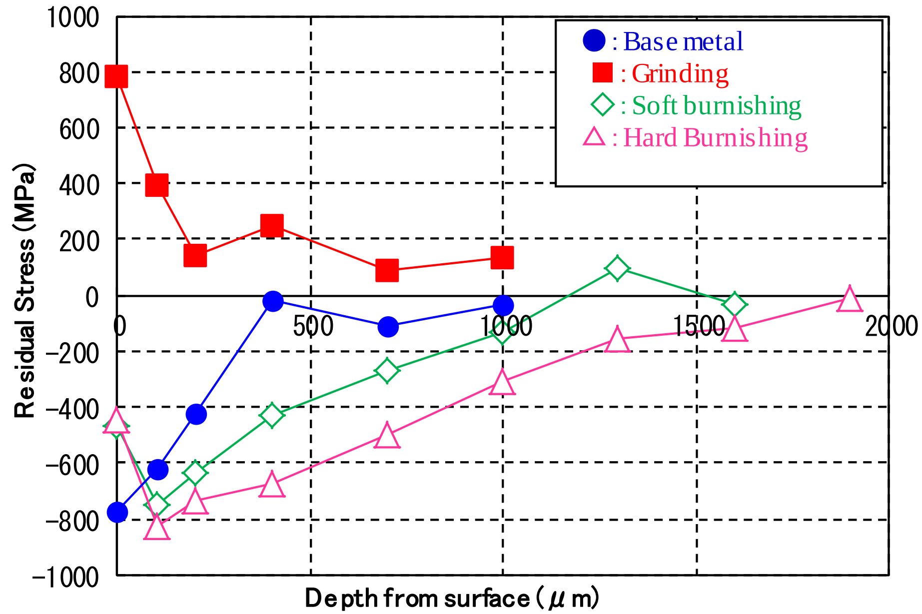
Solution of the issue

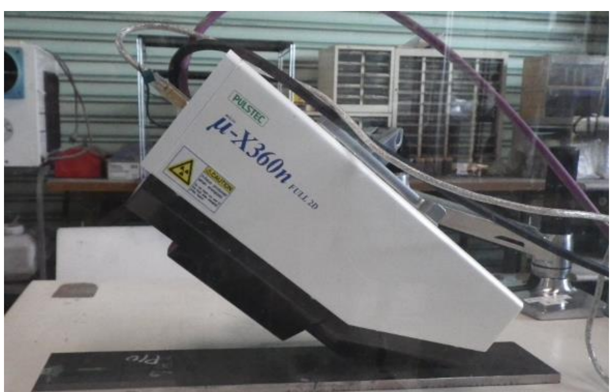
Residual stress measurements

Zirconia peening



Burnishing

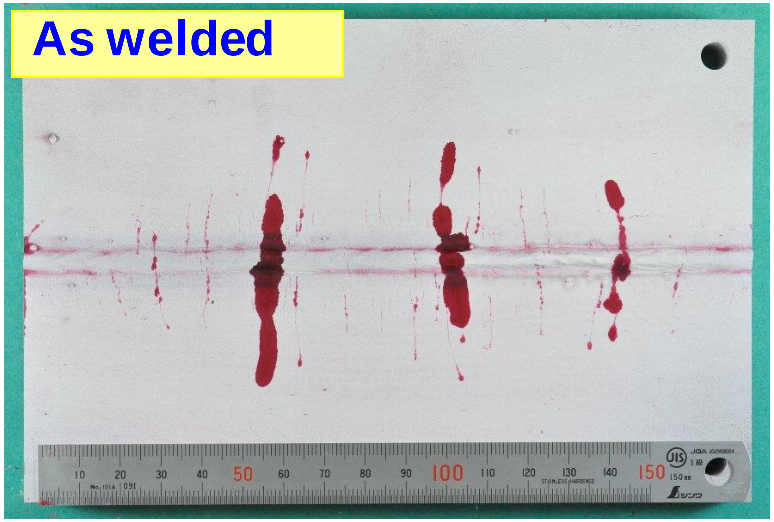


