University of Pisa
Department of Civil and Industrial Engineering
Master Degree in Materials and Nanotechnology

Master Thesis Defense

Surface reconstructions induced by Rb on Si(111)

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Outline

- Introduction, Motivations and State of the Art
- Experimental Methods and Setup
- Experimental Results
  - Si(111)-(7×7)
  - Rb on Si(111)
    - Rb deposition at RT
    - Rb deposition at HT
- Conclusions

Introduction

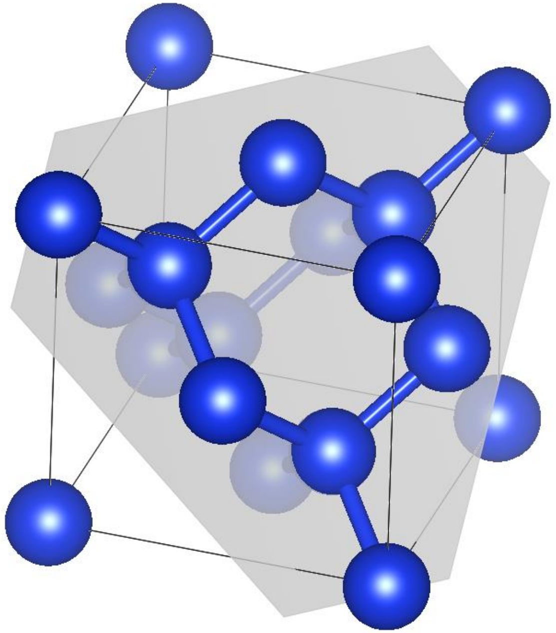
- Studies of semiconductor surfaces have been an active field due to the wide use of semiconductor devices in electronic industry.

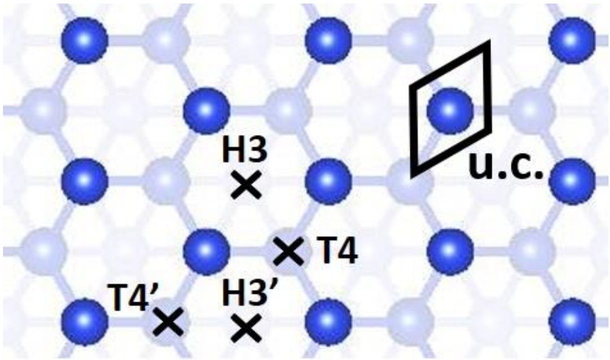
- Ongoing reduction in size of electronic devices, surface effects are becoming more and more important.

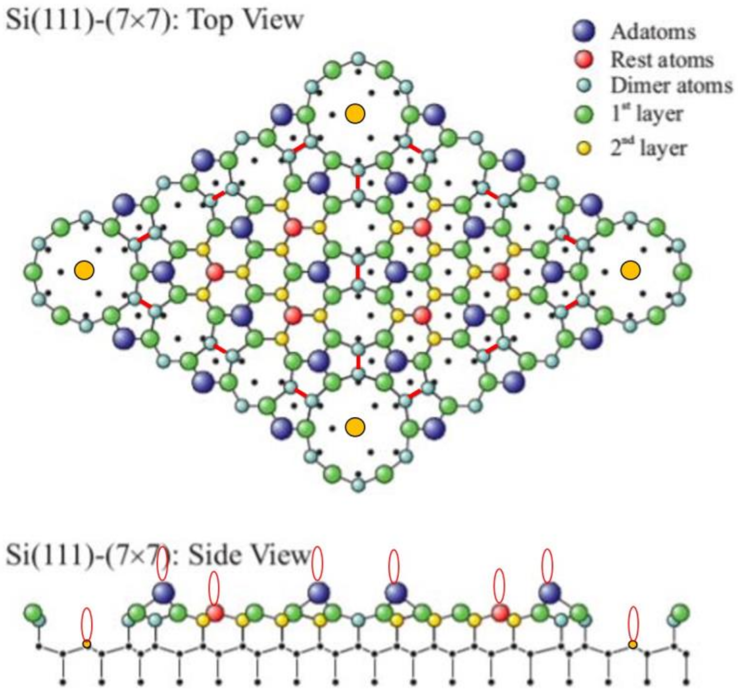
- Surface analysis provides a means to correlate device performance with surface or thin film composition. This knowledge can be used to accelerate the development of new materials and to improve the performance of existing systems.

Si(111) and the (7×7) reconstruction

- Si(111) and DAS model: Si(111)-(7×7) surface.







Motivation

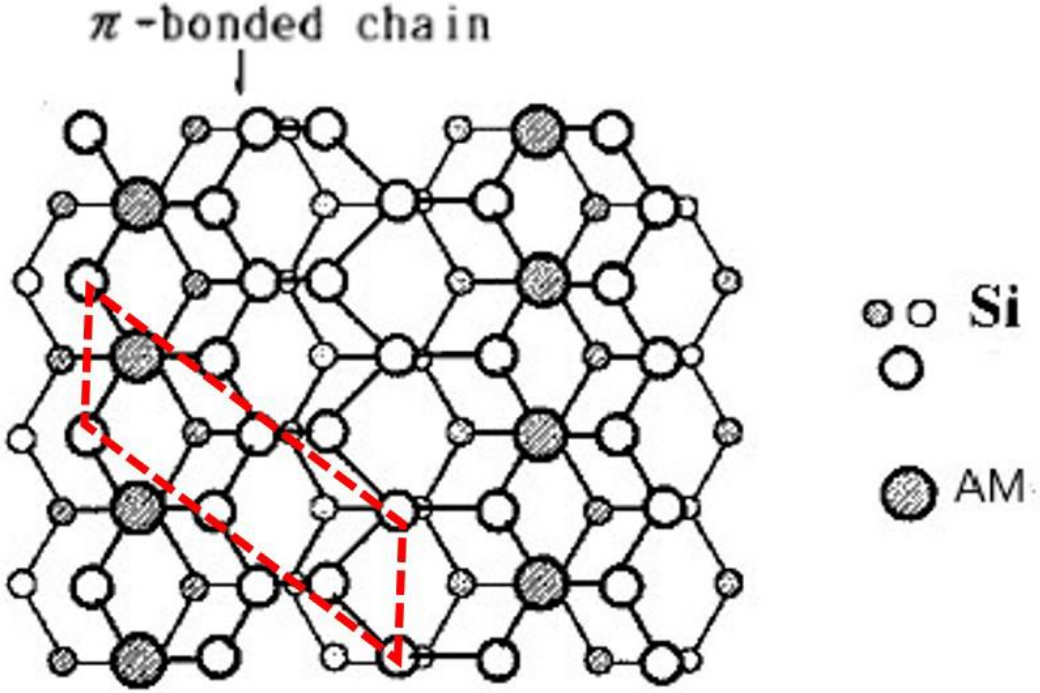
- Development of nanoelectronic devices increased technological and fundamental scientific interest in metal/semiconductor interfaces.

- Adsorption of metal atoms modifies electronic structures and, in many cases, changes the geometric structure.

