High Intense Vanadium-Ion Beam Production to Search for New Super-Heavy Element (SHE) With Z = 119

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Introduction (1)

“Synthesis super heavy element (SHE) with Z = 119” was started since 2016

\[ {\text{V}} + {\text{Cm}} \rightarrow {\text{SHE}} \]
1) Higher acceleration energy than before
2) High Intensity vanadium-ion (V-ion) beam
3) About 1-month stable beam supply without interruption

An emerging issue in SRILAC operation is

**Particulate matters (PM)** produced by sputtering (beam loss).

PM adsorbed on the surface of cavity

→ **Serious reduction of the accelerate voltage**

→ Emittance Limitation using “Slit Triplet” of **LEBT**

The intensity was reduced to ~30% of that of analyzed beam.

To meet the requests 2) and 3)

a) **Investigate Optimum Parameters**, the V-vapor amount and the microwave power

b) Develop Large-capacity **High Temperature Oven system (HTO)**.
a) Optimization of the V-ion-beam intensity

- Total microwave power (18 and 28GHz)
- V-vapor amount

\[ \text{V}^{13+}-\text{beam intensity} \]

- V-ion-beam Intensity
- Total microwave power
  
  Temperature raise + Flow rate of Cooling water

- The V-vapor amount is equivalent to the V-sample consumption rate.

Figure 3: HTO Crucible and the V-consumption rate

Figure 2: Experimental Setup
b) Large capacity High Temperature Oven (HTO)

- A crucible is heated by the Joule heating (DC current).
- **Two Crucibles** were equipped as shown in Fig. 3.
  → 4.4 g of granular V sample is available.

- The intensity clearly depends on the consumption rate and the microwave power as shown as the 2-D contour plots.
- No significant difference between the different HTO positions using the Faraday cup only.

**Figure 4: Double HTO system**

**Figure 5: Obtained V$^{13+}$-beam intensity “individually” using HTO 1 and 2**
Result (2) “Simultaneously” using HTO 1 and 2

400 $\mu$A with $\sim$ 6 mg/h and 2.5 kW

Approximately 1 month beam supply for Synth. Exp.

Figure 6: Obtained $V^{13+}$-beam intensity “simultaneously” using HTO 1 and 2

600 $\mu$A with $\sim$ 24 mg/h and 2.9 kW

Approximately 1 week beam supply for Dev.

Figure 7: M/Q spectrum as a function of current of the analyzing magnet
Figure 7: The V$^{13+}$-ion beam intensity obtained as a function of the microwave power when the $B_{\text{ext}}$ is changed from 1.34 to 1.51 T.

- No significant difference between the changes in $B_{\text{ext}}$ from 1.34 to 1.51 T.
Conclusions

1) We measured the \( \text{V}^{13+} \)-beam intensity as a function of both the V-consumption rate and the microwave power.

- The optimized beam intensity was plotted as the two-dimensional contour plot.

- Simultaneously using two HTO crucibles allows us to execute SHE synthesis.

- The \( \text{V}^{13+} \)-beam intensity of 400 \( \text{e} \mu \text{A} \) at a consumption rate of \( \sim 6 \text{ mg/h} \) and a microwave power of 2.5 \( \text{kHz} \).

  \( \rightarrow \) The high-intensity beam lasts \( \sim 1 \text{ month} \) without interruption for SHE synthesis.

- The \( \text{V}^{13+} \)-beam intensity of 600 \( \text{e} \mu \text{A} \) at a consumption rate of 24 \( \text{mg/h} \) and a microwave power of 2.9 \( \text{kHz} \).

  \( \rightarrow \) The extra-high-intensity beam lasts for \( \sim 1 \text{ week} \), for the essential development.

2) No significant effects by changing the oven position and varying \( B_{\text{ext}} \) between 1.34 and 1.51 T on the beam intensity were observed within the scope of the simple measurement using only a Faraday cup.
Pressure of the plasma chamber ($10^{-5}$ Pa)
The graph shows the consumption rate (mg/h) plotted against heating power (W). Two curves are depicted: one for Ti (green) and one for V (red). The consumption rate increases as the heating power increases for both materials.