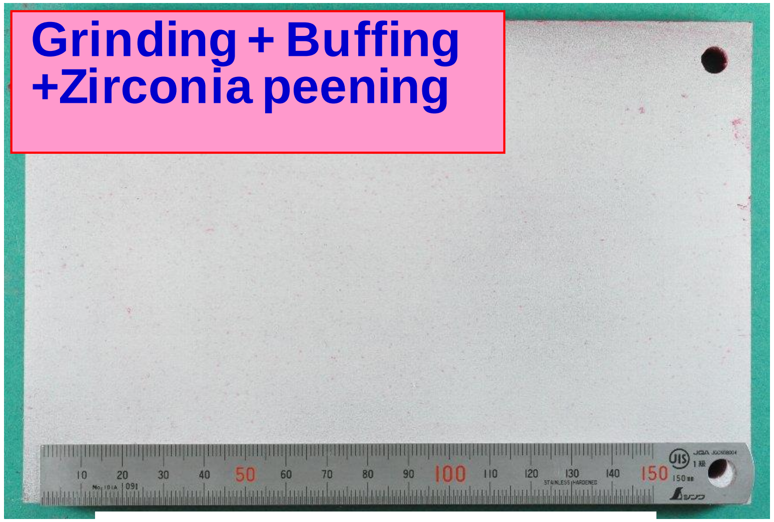


[Measurement of Residual Stress with X-Ray Diffraction]

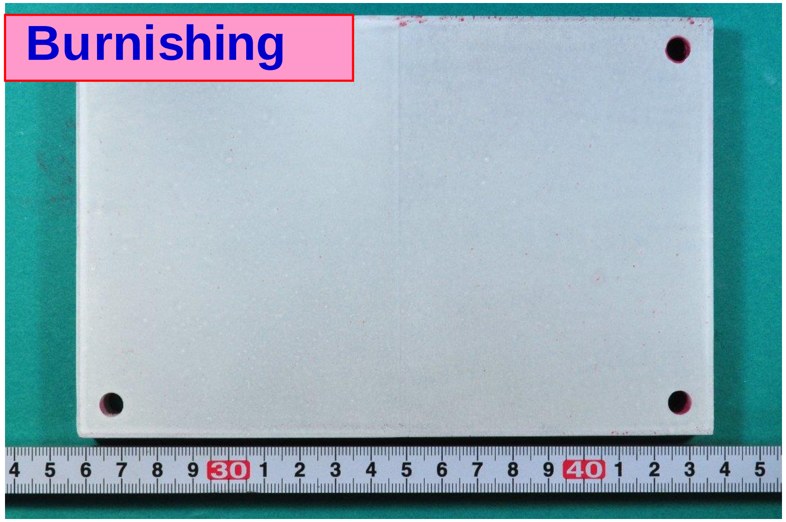
Solution of the issue

Stress corrosion cracking test in 42% $MgCl_2$ aqueous solution at 143℃ (JIS G0576)





