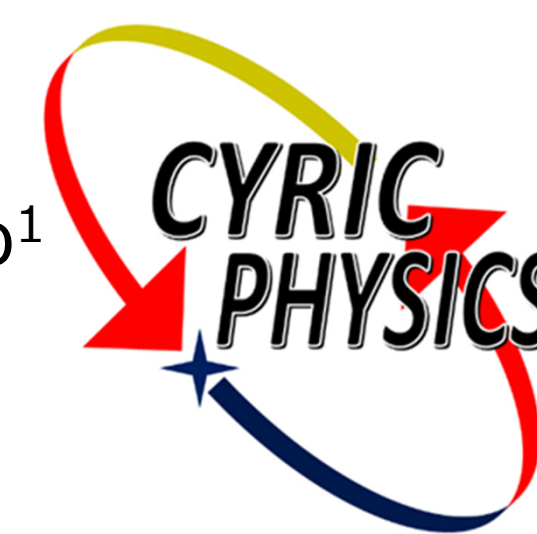


Light induced desorption of alkali atoms from OTS-coated glass and yttrium metal for an electron electric dipole moment search



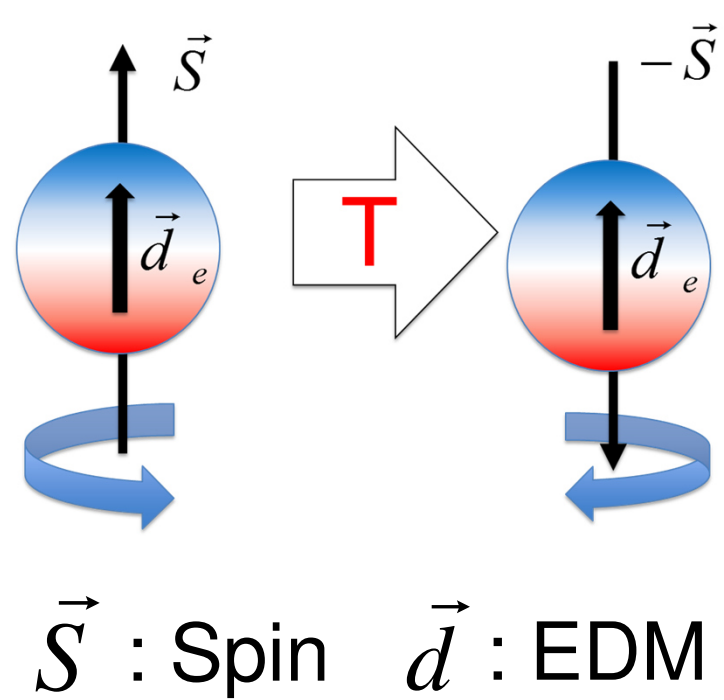
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We have investigated light induced desorption (LID) effect from the OTS coated glass cell and yttrium (Y) for an electron EDM search using laser cooled francium (Fr) atom. It is major challenge to increase the number of the Fr atoms because Fr is radioactive atom. LID, which desorbs the atom from a surface of material by lights, is useful for increasing the number of trappable atoms. We have observed the LID effect from OTS coated glass cell and Y. We have also investigated the Y surface by XPS.

EDM (permanent Electric Dipole Moment)



Non-zero EDM = time-reversal symmetry violation

CPT theorem
C : Charge conjugation symmetry
P : Parity symmetry
T : Time reversal symmetry

CP-violation

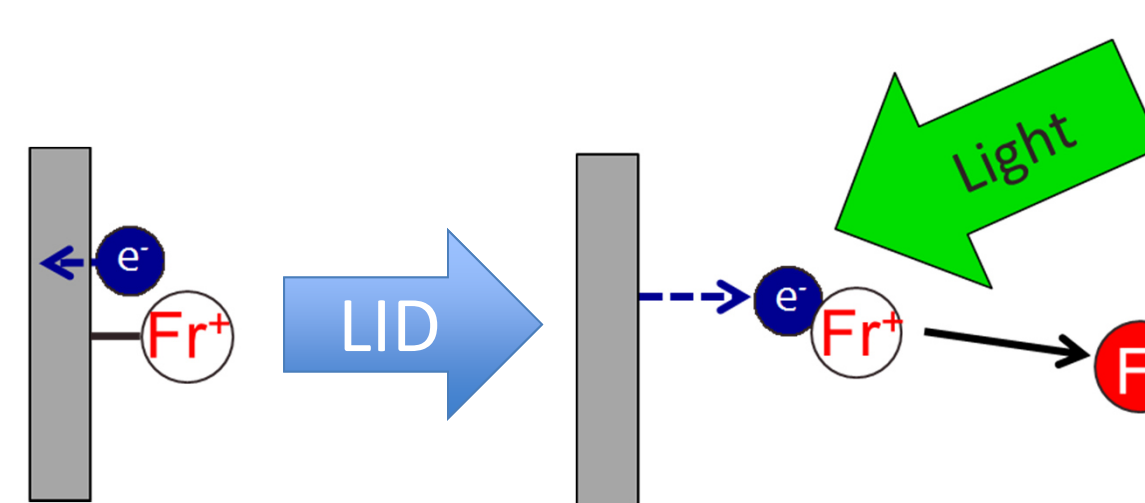
Francium (Fr)

- The heaviest alkali metal atoms.
- Large enhancement for the electron EDM ($Z=87 \Rightarrow K=895$)
- Suitable for laser cooling and trapping (Simple atomic structure)
 - Long interaction time with external electric field
- Radioactive atom (cyclotron operation is required)
 - Half life time ~ 3 min (^{210}Fr)

$$K = \frac{d_{\text{atom}}}{d_e} \propto Z^3 \alpha^2$$

K : enhancement factor for EDM
 d_{atom} : atom EDM
 d_e : electron EDM
 Z : atomic number
 α : fine-structure constant

LID(Light induced desorption)



Electron of Fr is moved to the surface and Fr is adsorbed on the surface as ion.