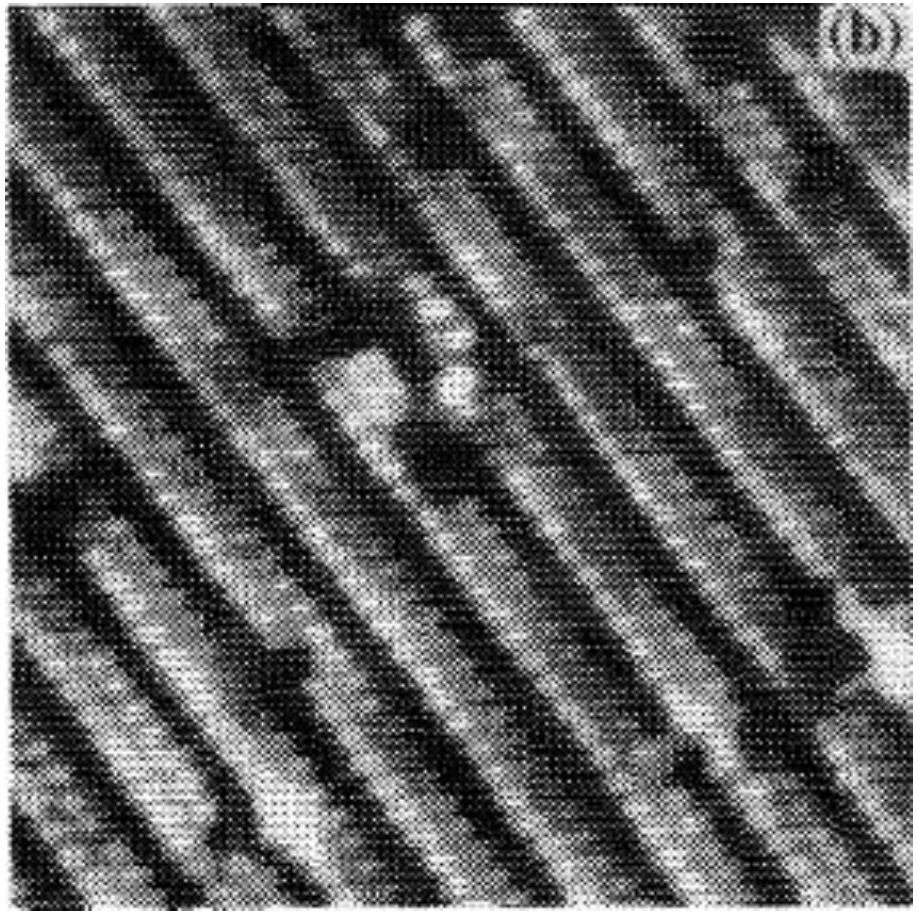
- Particular interest in the chemisorption of alkali metals on semiconductors. AM have a simple electronic structure: a single valence s electron interacting with the surface.

Alkali-Metals/Si(111)- (3×1)

- A or
  A
- S
  e



- Surface shows double parallel rows separated by 11.52 Å.



STM image of Na/Si(111)- (3×1)

Rb/Si(111)-(3×1)

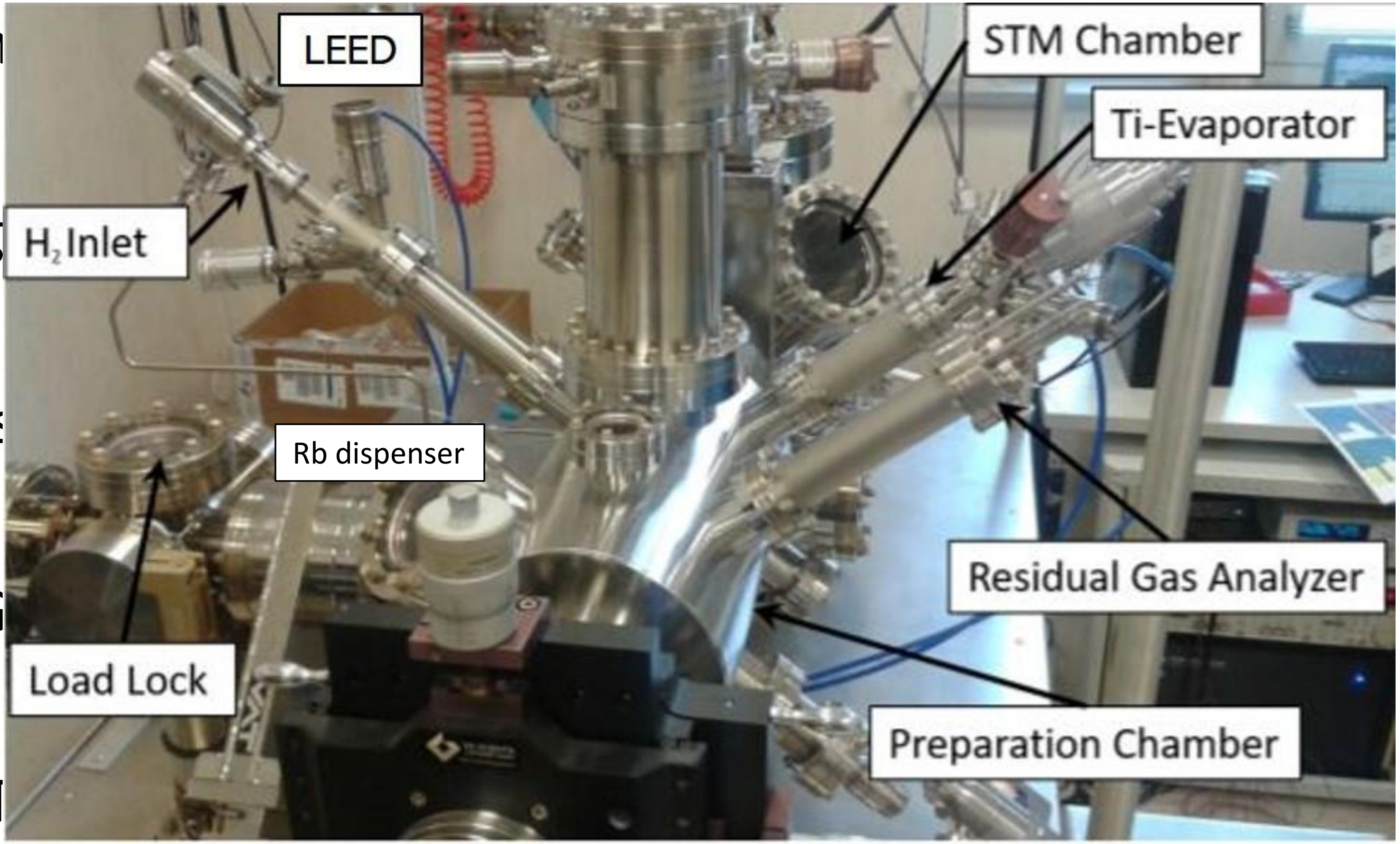
- Experimental evidences for the formation of the (3×1) reconstruction induced by all alkali metals. Evidence for Rb just limited to the reciprocal space.

- Characterization of the adsorption and desorption behavior is missing.

- **Real space investigation is still missing!**

Experimental Methods and Setup

- UHV cham
- Low Energ
- Rb dispens
- Residual G
- Scanning T

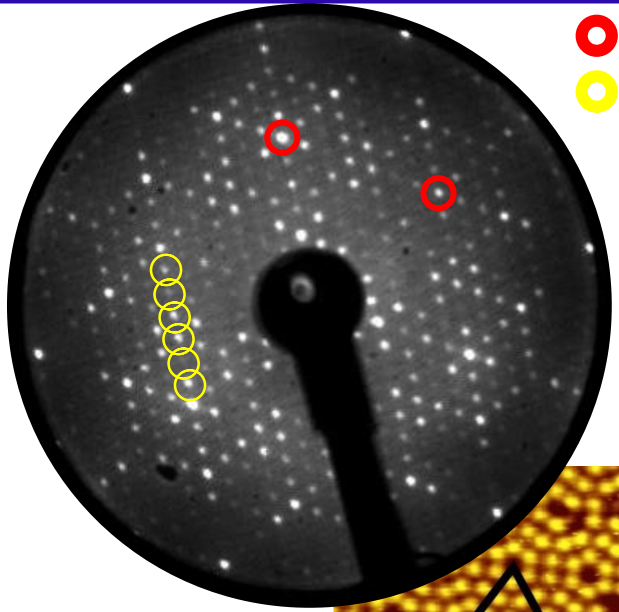


Outline Experimental work

Pristine

Si(111)-(7×7)

Si(111)-(7×7)