Crack is not observed



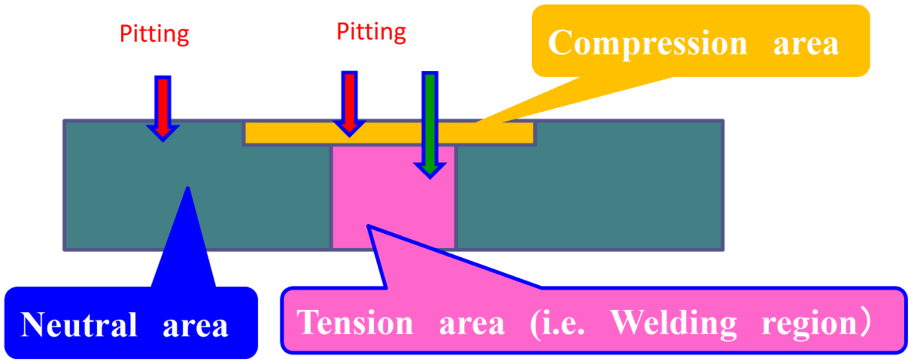
Crack is not observed

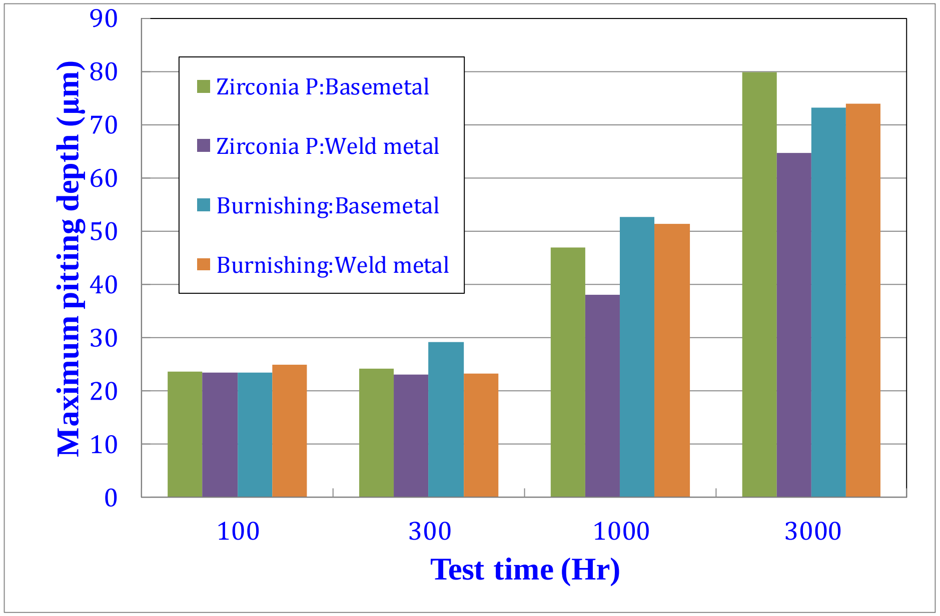
Solution of the issue

- Pitting corrosion test

In long-term use, the SCC generation from the site of tensile layer beneath the compression layer by pitting, is a concern.

- ➢ Chloride Density : 10 g/m^2
- ➢ Environment : 50℃, 35%-RH
- ➢ Material : 304L, 316L





Maximum pitting depth（SUS316L）

Solution of the issue

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Estimation of Maximum pit depth

	Pitting depth for 60 years	Depth of compressive stress area
316L-Zirconia peening	401μm	800μm
316L-Burnishing	402μm	1500μm

- Assumed that the pitting corrosion is grown linearly based on the maximum pitting late of 3000h at 50 ℃ 35% RH
- Time of exposure to corrosive environments is the time that relative humidity becomes more than15%RH