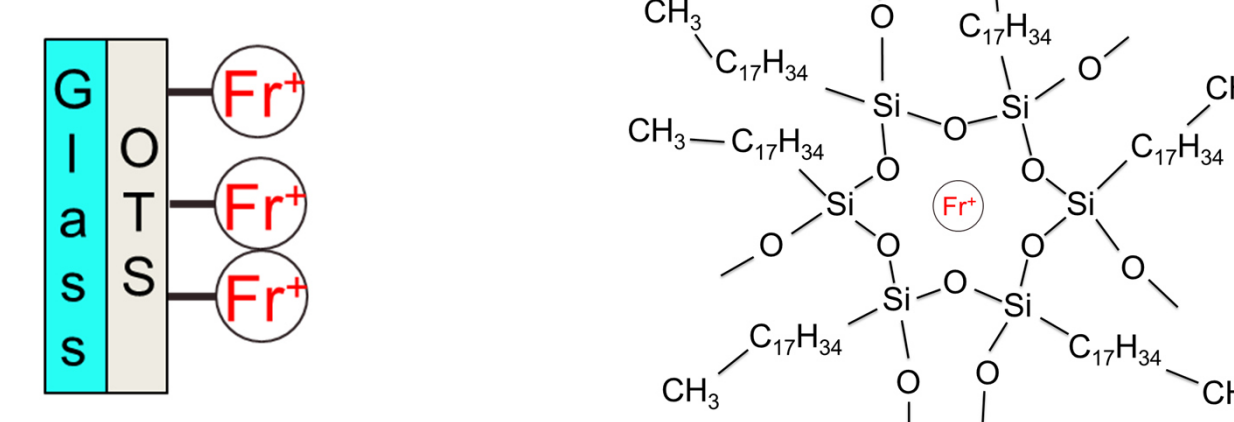
Electron moves to Fr and Fr is desorbed as neutral atom.

The adsorption mechanism

OTS(octadecyltrichlorosilane) coated glass

- OTS reduces the adsorption energy.

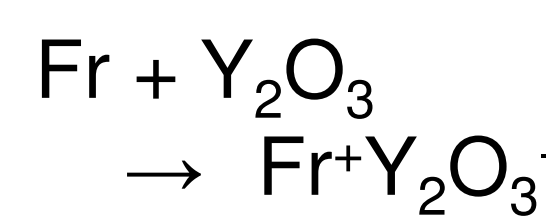
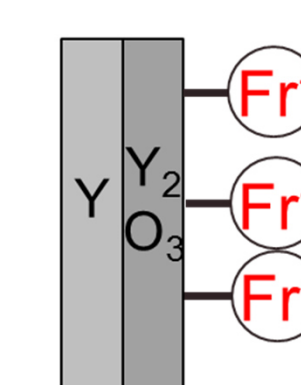
Easy to desorb Fr



Fr⁺ is complexed by OTS which acts like a cage.

Y metal

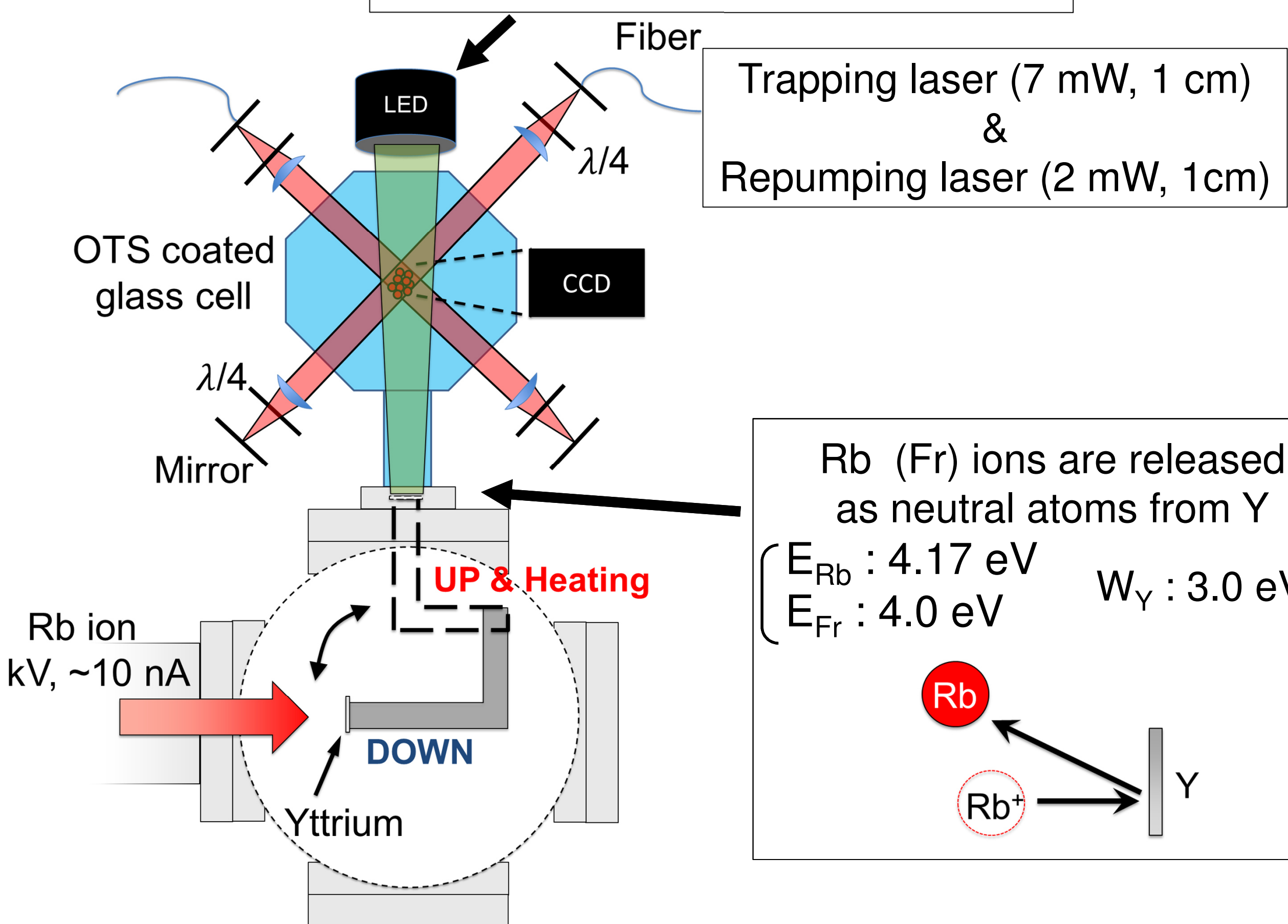
- Purity 99%
- Fr is adsorbed on the oxide surface(Y_2O_3).



