Offline experiment of high-resolution resonance ionization spectroscopy on Titanium using injection-locked Ti:Sapphire laser system

T. Takamatsu,[*1] H. Tomita,[*1,*2] T. Takatsuka,[*1,*2] Y. Adachi,[*1,*2] Y. Furuta,[*1]
K. Wendt,[*3] V. Sonnenschein,[*4] T. Noto,[*1,*2] T. Iguchi,[*1] T. Sonoda[*2] and M. Wada[*2]

Resonant ionization is useful for precise optical spectroscopy of radioactive isotopes of many elements to investigate the structures of unstable nuclei. We have developed a high-resolution resonance ionization spectroscopy (HR-RIS) combined with a supersonic gas jet system [1,2] in the PArasitic Laser Ion Source (PALIS) system at RIKEN and a narrow bandwidth tunable pulsed laser system, *i.e.*, an injection-locked Ti:Sapphire laser system [3,4]. An offline experiment was performed using this injection-locked Ti:Sapphire laser system.

The experimental setup for HR-RIS on Ti are shown in Fig.1. Titanium atomic vapor was evaporated by resistive heating of a Ti filament in a vacuum chamber called a reference cell. For optical resonance excitation and ionization from the ground state or a thermally populated low-lying excited state using the Ti:Sapphire laser, an ionization scheme shown in Fig.2 (a) was used. The titanium atomic vapor was irradiated using the second harmonics of the injection-locked Ti: Sapphire laser tuned to the first step transition. The second harmonics of a standard Ti: Sapphire laser was additionally used for efficient ionization via autoionization states. Here, an external cavity diode laser (ECDL) was used as a master laser of the injection-locked Ti:Sapphire laser. We achieved a line width of 20 MHz and a 0.4 mJ/pulse at the maximum output of the injection-locked Ti:Sapphire laser operated at a repetition rate of 1 kHz. Titanium ions produced by resonance ionization were accelerated with an electric field and detected by a multi channel plate (MCP) after traversing the field free region. The number of pulses from MCP was obtained from a counter with a timing gate in the time-of-flight of Ti ions.

We investigated the Rydberg and autoionization states by scanning of the second step laser from 554800 cm^{-1} to 55600 cm^{-1} for a higher count rate. We identified a strong and broad autoionization state around 55400 cm^{-1} as shown in Fig.2 (a). The optical spectrum of stable Titanium obtained by the frequency scan of ECDL, *i.e.*, the scanning of the first step laser is shown in Fig.2 (b). The line-width in the spectrum was estimated to be approximately 210 MHz, and five peaks corresponding to the ^{46,47,48,49,50}Ti isotopes were clearly resolved in the spectrum. Further, their ratios were in good agreement with the natural abundances of Ti isotopes (^{46}Ti-8.0% ^{47}Ti-7.3% ^{48}Ti-73.8% ^{49}Ti-5.5% ^{50}Ti-5.4%). The isotope shift of the optical transition of ^{46}Ti and ^{50}Ti to ^{48}Ti were evaluated to be approximately 1.7 GHz and 1.6 GHz, respectively. Presently, the particularly narrow hyperfine splitting of ^{47}Ti and ^{49}Ti is not resolved because of the remaining Doppler broadening of the experimental geometry. In the near future, the resolution will be improved by applying the supersonic gas-jet system.

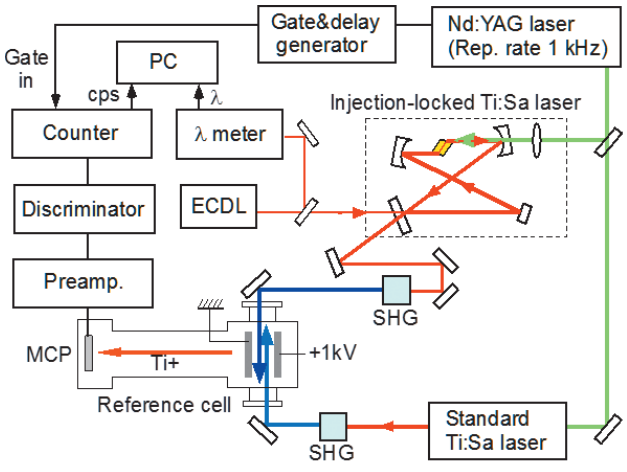

Fig.1 Experimental setup for HR-RIS on Ti

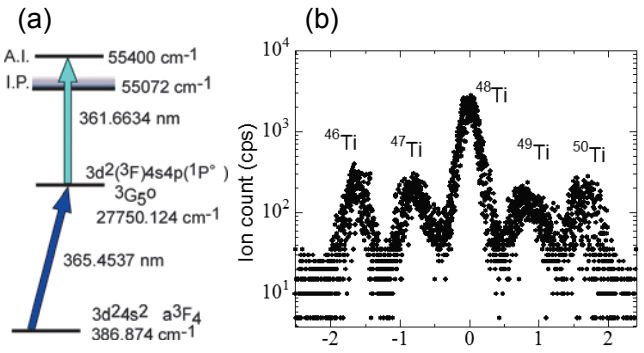

Fig.2 (a) Ionization scheme on Ti
(b) Optical spectrum of Ti isotopes.

[*1] Department of Quantum Engineering, Nagoya University
[*2] RIKEN Nishina Center
[*3] Institute of Physics, Johannes Gutenberg-University Mainz
[*4] Department of Physics, University of Jyväskylä

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