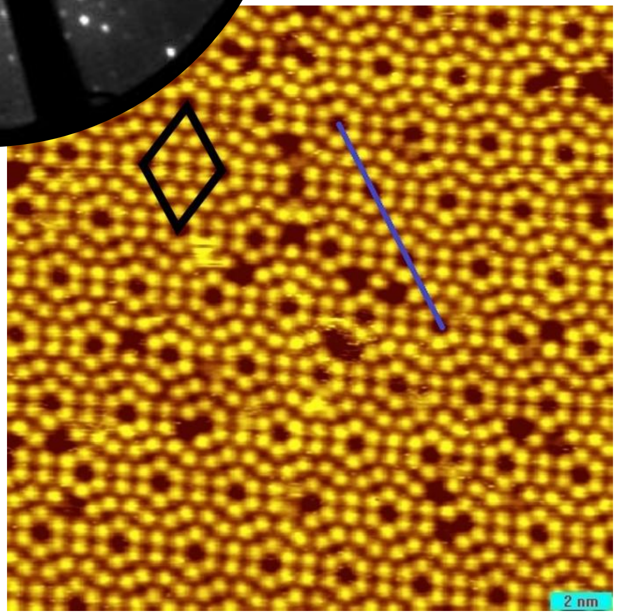
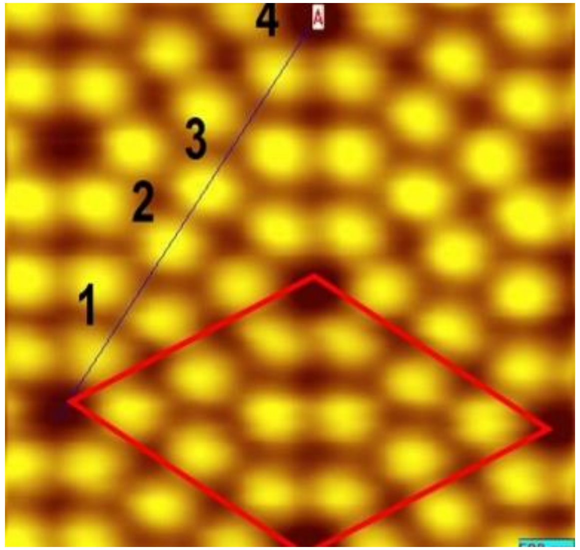
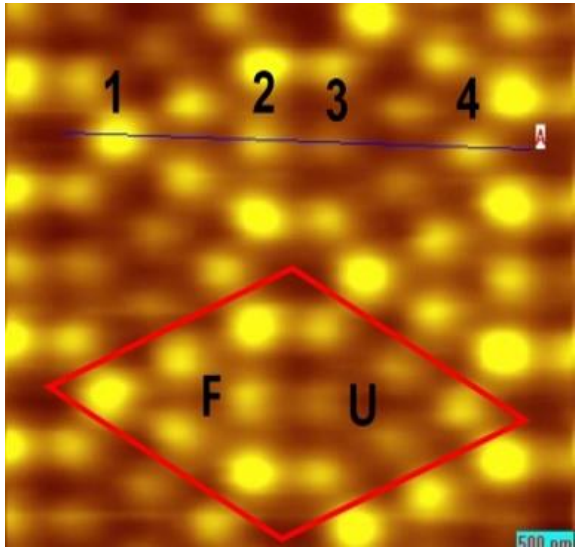


Image parameters:
(I, V) = (0.9 A, 1.3 V)



Positive Bias
(I, V) = (1.0 A, 1.3 V)



Negative Bias
(I, V) = (0.8 A, -1.3 V)

Outline Experimental work

Pristine

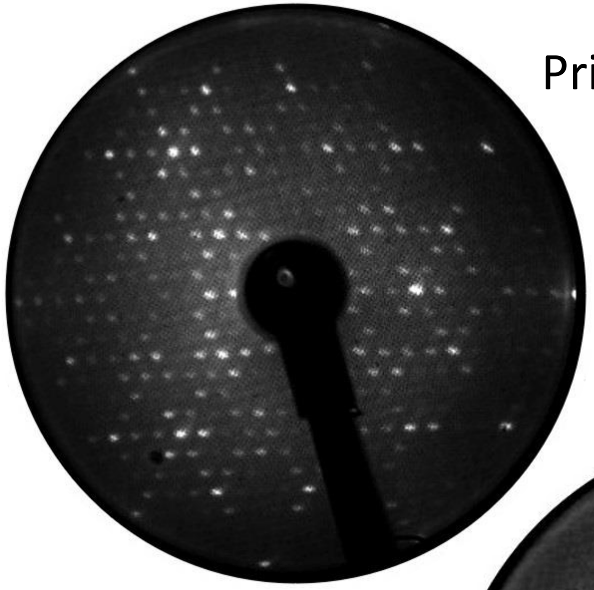
Si(111)-(7×7)

Rb on Si-(7×7)

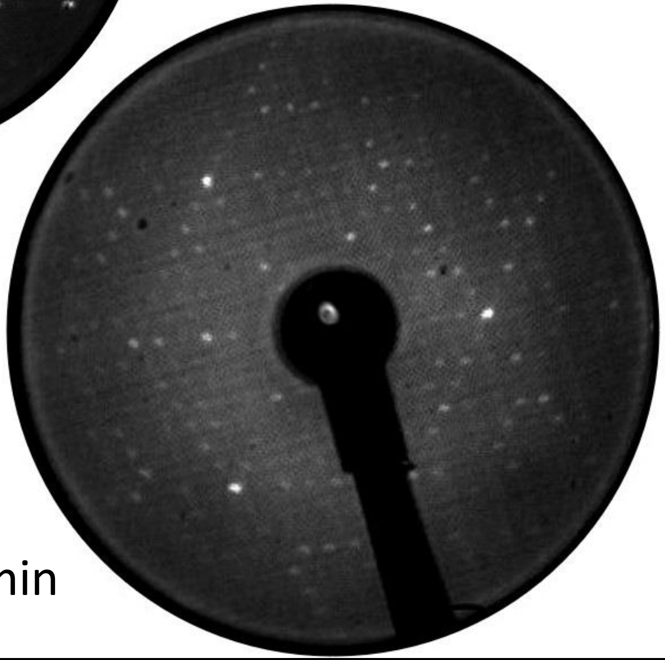
Monitoring deposition rate, time and temperature

