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Jožef Stefan International Postgraduate School
and Young Researchers' Day CMBO

19 and 20 April

Supervising nano-construction:

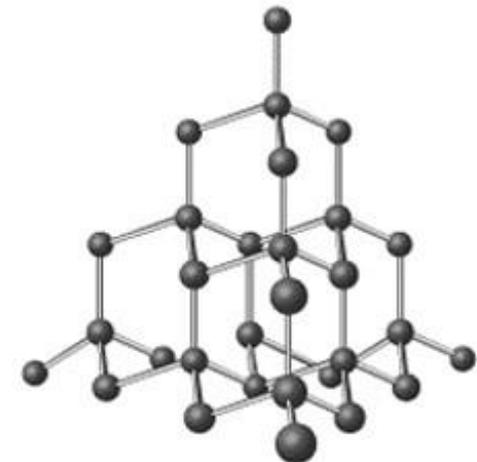
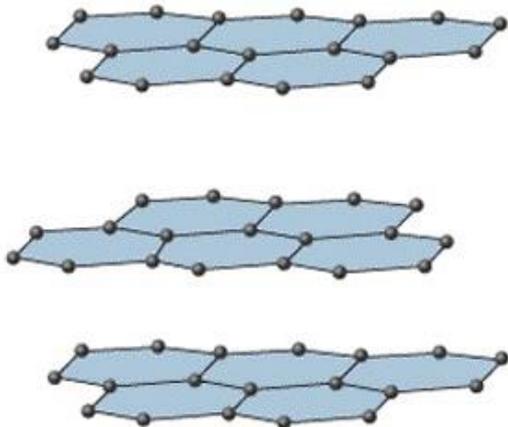
Local structural studies of Sr-buffered Si surface
prepared with Pulsed Laser Deposition

Tjaša Parkelj^{1,2}

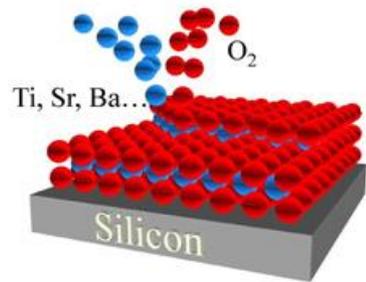
¹Jožef Stefan International Postgraduate School

²Advanced Materials Department, Jožef Stefan Institute

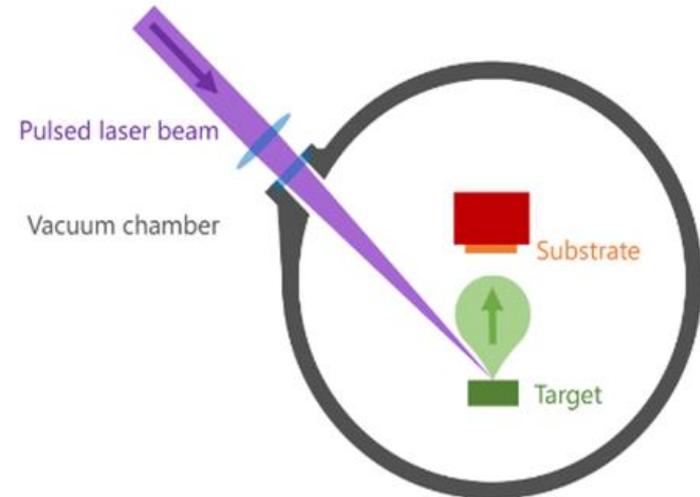
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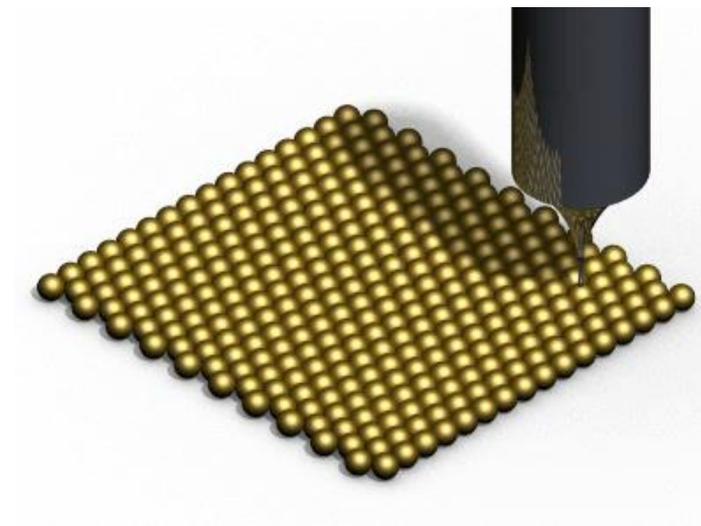
Functional oxides