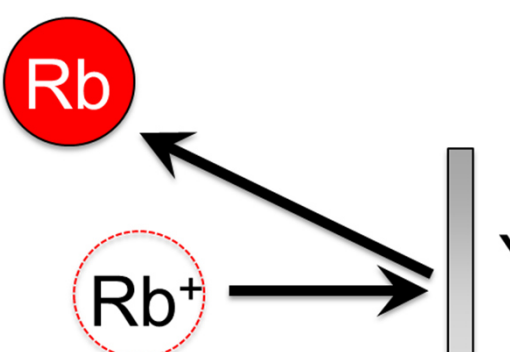
Experimental setup I

- Applicate the LID effect to Rb MOT (Rb : Test source for the Fr experiment)

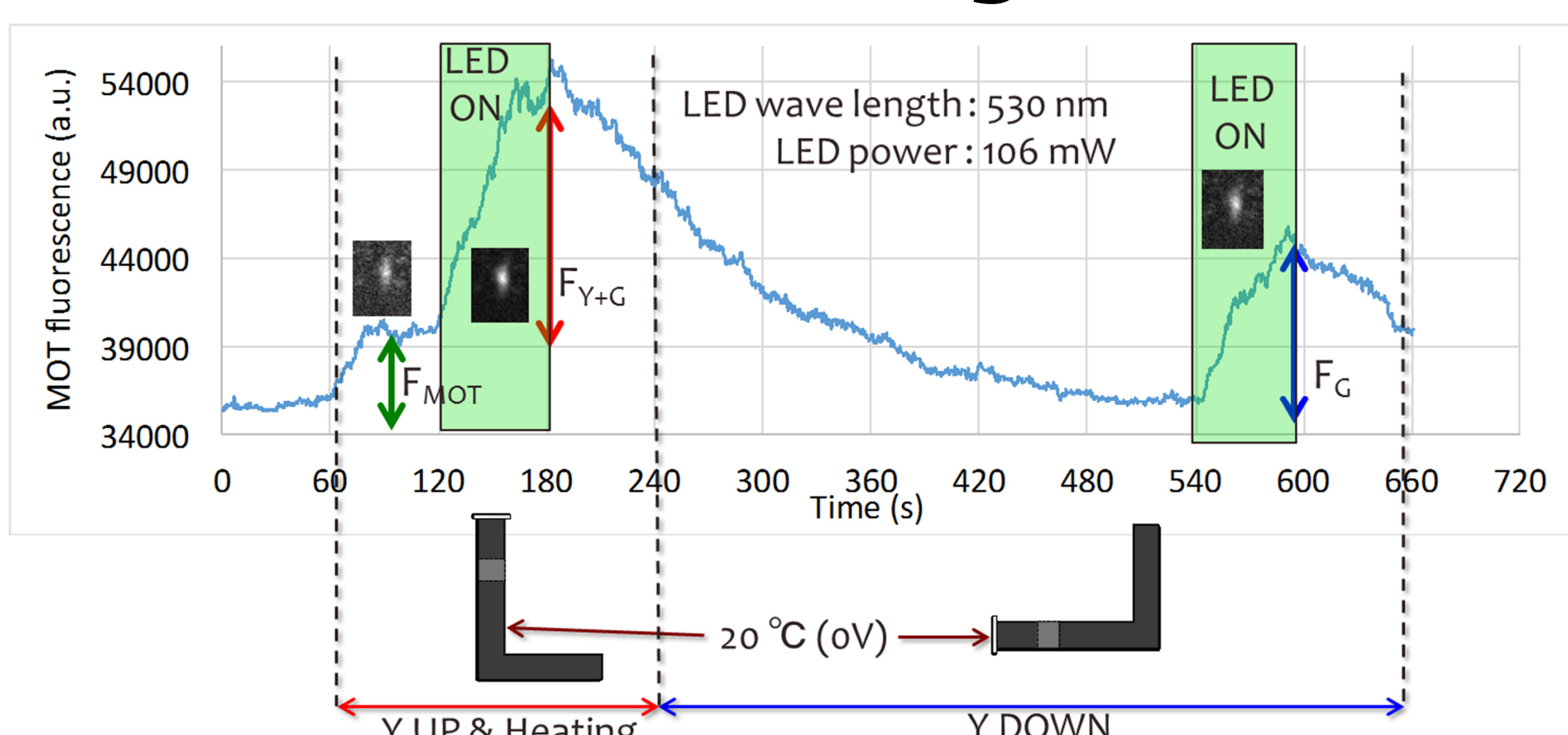
Collimated Green LED (M530L3-C2)
Max Power : 106 mW
Wave length : 530 nm
Beam diameter : 25 mm