RT deposition

Rb/Si(111)-(7×7): RT deposition

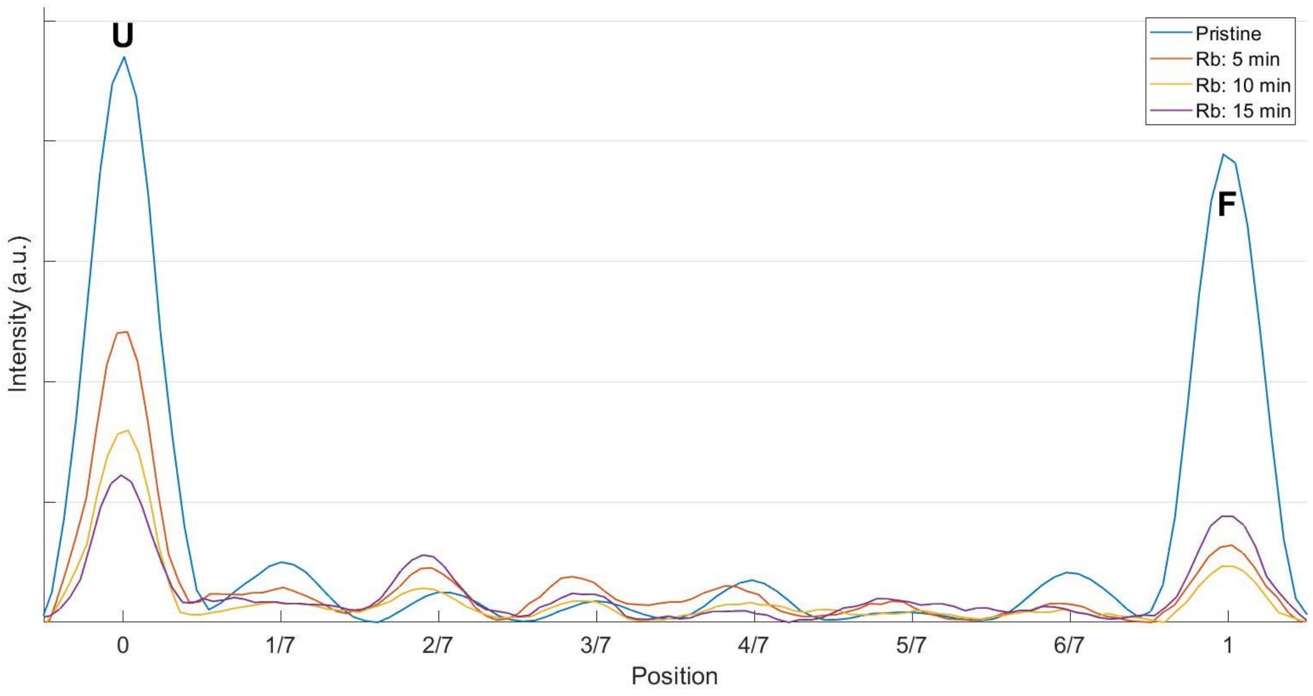


Pristine



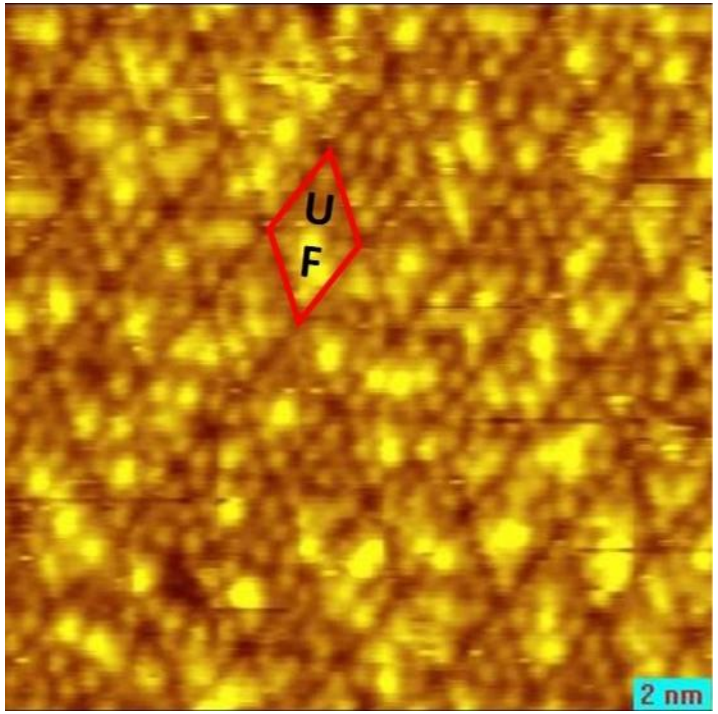
Rb/Si: Rb 10 min

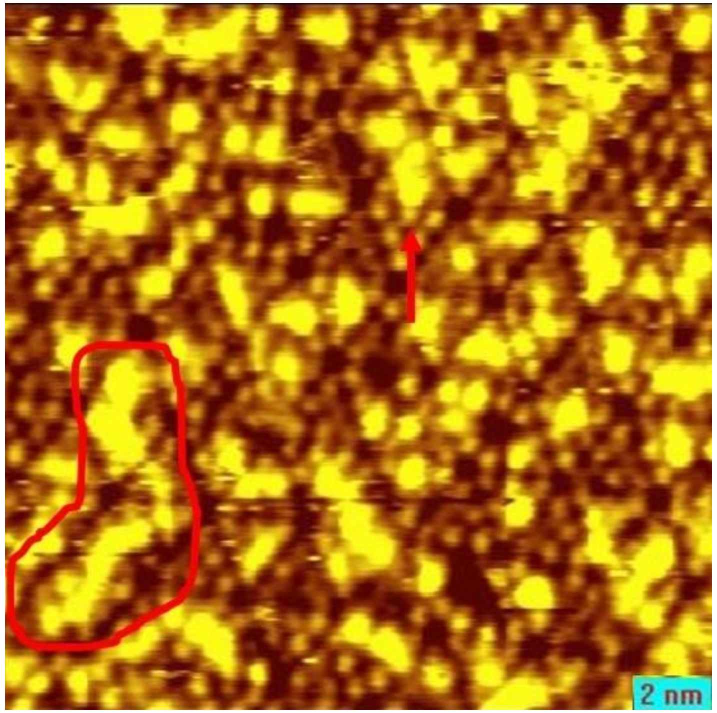
Beam Energy: 76.5 eV

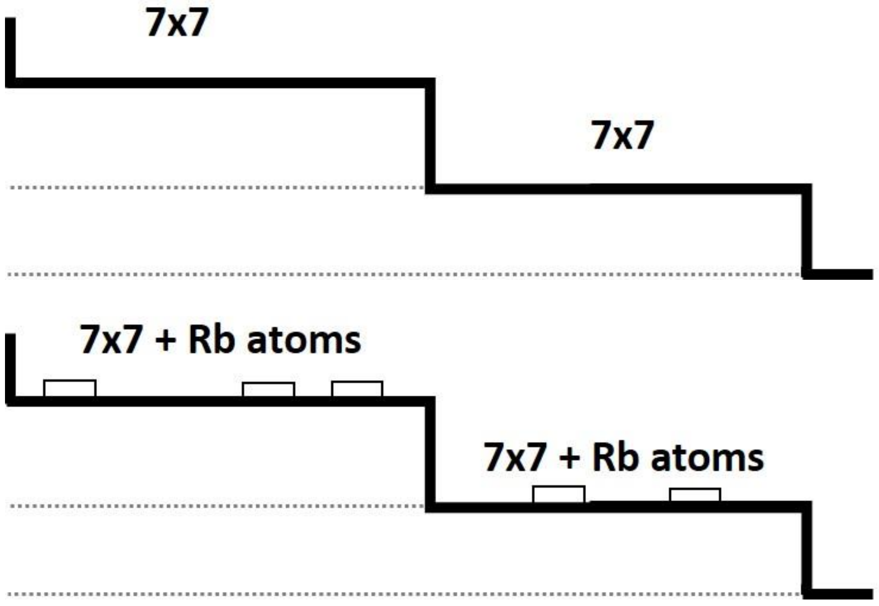


Rb/Si(111)-(7×7): RT deposition

- Rb disordered adsorbed, but preferentially on the faulted half.
- Rb single atoms or clusters.
- Clustering behavior increasing with deposition time.







Outline Experimental work

Pristine

Si(111)-(7×7)

↓

Rb on Si-(7×7)

