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Supplementary Material: Isotope analysis of iron on structural materials of nuclear power plant using double-pulse laser ablation molecular isotopic spectrometry

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S-1. Chemical composition of structural materials

Table S-1. Chemical Composition of Utilized Specimens

Stainless steel 304 (wt%)		Inconel 690 (wt%)		Portland cement (wt%)	
Fe	70.9	**Ni**	60.4	**CaO**	64.6
Cr	18.2	**Cr**	31.0	**SiO_2**	21.3
Ni	8.5	**Fe**	7.0	**Al_2O_3**	5.6
Mn	1.8	**Cu**	0.5	**Fe_2O_3**	3.4
Si	0.6	**Mn**	0.5	**MgO**	2.1
N	0.05	Cu	0.5	**SO_3**	2.1
C	0.05	**C**	0.05	**N_2O**	0.05
S	0.01	**Si**	0.02		
P	0.03				

S-2. Optimized measurement condition according to matrix

The optimized measurement conditions (see Table S-2) were determined by considering the result of Figure S-1.

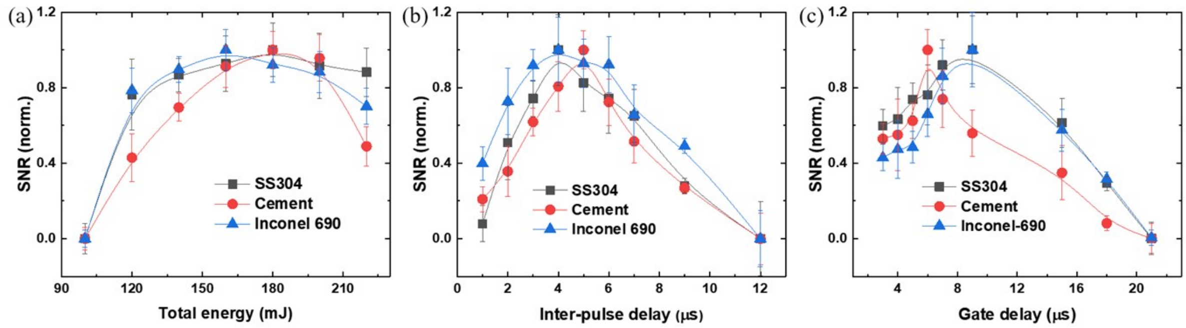

Figure S-1. Signal to noise ratio (SNR) of iron oxide emission as a function of (a) total energy, (b) inter-pulse delay, and (c) gate delay according to the matrix

Table S-2. Optimized Measurement Conditions for Surface Detection of Each matrix

	Total energy (mJ)	Inter-pulse delay (μs)	Gate delay (μs)	Gate width (μs)
SS304	180	4	4	100
Inconel	165	4	4	100
Cement	180	5	4	100

S-3. Methods of plasma characterization

Under the local thermal equilibrium (LTE) condition, plasma temperature (T) could be determined by Boltzmann plot method with below equation (1)[S-1].

$$\ln\left(\frac{I_{mn}\lambda_{mn}}{A_{ki}g_m}\right) = -\frac{E_m}{k_B T} + \ln\left(\frac{hcn_0(T)}{4\pi Z(T)}\right) \quad (1)$$

I_{mn}: Line intensity of transition from upper level m to lower lever n
λ_{mn}: Wavelength of the transition
A_{mn}: Spontaneous emission probability
g_m: Statistic weight of the upper level m
E_m: Energy of the upper level m
k_B: Boltzmann constant
h: Planck constants
$n_0(T)$: Number density
$Z(T)$: Partition function

Table S-3. Utilized Spectral Parameters of Iron Atomic Emission[S-1]

λ_{mn} (nm)	E_m (cm^{-1})	g_m	A_{mn} ($x10^8$ s^{-1})
371.9	26875	11	0.163
373.5	33695	11	0.902
374.6	27395	7	0.115
375.8	34329	7	0.634
376.4	34547	5	0.540

Plasma electron density could be obtained using Stark broadening effect of Fe I (541.4 nm) with the below equation (2)[S-2].

$$\Delta\lambda_S^{Fe} = 0.3612\frac{N_e}{10^{23}}\left(\frac{T}{13000}\right)^{1.6551} \quad (2)$$

$\Delta\lambda_S^{Fe}$: Linewidth of iron atomic line (541.4 nm)
N_e: electron density [m^{-3}]

References

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(S-2) Zielinska, S.; Pellerin, S.; Dzierzega, K.; Valensi, F.; Musiol, K.; Briand, F. Measurement of atomic Stark parameters of many Mn I and Fe I spectral lines using GMAW process. *J. Phys. D: Appl. Phys.* **2010**, 43(43), 434005.