Conclusions

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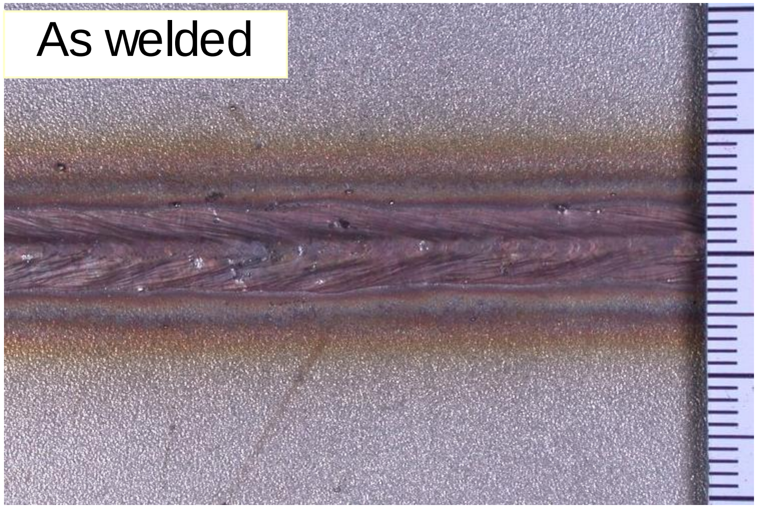
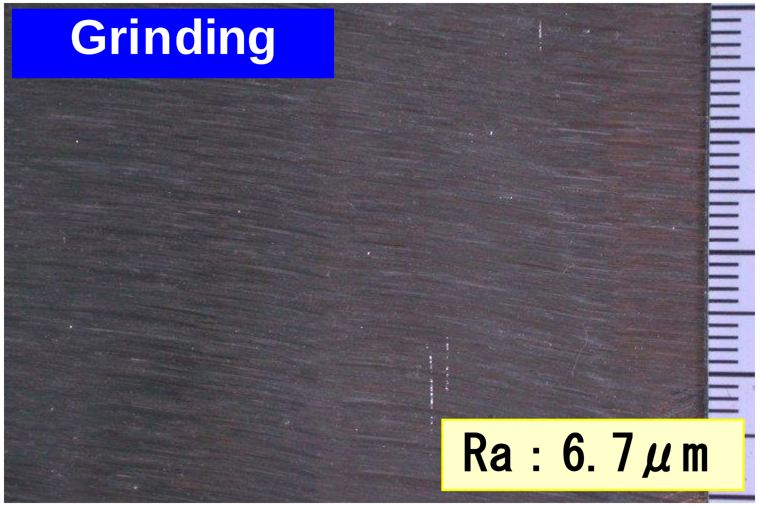
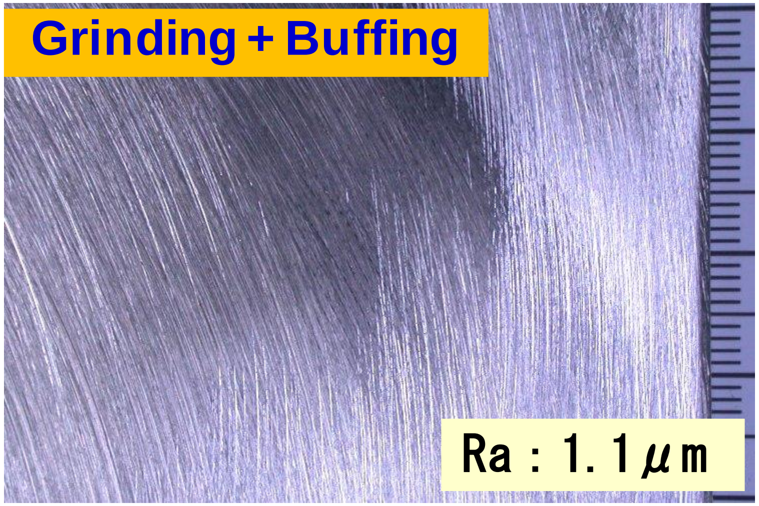
- Both Zirconia peening and burnishing are very effective methods for preventing SCC.
- Zirconia peening and burnishing can give deep compressive residual stress.
- Pitting originated SCC may not occur during 60 years because the maximum pit depth of the material with burnishing or zirconia peening, is less than that of compression depth.

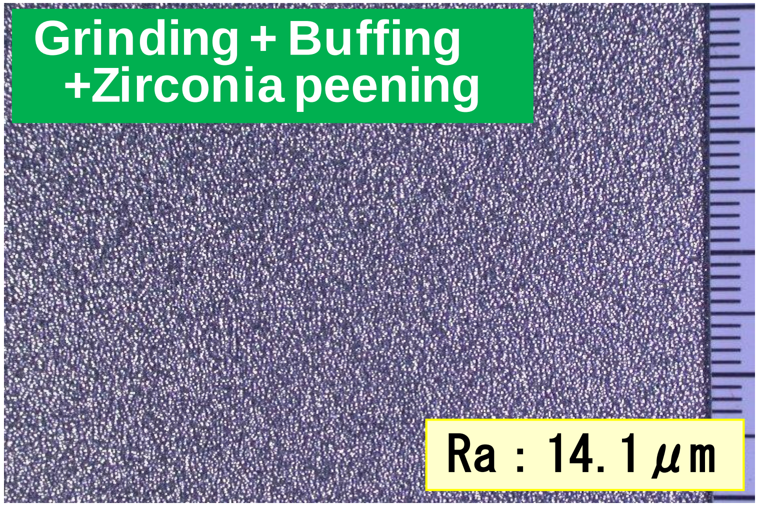
Thank you for your attention!