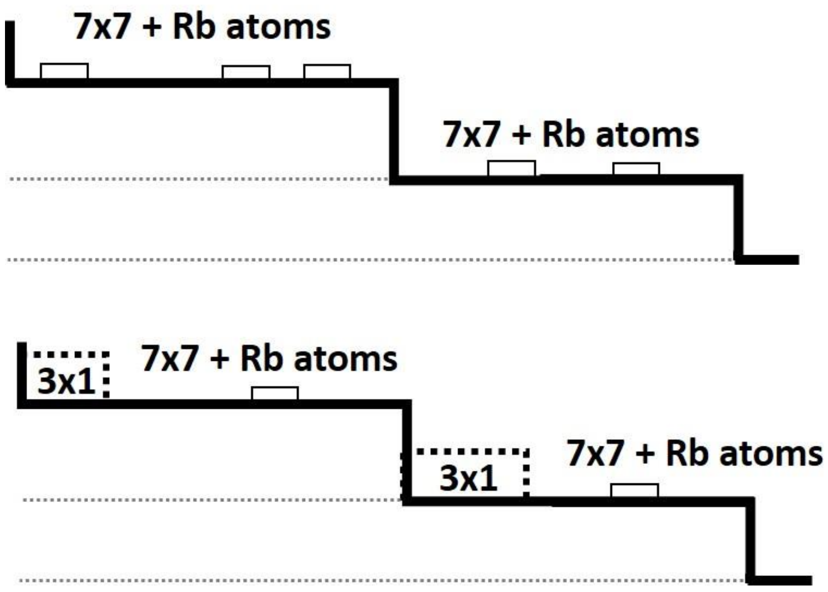
↙

RT deposition

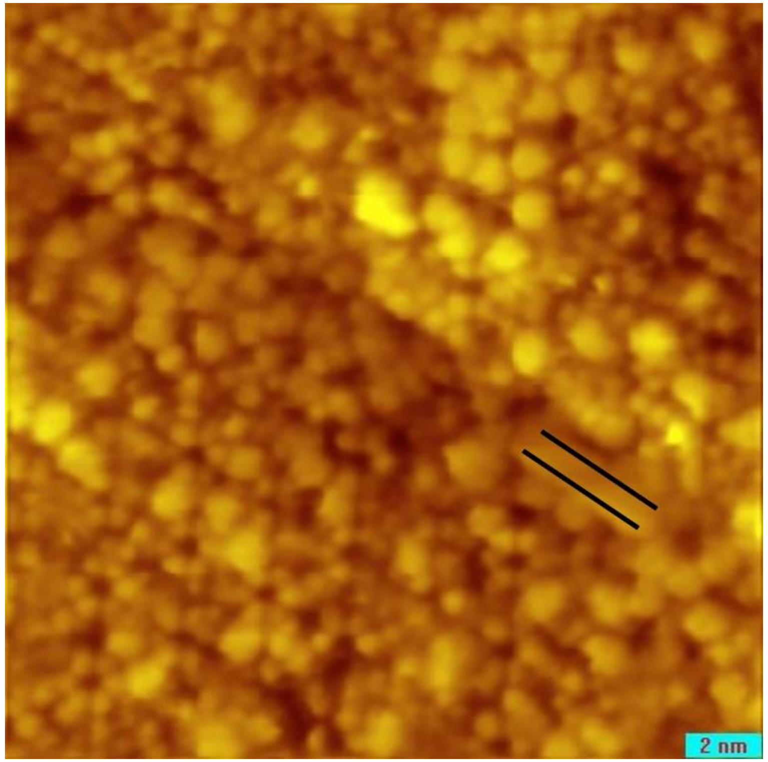
↙

Annealing

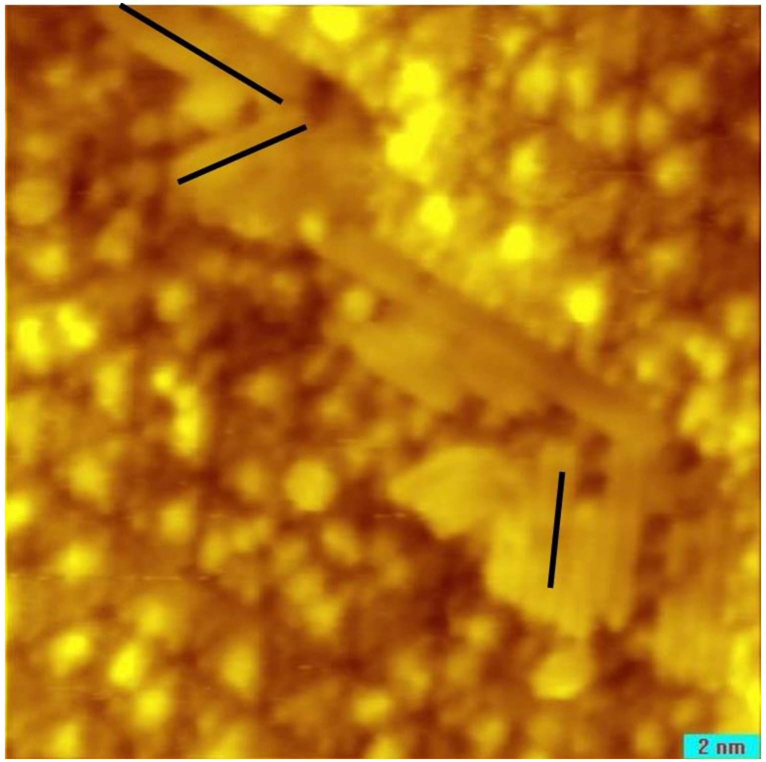
Rb/Si(111)-(3×1): RT deposition, Annealing 300°C



Parallel chains of the (3×1) reconstruction



5 minutes Rb deposition



15 minutes Rb deposition

Outline Experimental work

Pristine

Si(111)-(7×7)

↓

Rb on Si-(7×7)

Monitoring deposition rate,
time and temperature

↘

HT deposition

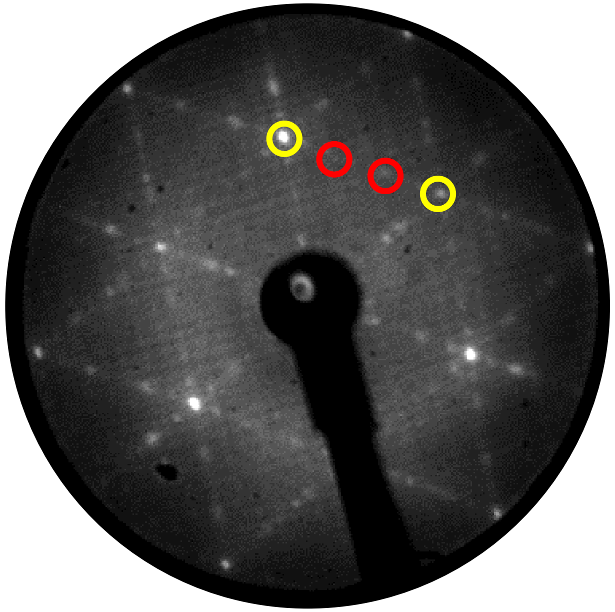
(300-400°C)

Rb/Si(111)-(7×7): HT deposition

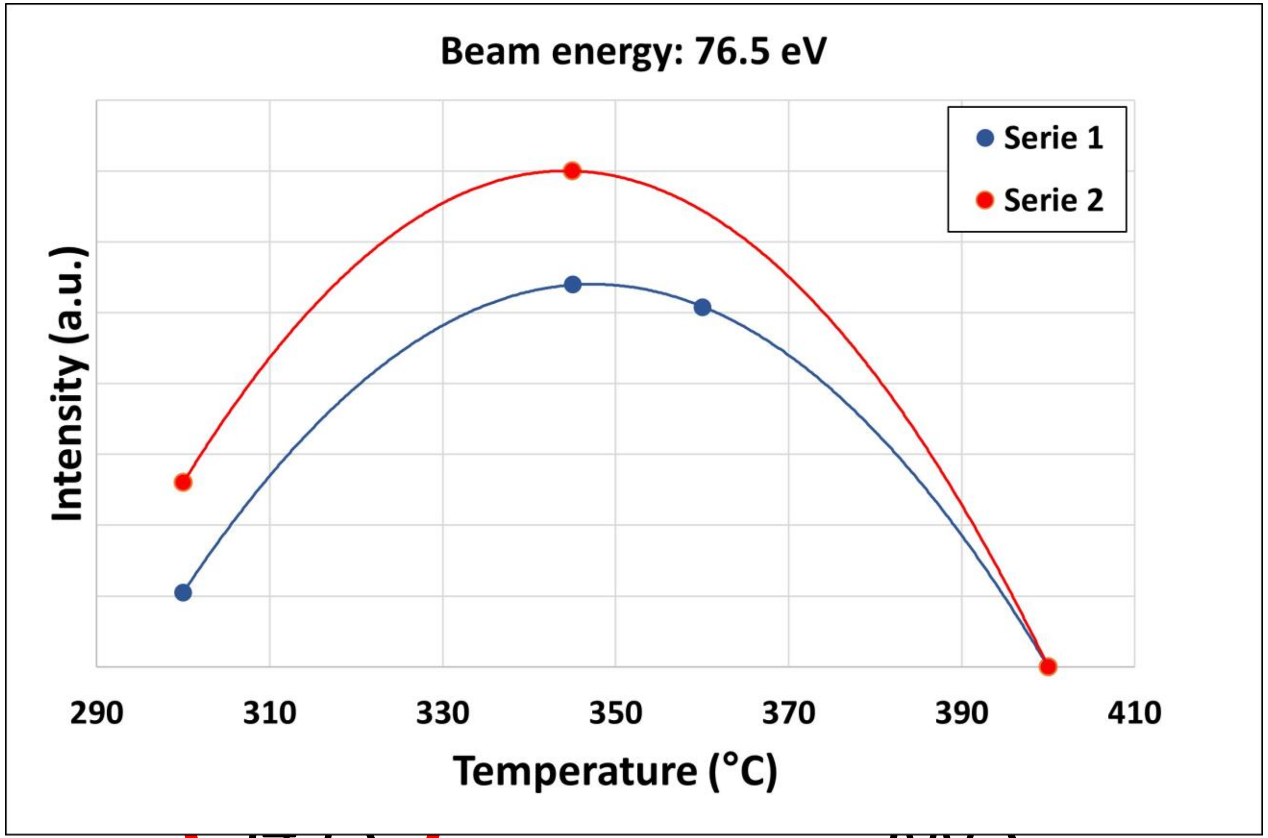
System Variables (controllable)

- Substrate (i.e. Silicon) temperature during deposition;
- Deposition time (Rb quantity deposited);
- Deposition Rate.