Rb (Fr) ions are released as neutral atoms from Y
($E_{\text{Rb}} : 4.17 \text{ eV}$ $E_{\text{Fr}} : 4.0 \text{ eV}$ $W_{\text{Y}} : 3.0 \text{ eV}$)



LID from OTS coated glass cell and Y



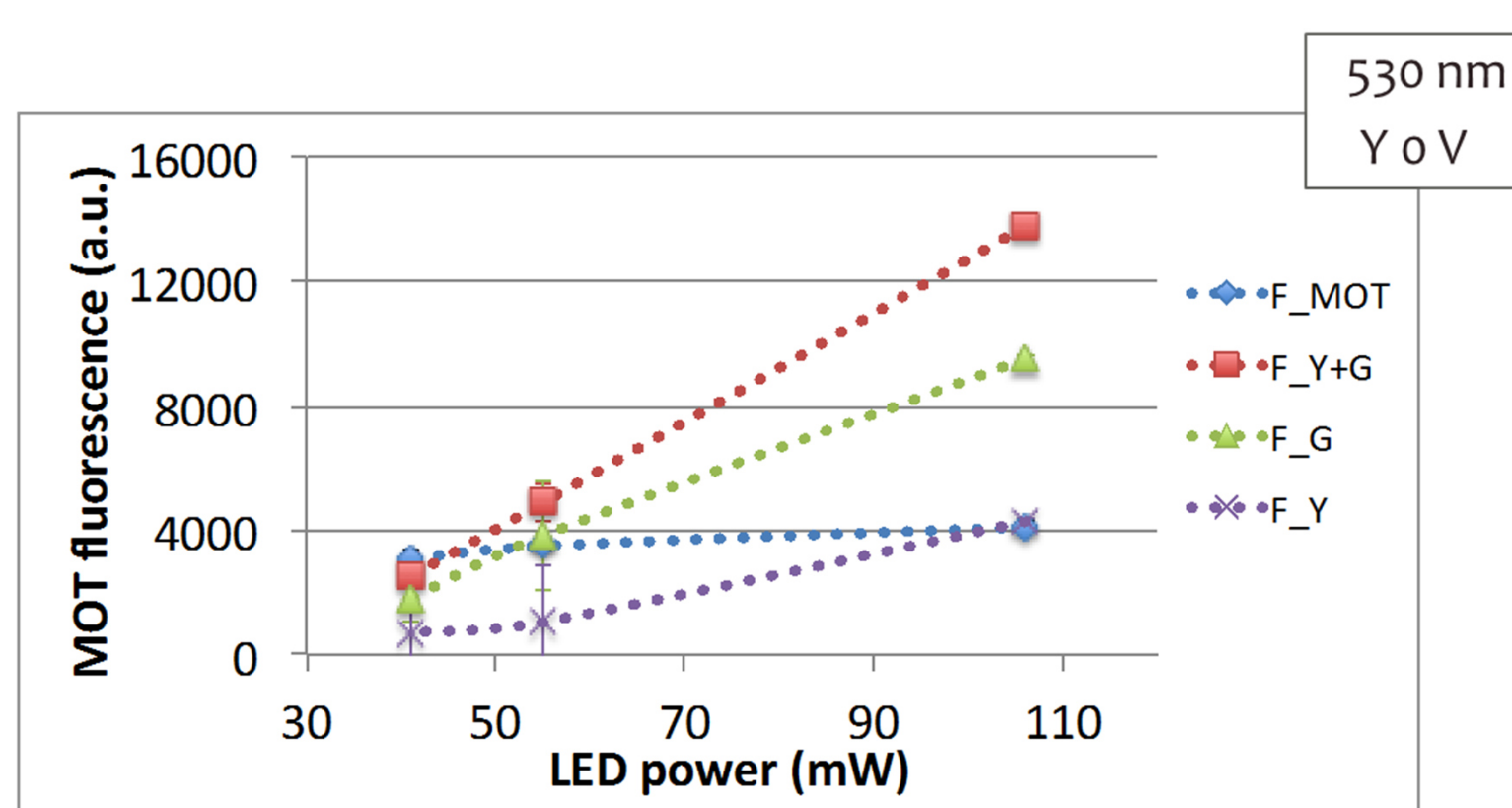
The increase of MOT fluorescence intensity
 F_{MOT} : Thermal desorption from Y

