Observation of Nuclear Transmutation Reactions induced by D₂ Gas Permeation through Pd Complexes

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Contents

<u>1. Introduction</u>

2. Experimental method and the Results so far

- **3. Experimental Results and Discussion**
 - 3-1 Transmutation of ¹³⁷Ba and ¹³⁸Ba into ¹⁴⁹Sm and ¹⁵⁰Sm
 - : Mass distribution of Sm depending

on the given mass distribution of Ba

3-2 Pr confirmation by XRF and experiments for

in-situ measurement at SPring-8

- **3-3** Consideration on the role of CaO layer
- 4. Concluding Remarks

Features of the Present Method

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D₂ gas permeation through the Pd complex



Fabrication of Pd Complex

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Schematic View of the Experimental Apparatus Apparatus



Photograph of the Experimental Setup



Decrease of Cs and Emergence of Pr



Identification of Pr by TOF-SIMS

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TOF-SIMS device (TRIFTTMII;ULVAC-PHI)

Decrease of Sr and Emergence of Mo

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Relation of Isotopic Composition between Sr and Mo. MITSUBISHI HEAVY INDUSTRIES





Recent Results; Part 1

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Transmutation of ¹³⁸Ba into

¹⁵⁰Sm and ¹³⁷Ba into ¹⁴⁹Sm

Transmutation of Ba into Sm; Natural Ba



¹⁵⁰Sm was detectedafter D permeationon the Pd complex

Schematic View of the Ex-situ Measurement Apparatus



XPS Spectra for detected Sm

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Sm Natural Abundance

¹⁴⁴ Sm	¹⁴⁷ Sm	¹⁴⁸ Sm	¹⁴⁹ Sm	¹⁵⁰ Sm	¹⁵² Sm	¹⁵⁴ Sm
3.2%	15.1	11.3	13.8	7.5%	26.6	22.5
	70	70	70		70	70



SIMS Spectra for Given and Detected Elements MITSUBISHI HEAVY INE ADVANCED TECHNOLOGY RESEAR



Examination of Molecular Ions

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Pd	Pd ⁴⁰ Ca
102(1%)	142
104 (11%)	144
105 (22%)	145
106 (27%)	146
108 (26%)	148
110 (12%)	150

Ba	Ba ¹⁶ O
130(0.1%)	146
132(0.1%)	148
134(2.4%)	150
135(6.6%)	151
136(7.8%)	152
137(11.3%)	153
138(71.7%)	154

No Molecular Ions for 149.

 110 Pd(12%)Ca and 134 Ba(2.4%)O for mass150, however their effects should be lower than 106 Pd(27%)Ca and 138 Ba(71.7%)O

Transmutation of Natural Ba into Sm

- XPS analysis showed Sm signal.
- SIMS analysis showed the increase of mass 150.
- Natural Sm isotopic distribution did not match with SIMS mass data.
- These facts strongly suggests that 150 Sm exists on the Pd complex after D₂ gas permeation.

Transmutation of Ba into Sm; mass 137 Enriched Basubishi HEAVY INDUSTRIE



SIMS Spectra for #1Experiment



SIMS Spectra for #2 Experiment

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Transmutation of ¹³⁷Ba into Sm

- SIMS analysis showed the increase of mass 149.
- Natural Sm isotopic distribution did not match with SIMS mass data.
- XPS analysis showed very weak Sm spectra. Now we are trying to obtain clear XPS signals.
- These facts suggests that ¹⁴⁹Sm exists on the Pd complex if we consider that Sm spectra were obtained by XPS using natural Ba.

Mass Correlation between Given and Detected Elements UBISHI HEAVY INDUSTRIES, I STORAGED TECHNOLOGY RESEARCH CENTER





If we measure the Mossbauer effect of ¹⁴⁹Sm, we will obtain clear evidence of generation of ¹⁴⁹Sm. And the information on the ultra fine structure relating to the electronic state and phonon of the generated ¹⁴⁹Sm will be obtain.

Recent Results; Part 2

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Pr Confirmation by XRF and Experiments for in-situ Measurement at SPring-8

Identification of Pr by X-ray Fluorescence



Detection of Pr using SOR X-ray at Spring-8, Harima, Japan (FG1,FG2:Signals from Samples after D2 Permeation BG:Signals from the sample before Permeation)

Experimental Set-up for *in-situ* Measurement located at Spring-8



Photograph of the Experimental Set-up



An Example of Pr Detection by the Experiments at SPring-8 Ishi HEAVY INDUSTRIES, LT



Recent Results; Part 3

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Measurement and Experiments relating to the role of CaO

TEM Photograph of the Pd Complex



Depth Profile of Cs and Pr by TOF-SIMS A MITSUBISHI HI



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Depth Profile of Cs and Pr by XPS(1)

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D+ Ion Bombardment Experiment Performed at Tohoku University HEAVY INDUSTRIES, LT

D+ Ion beam bombardment on metal target



Experimental Apparatus



Deuterium Density measured by D⁺ Ion Bombardment Experiment



MgO cannot work instead of CaO



Consideration on the Role of CaO

- Increase of Deuterium Density ?
- Modify the Electronic State of Surface Pd?

Depth Profile Measurement of D By a Resonance Nuclear Reaction ${}^{7}_{3}Li({}^{2}_{1}d,\gamma){}^{9}_{4}Be$

Concluding Remarks

- Transmutations of Ba into Sm were observed both for the case of giving natural Ba on Pd complex samples and for the case of giving mass 137 enriched Ba. It means that we obtained mass distribution of Sm depending on given isotopic distribution of Ba by our experimental method.
- 2. One of our experimental apparatus was carried to SPring-8 for the purpose of in-situ measurement and we obtained some Pr signals by the X-ray Fluorescence method.
- 3. According to a D⁺ ion beam bombardment experiment performed at Tohoku University, deuterium density of our Pd complex indicated one order larger than normal Pd.