Rb/Si-(3×1): HT deposition – Substrate Temperature



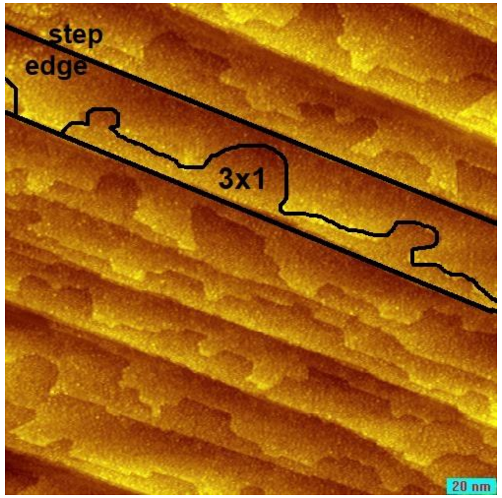
300°C

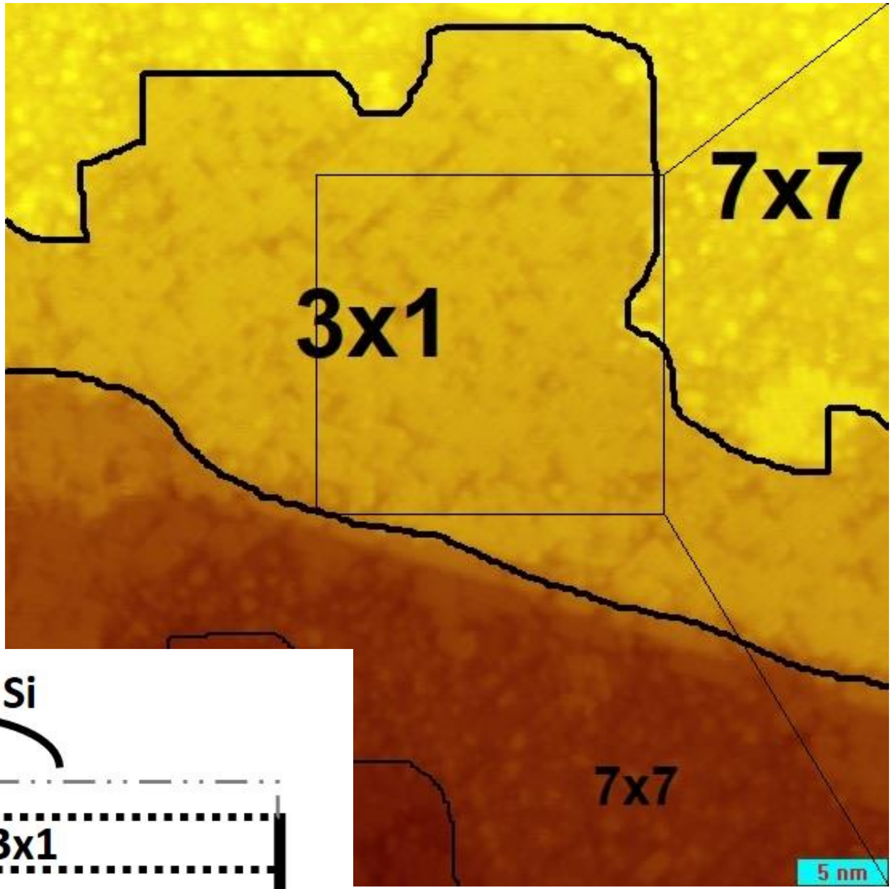


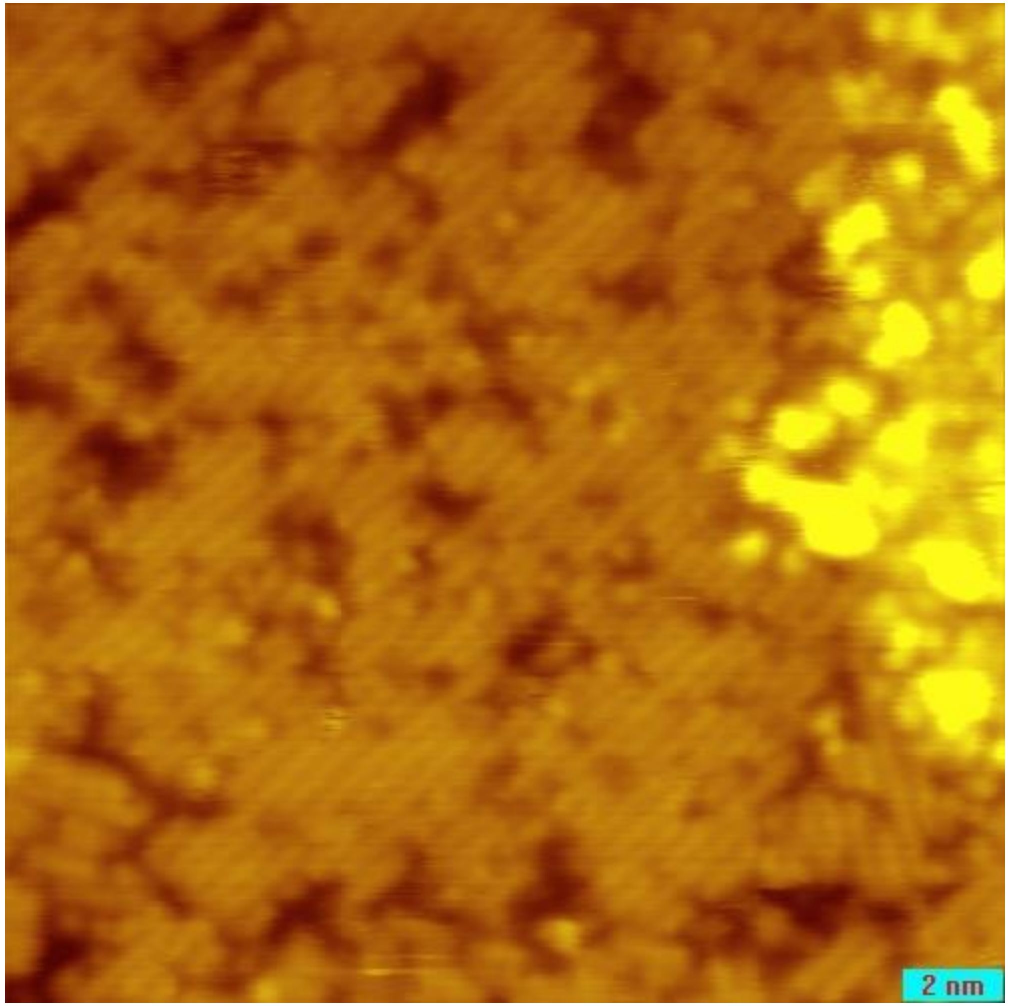
400°C