$F_{\text{Y+G}}$: LID from OTS coated glass and Y

F_{G} : LID from OTS coated glass

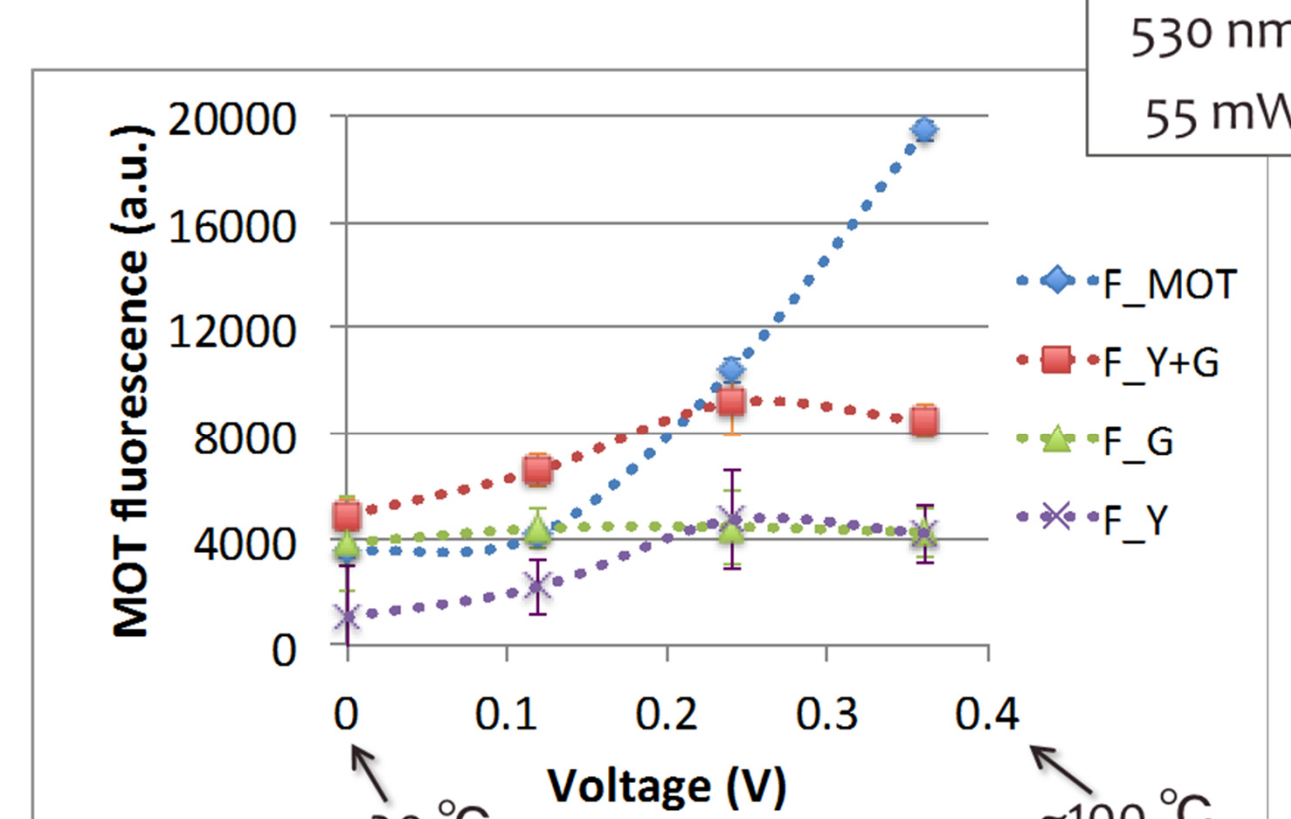
$F_{\text{Y}}(F_{\text{Y+G}} - F_{\text{G}})$: LID from Y

Desorbing light power dependence



F_{G} : Linearly proportional to light power
 F_{Y}

Y surface temperature dependence



F_{G} : No change

F_{Y} : The increase was suppressed at 0.36 V.

