

## Synthesis and chemistry of new elements at RIKEN

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### Abstract

Since the official approval of four new heavy elements with atomic number  $Z = 113, 115, 117,$  and  $118$  by IUPAC in 2016, the 7th period of the periodic table of the elements has been complete. Element 113 was synthesized in the fusion reaction of  $^{70}\text{Zn}$  ( $Z = 30$ ) on  $^{209}\text{Bi}$  ( $Z = 83$ ) using the Gas-filled Recoil Ion Separator (GARIS) at the RIKEN linear accelerator facility. The name "nihonium" and symbol "Nh" were given for the new element, the first discovered in Asian countries. An attempt to create element 119 is under way through the  $^{248}\text{Cm}$  ( $Z = 96$ ) +  $^{51}\text{V}$  ( $Z = 23$ ) reaction. To study chemical properties of the new elements, we have been developing a novel chemistry setup using GARIS. This system is promising for exploring new frontiers in the superheavy element chemistry. Background radiations from unwanted byproducts are suppressed, high production yields are achieved and new chemical reactions can be investigated. Long-lived isotopes of  $^{261}\text{Rf}$  ( $Z = 104$ ),  $^{262}\text{Db}$  ( $Z = 105$ ),  $^{265}\text{Sg}$  ( $Z = 106$ ) and  $^{266}\text{Bh}$  ( $Z = 107$ ) useful for chemistry studies were produced in the heavy-ion induced reactions on the  $^{248}\text{Cm}$  target and their decay properties were investigated in detail. Present status and perspectives of the superheavy element chemistry at RIKEN are also presented. The search for "superheavy elements", unstable synthetic elements with extremely short half-lives, is a difficult and painstaking process. Such elements do not occur in nature and must be produced through experiments involving nuclear reactors or particle accelerators, via processes of nuclear fusion or neutron absorption. Since the first such element, neptunium (Np) with atomic number 93, was discovered through synthesis in 1940, the US, Russia, and Germany have competed to synthesize more of them.

Japan joined the race in 2004, with its first synthesis of element 113. The discovery

was made by the Superheavy Element Laboratory, headed by Associate Chief Scientist Dr. Kosuke Morita. Using the Riken LineAC (RILAC) linear accelerator and a novel nuclei separator, called the gas-filled recoil separator (GARIS), the group generated element 113 on the night of July 23, after years of research and preparation. The discovery was made possible thanks to the high performance capacity of RILAC and the careful selection of optimal incident energy for the beam nuclei. Two other events were recorded, on April 2, 2005 and then on August 12, 2012, cementing Morita's group's claim to the discovery, and on December 31, 2015, the International Union of Pure and Applied Chemistry (IUPAC) officially announced that element 113 was the first element to be discovered in Asia.

The new element was given the name "nihonium" and the chemical symbol Nh.

### Biography :

Hirimitsu Haba received his PhD from Kanazawa University in 1999. In the following years, he worked at Japan Atomic Energy Institute as Postdoctoral Researcher (1999–2001) and at RIKEN as Special Postdoctoral Researcher (2002–2004), Research Scientist (2004–2006), Senior Research Scientist (2007–2010) and Team Leader (2011–2017). Since 2018, he has been Group Director of RI Application Research Group, Nishina Center for Accelerator-Based Science, RIKEN. In 2001, he was awarded the "Young Scientist Award" of the The Japan Society of Nuclear and Radiochemical Sciences. His scientific interests are nuclear and radiochemistry in general, with one focus on the synthesis and chemistry of superheavy elements.