Rb/Si-(3×1): HT deposition – Substrate Temperature

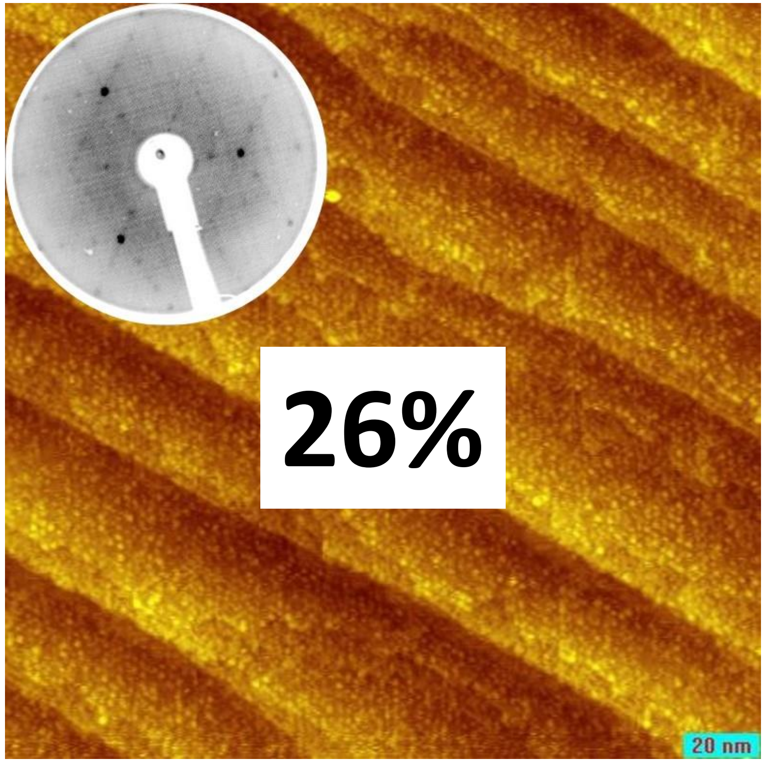
345°C



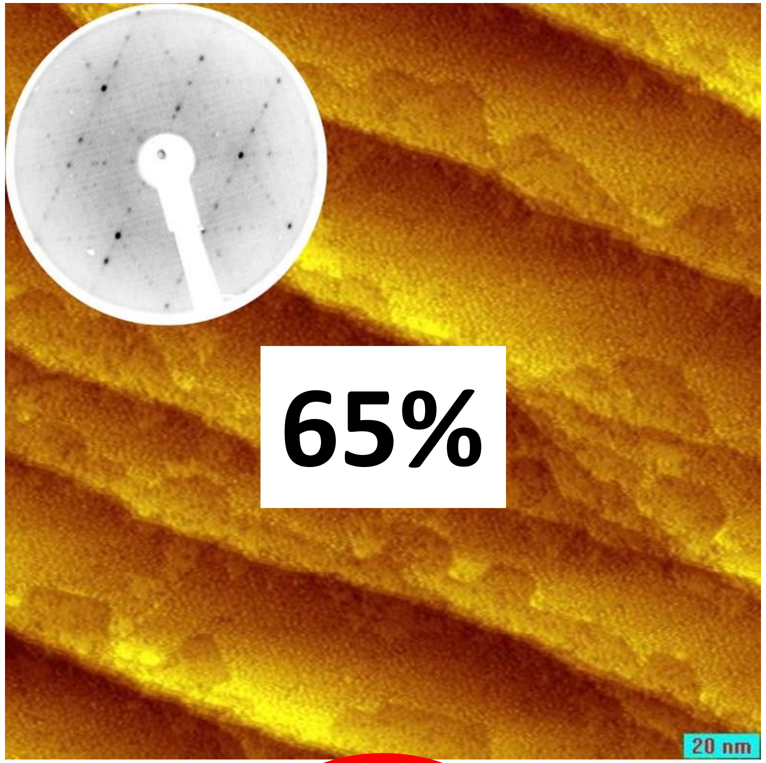




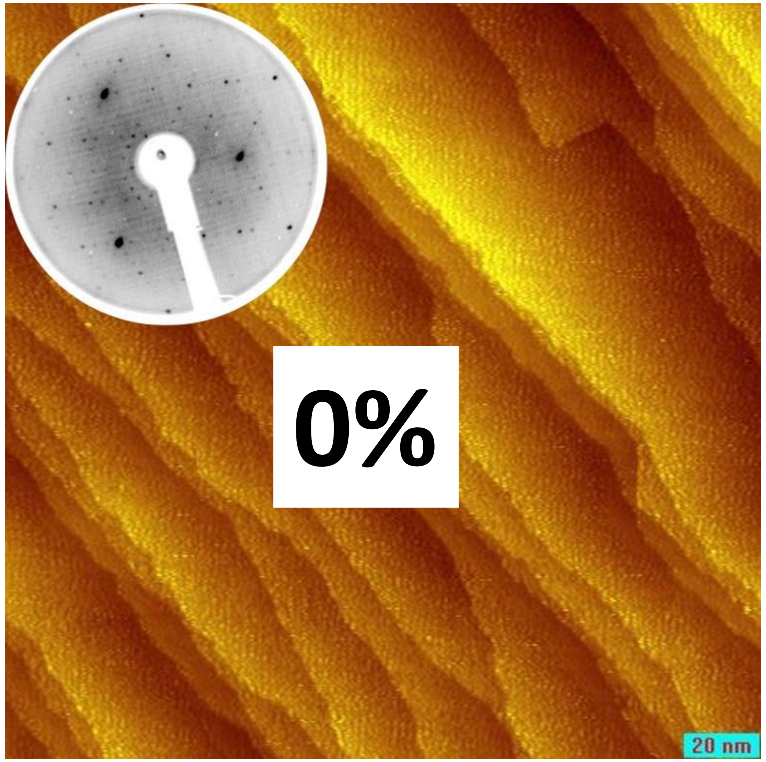
Rb/Si-(3×1): HT deposition – Substrate Temperature