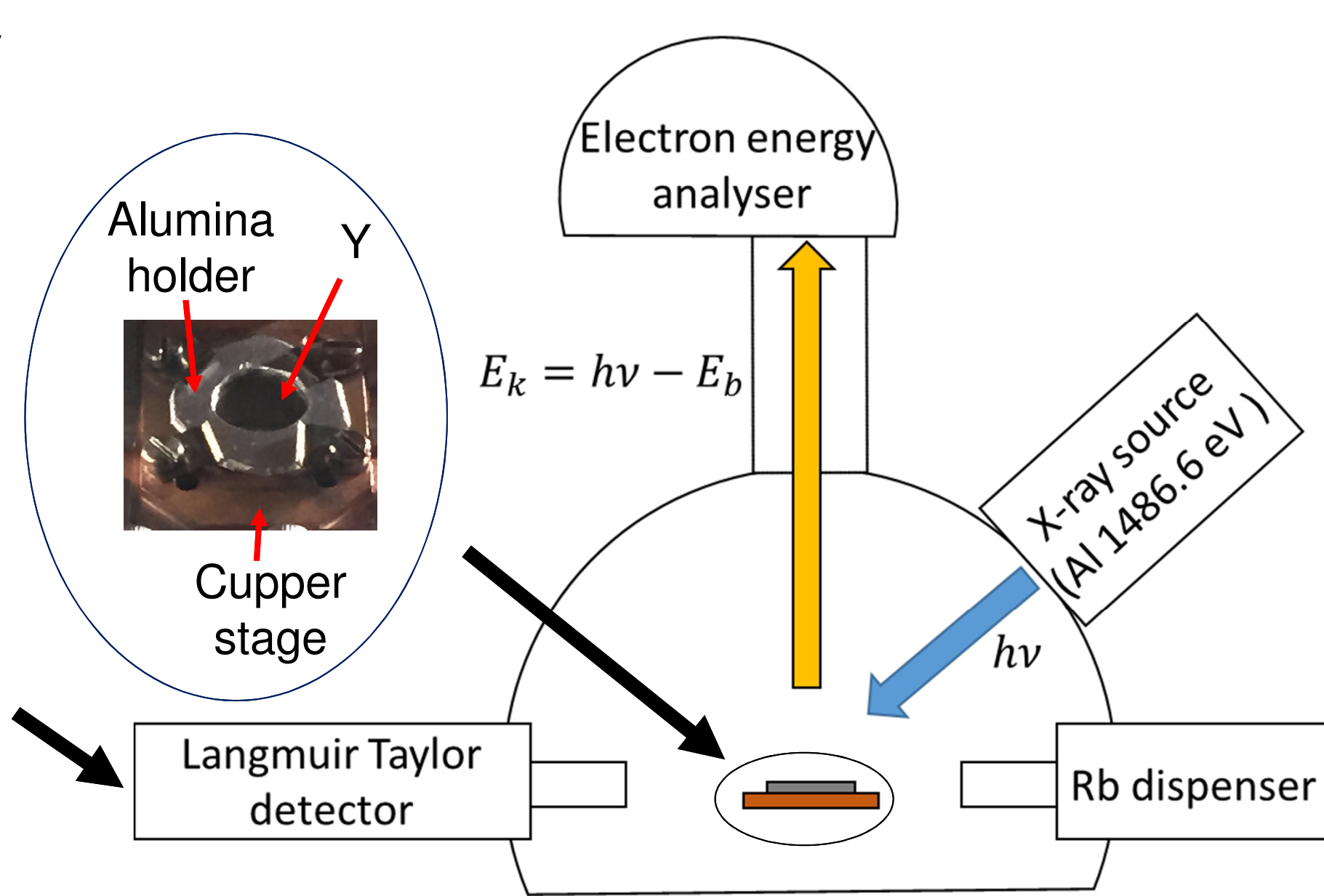
The trapping efficiency decreased by vacuum down.

Experimental setup II

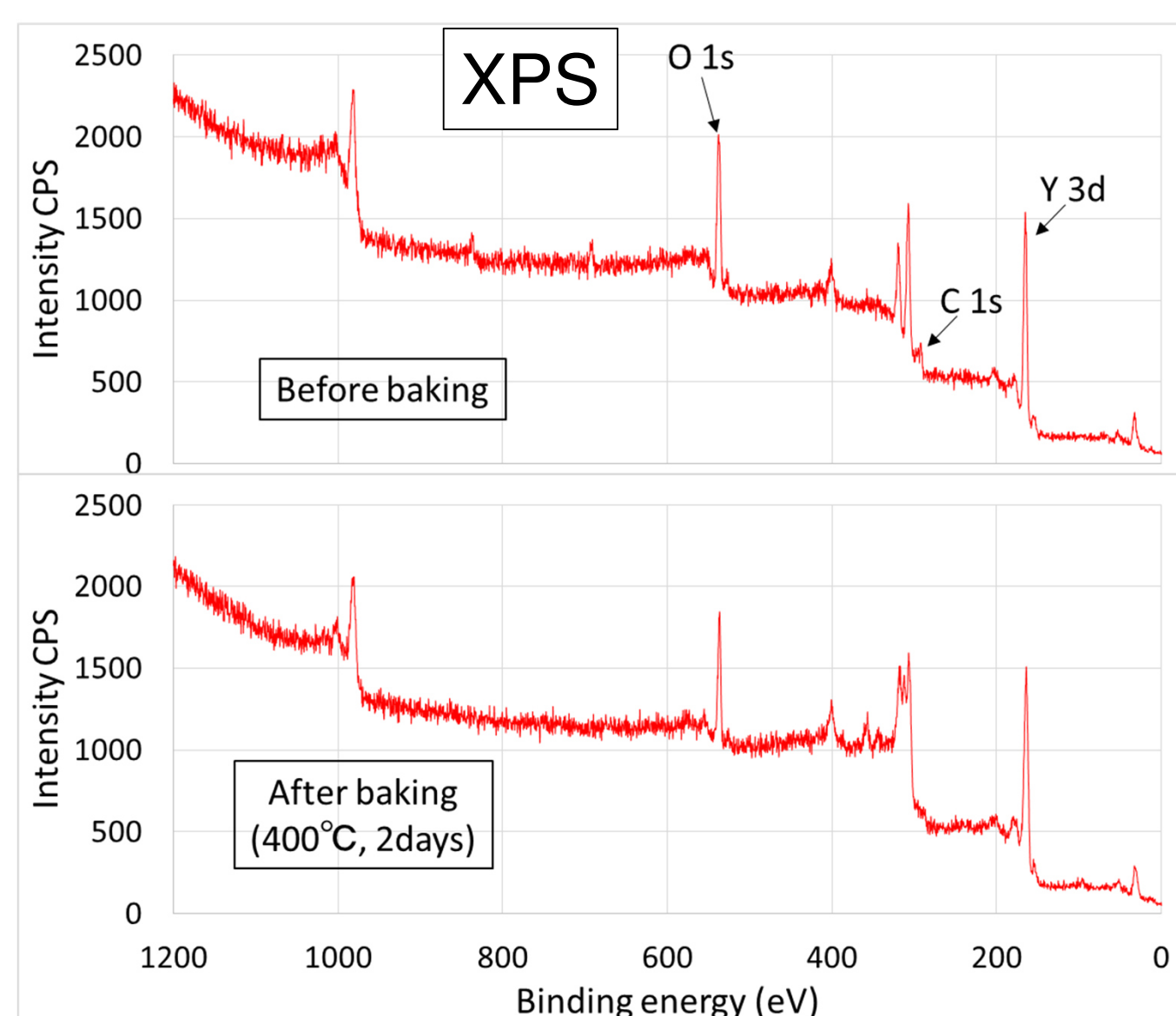
- Investigate the Y surface by X-ray photoelectron spectroscopy(XPS)
- Investigate the reason of the decrease of trapping efficiency by LID effect
- Y : baked at 400°C for 2 days