Surface appearance change due to fabrication process

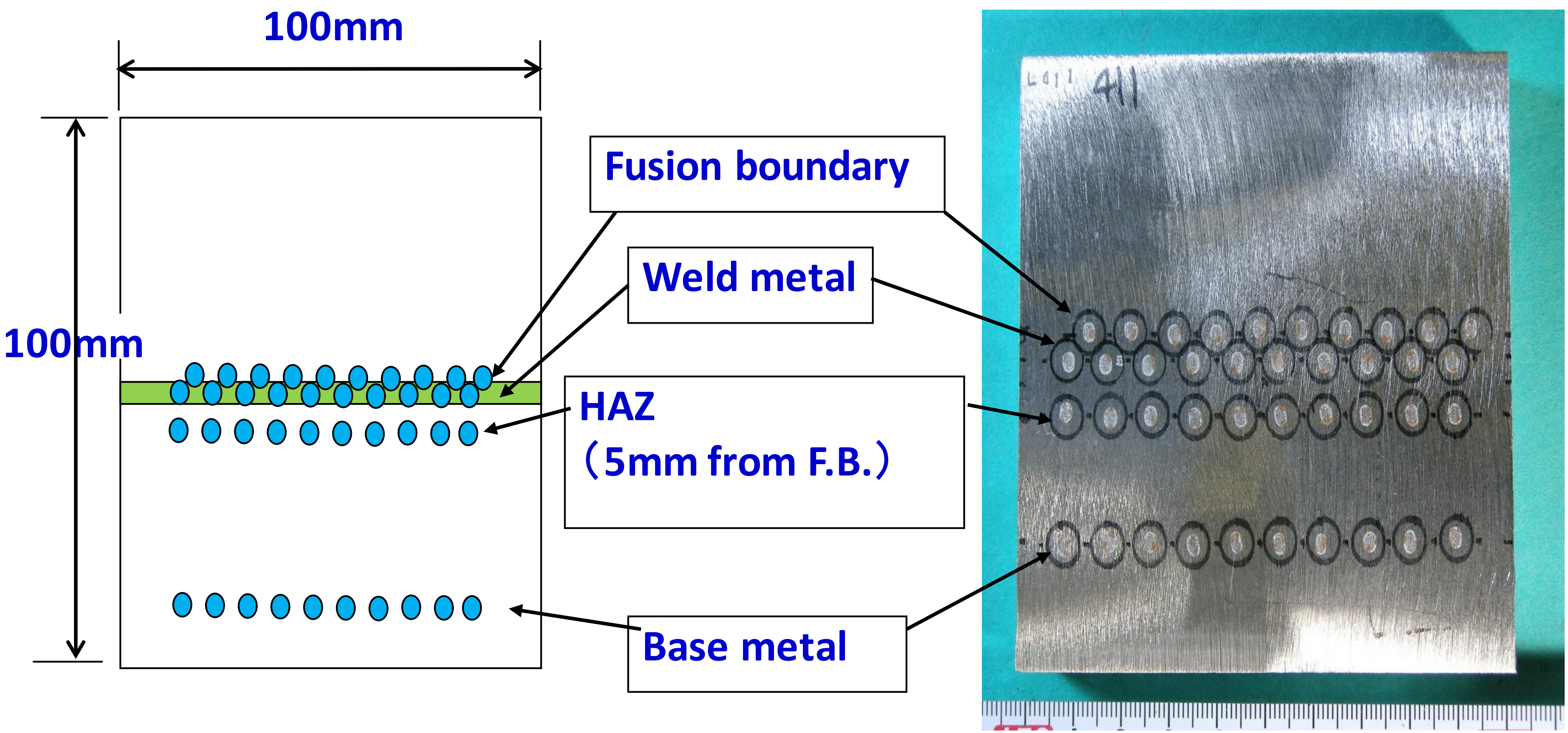




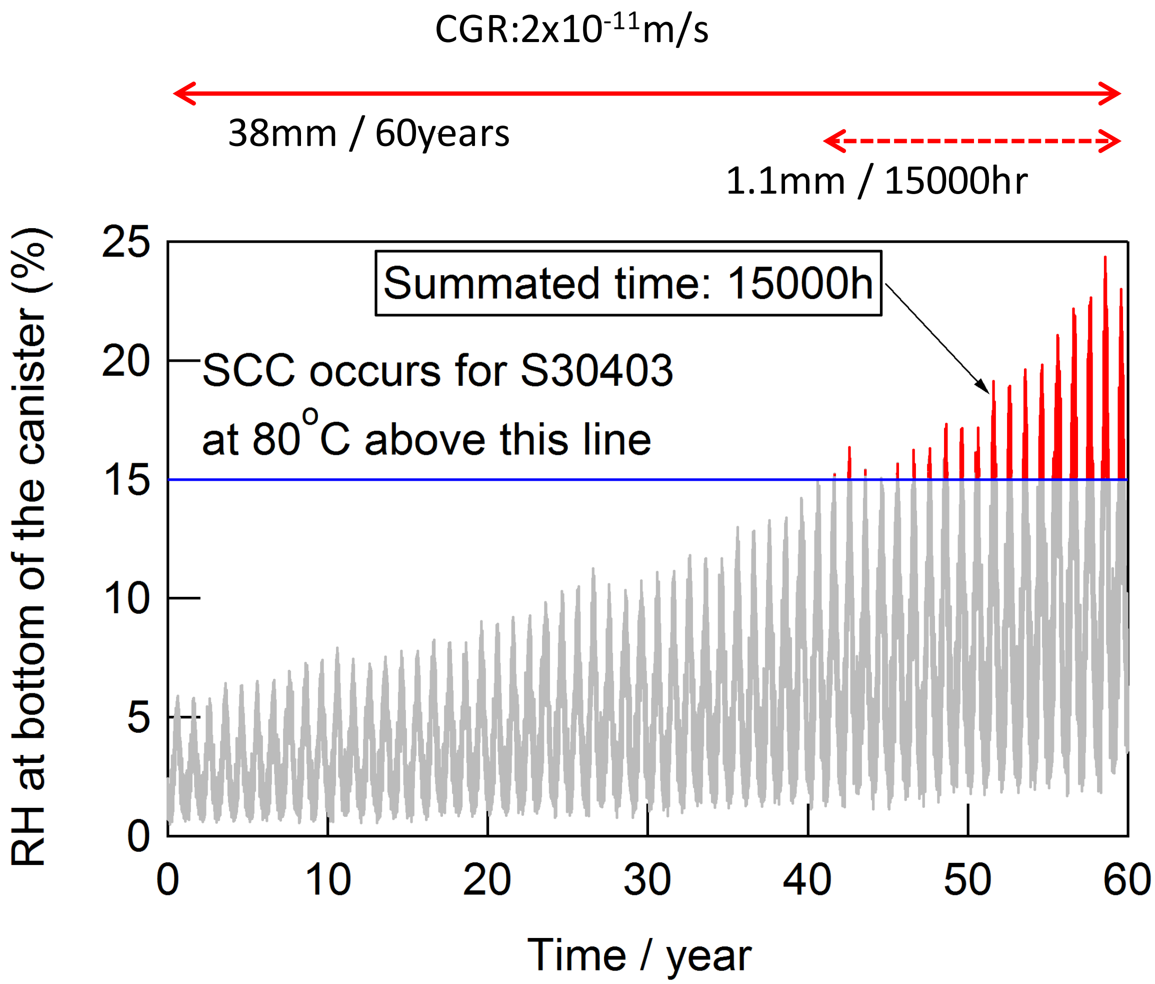




Pitting test specimen



Estimation of the Humid Period



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