300°C

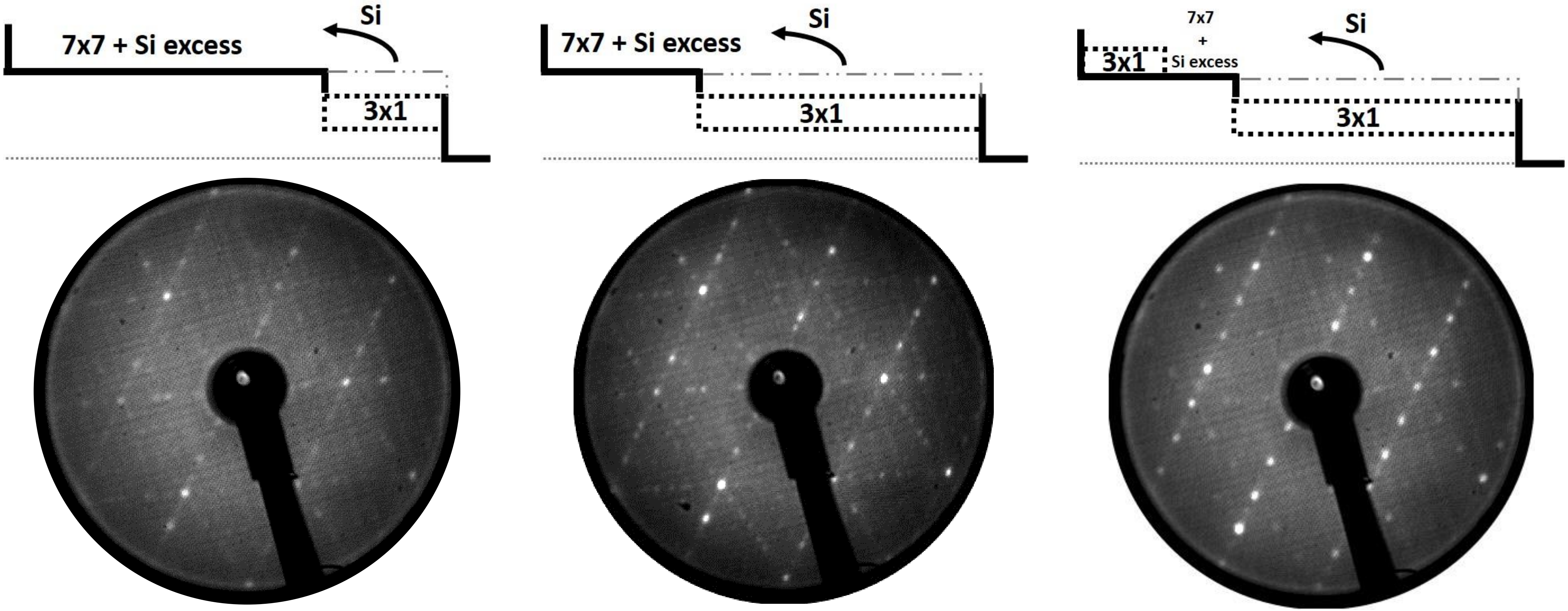


345°C



400°C

Rb/Si-(3×1): HT deposition – Rb amount

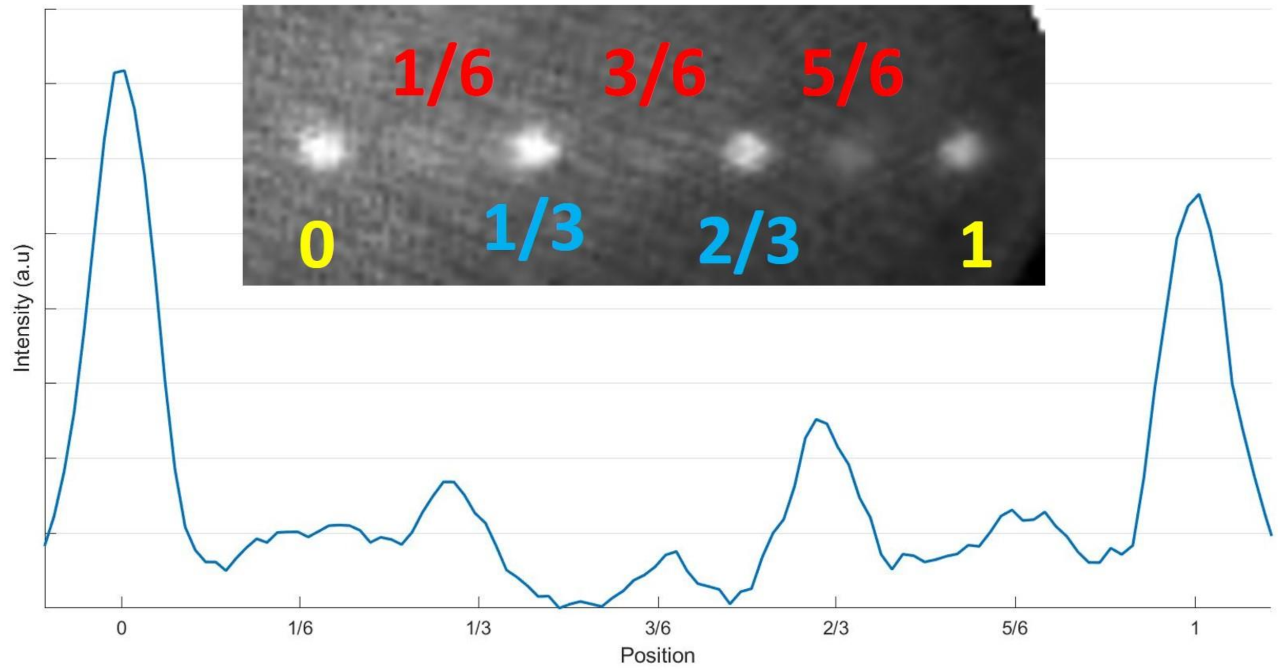


3 min

9 min

12 min

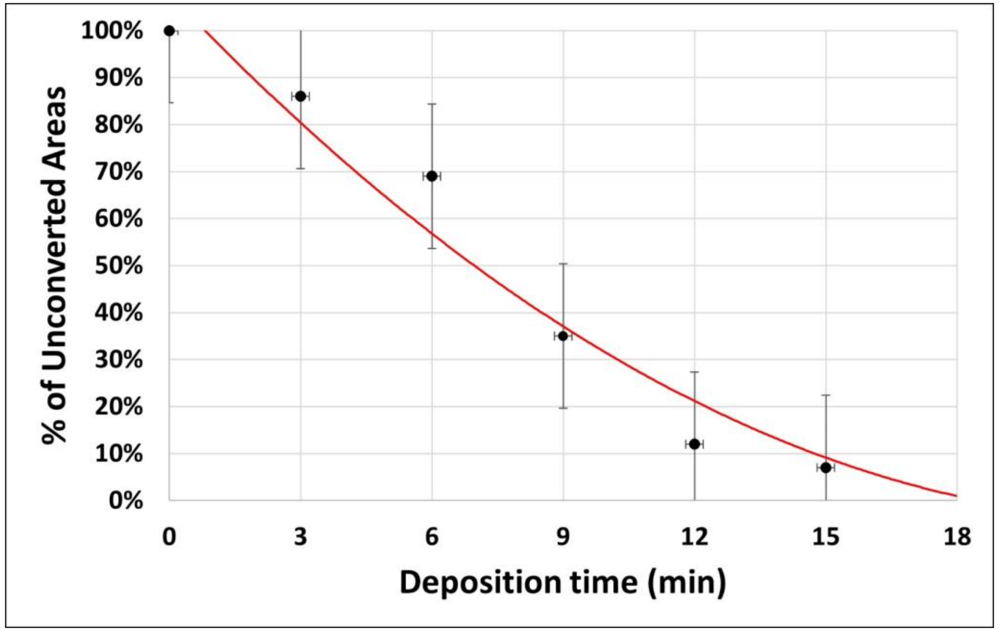
Rb/Si-(3×1)/(6×1): HT deposition – Rb amount



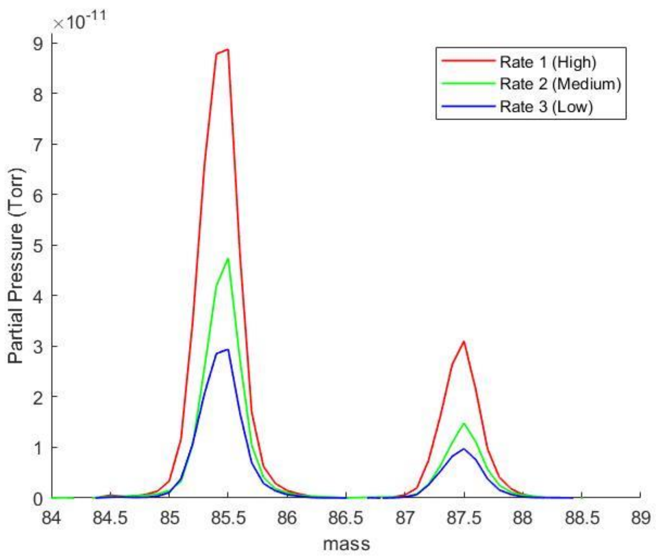
LEED of Rb(6×1)

Observed upon Rb deposition from 12 min on.

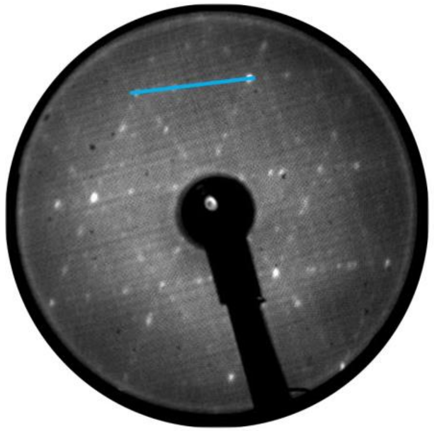
(7×7) Areas

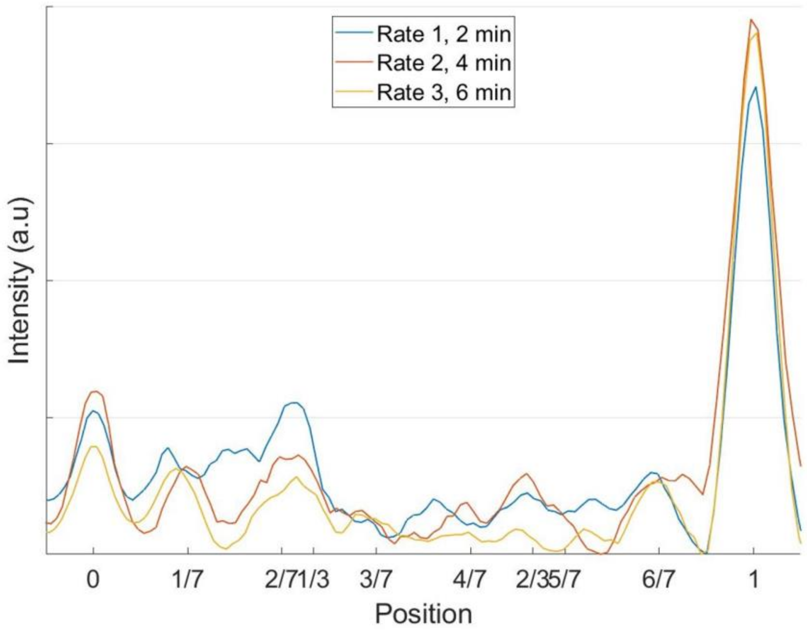


Rb/Si-(3×1): HT deposition – Deposition Rate



LEED





STM (3×1) areas: approximately 33% for all the three samples

- Not a critical parameter for the reconstruction

Conclusions

- A wide investigation on the interaction and induced reconstructions by Rb on the Si(111)-(7×7) surface has been reported. A better and more detailed understanding of the Rb/Si(111) system has been gained.

- Sample analysis via LEED allowed to **observe for the first time a Rb/Si-(6×1) reconstruction**.

- The use of STM allowed to obtain the **first real space characterization of the Rb/Si-(3×1) surface**.

Thanks for the attention !