Platinum Ionizes the desorbed Rb by surface ionization process ($E_{\text{Rb}} : 4.17 \text{ eV}$, $W_{\text{Pt}} : 5.70 \text{ eV}$)

Detect the produced ion by secondary electron multiplier

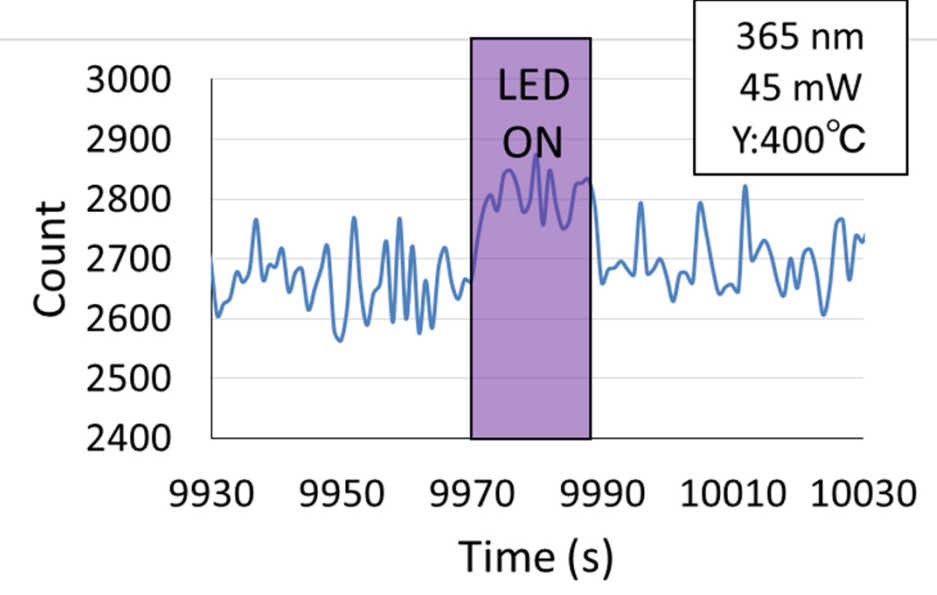


XPS and LID without Rb



Y, C, and O peaks were observed. Alumina peaks were observed after baking (Holder melted at 400°C)

