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Investigation of the effects of irradiation on corrosive environments using *in-situ* electrochemical measurements during gamma-ray irradiation

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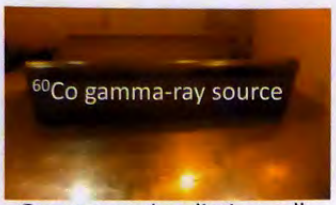
Introduction (background and objective)

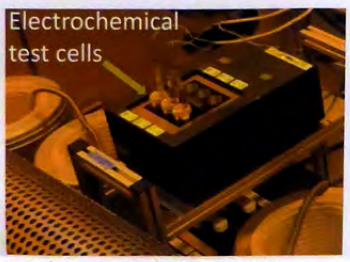
- The structural materials of the nuclear power plant and decontaminating systems of the Fukushima Daiichi nuclear power station were exposed to corrosive conditions containing high concentrations of seawater components under irradiation conditions.
- One of the major materials exposed to these corrosive conditions in the Fukushima Daiichi nuclear power station is carbon steel (CS). It was reported that the irradiation enhanced the corrosion of carbon steel.
- To understand the corrosion mechanism of CS under irradiation, the qualitative evaluation for the effects of irradiation on corrosive environments is important.
- One of effective methods to evaluated the change in corrosive environments is continuous measurements of the electrochemical parameters.
- The continuous cyclic voltammetry measurements were performed to evaluated the change in corrosive condition under irradiation in this study. And the electrochemical impedance spectrometry of CS was also performed to investigate the effects of irradiation on polarization resistance (R_p) of CS.

Experimental

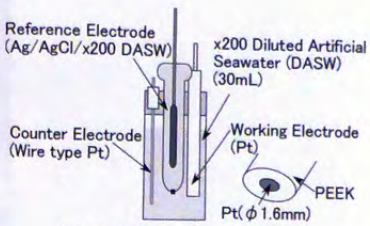
Gamma-ray irradiation facility, Takasaki Advanced Radiation Research Institute, National Institutes for Quantum and *Radiological Science* and Technology (QST)



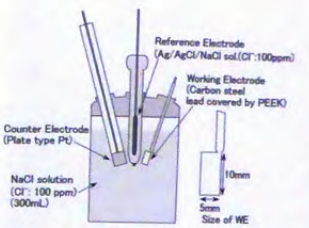
Gamma-ray irradiation cell



Thermostatic bath with electrochemical test cells



For cyclic voltammetry (CV) of Pt



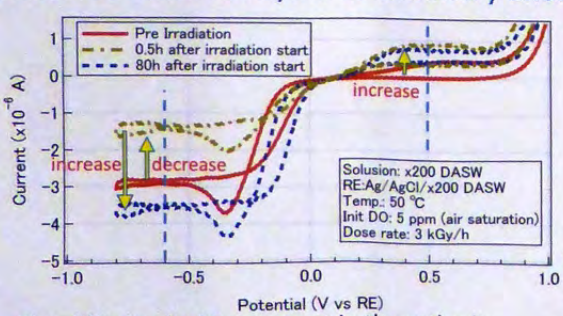
For electrochemical impedance spectrometry (EIS) of CS

Electrochemical test cell

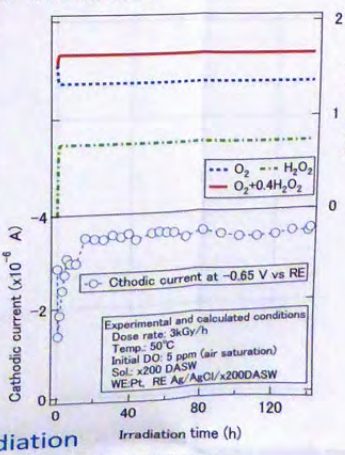
Parameters of experiments

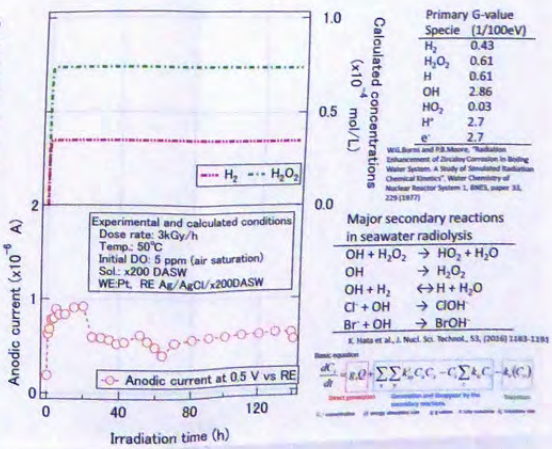
Temperature	50 °C
Gamma-ray dose rate	3 kGy/h
Solution	Diluted ASW (Cl^-: 100 ppm) (for CV) NaCl solution (Cl^-: 100 ppm) (for EIS of CS)
Initial dissolved oxygen	5 ppm (Air saturation)
Measuring device	Pocketstat (Ivium technologies)

Measured results of Cyclic voltammetry under irradiation

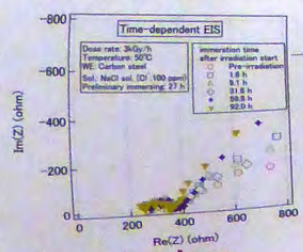


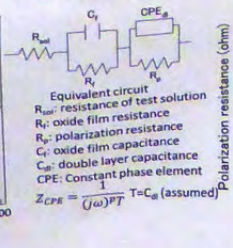
The diffusion limiting current in the cathodic region decreased just after the start of irradiation. And then the cathodic current increased. Anodic current increased by irradiation.

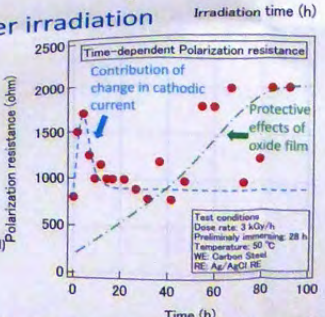




Measured results of Impedance under irradiation







Two half-circles were observed in the Nyquist plots. Polarization resistance (R_p) was determined by equivalent circuit analyses.
The peak was observed in initial stage of the time-dependent R_p. And then R_p increased. The peak might be determined by the change in cathodic current by the irradiation.
The increase of R_p might be determined by the formation of protective oxide film.

Conclusion

(1) The in-situ electrochemical measurements were successfully performed in this study.
(2) The diffusion limiting current in the cathodic region decreased just after the start of irradiation. And then the cathodic current increased. This tendency indicated that the dissolved oxygen was consumed rapidly by the irradiation.
(3) The cathodic current under irradiation was 20 % larger than that before irradiation. The anodic current increased just after the start of irradiation by the generation of hydrogen and hydrogen peroxide. The improvement of the calculation is one of the subjects in further study.
(4) The change in R_p under irradiation was determined by the change in cathodic current by irradiation at an early stage of irradiation.