LID from Y before deposition

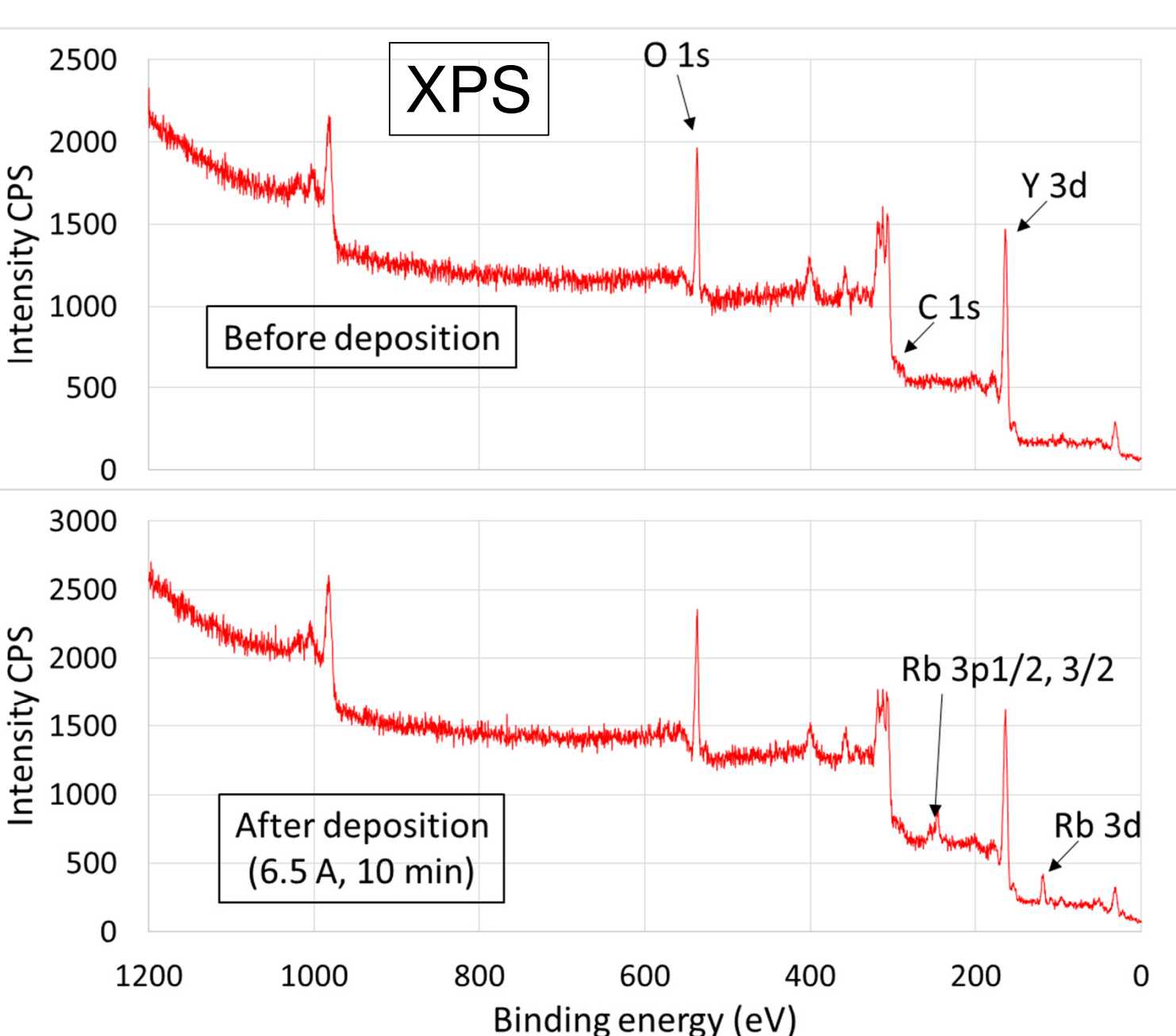


Y(30°C) Not observed

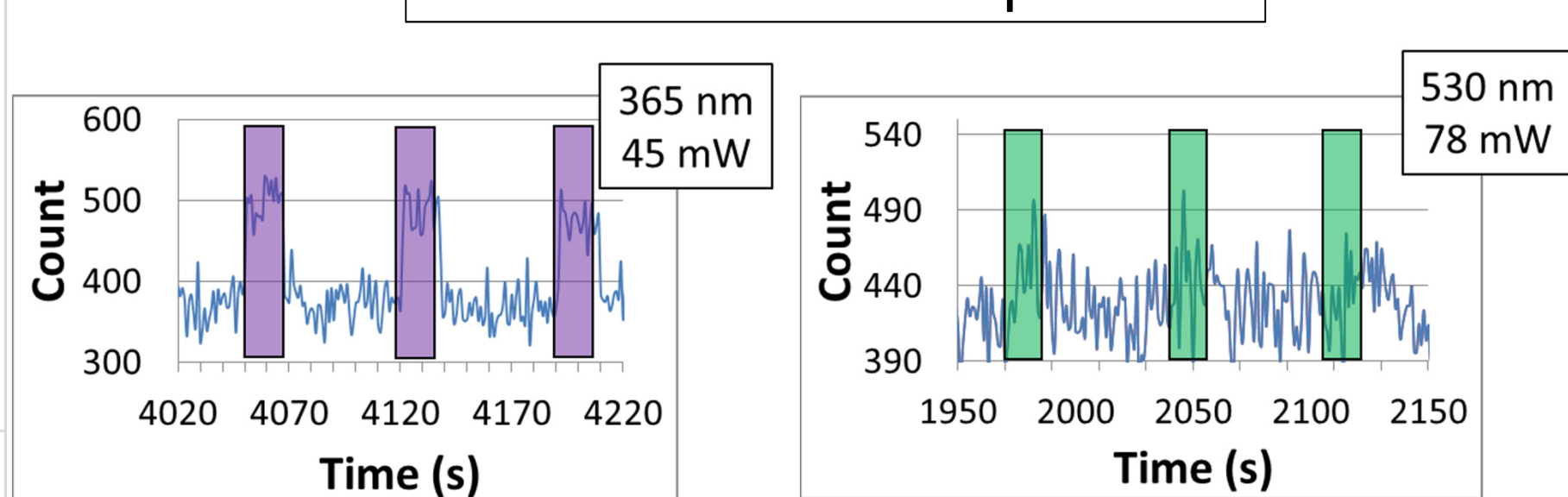
Y(400°C) Green(530 nm) : Not observed
UV(365 nm) : Observed

Molecules and atoms except Rb were observed at 400°C

XPS and LID after Rb deposition



LID from Y after deposition



Y(30°C) Green(530 nm) : <100 count
UV(365 nm) : ~100 count

UV LID (45 mW) > Green LID (78 mW)

Summary

Observe the LID effect by MOT

- Linearly proportional to Green LED power.
- The LID effect from Y was suppressed at 0.36 V.

Investigate Y surface by XPS

- C and O on the Y was observed.
- The desorption molecules and atoms except Rb from Y at 400°C was observed by UV LID.
- UV LID effect for Rb was more effective than green LID effect

Future plans

- Investigate the variation of the MOT fluorescence due to the UV LID effect
- Employ the LID effect to trap Fr efficiently