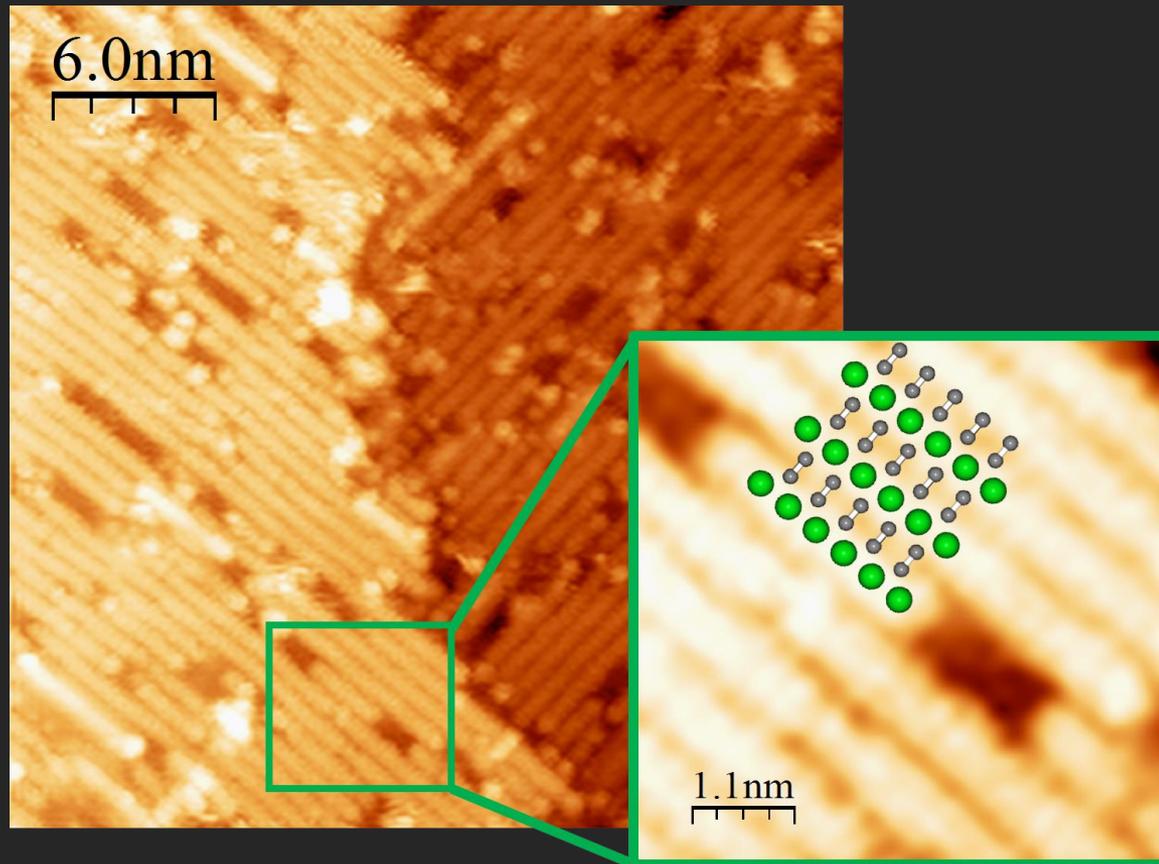


Pulsed Laser Deposition



Nano-structure supervisor: Scanning Tunneling Microscopy





You can find me by
the poster number

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Local structural studies of Sr-buffered Si surface prepared with pulsed laser deposition



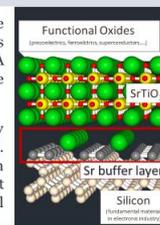
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MOTIVATION

A successful integration of **functional oxides** on **silicon (Si)** could lead to the design of a wide variety of novel microelectronic devices. However, a clean Si surface is **highly reactive** and forms an amorphous silicate layer in the presence of oxygen, thus disrupting epitaxial growth of oxides. A buffer layer based on $\frac{1}{2}$ **monolayer of strontium (Sr)** on Si is known to passivate the Si surface and is structurally compatible with the oxide films^{1,2}.

While the Sr buffer layer has been conventionally fabricated using **Molecular Beam Epitaxy (MBE)**, one of the most promising alternative techniques is **Pulsed Laser Deposition (PLD)**. The main advantages offered by PLD are stoichiometric transfer of material and tunable growth rates. Numerous studies of MBE-derived surfaces on Si can be found in the literature, but to the best of our knowledge, the Sr buffered Si prepared using PLD has not been characterized on the local level yet despite its importance in epitaxial integration of oxides.



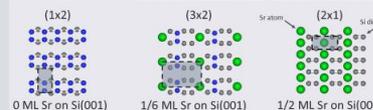
Our aim was to grow the Sr-buffer layer on Si(001) surface by PLD method and to evaluate the surface quality by studying its morphology and local structural properties.

METHODS

1. Removal of native SiO₂ layer from Si surface by high-temperature annealing (1200°C) in Ultra-High Vacuum (UHV) environment (2x10⁻⁹ mbar).
2. Growth of $\frac{1}{2}$ monolayer of Sr on Si(001) at 700°C by PLD.
3. In-situ monitoring of surface reconstruction during growth by Reflection High-Energy Electron Diffraction (RHEED) to control Sr coverage.
4. Transfer of prepared samples to local probe system using a UHV suitcase.
5. Control of surface structure quality after transfer by Low-Energy Electron Diffraction (LEED).
6. Local structural analysis using Scanning Tunneling Microscopy (STM).



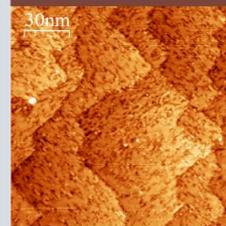
CONTROL OF THE Sr COVERAGE



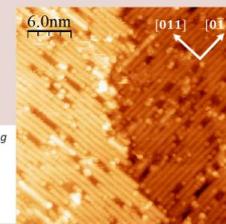
RHEED images of the Si surface reconstructions changing with the increasing Sr coverage.

- References:
1. M. Kuzmin, et al., *Surf. Sci.*, **2015**, 646, 140-145.
 2. C. J. Forst, et al., *Nature*, **2004**, 427, 53-56.

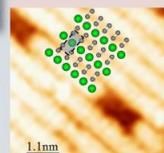
RESULTS OF STM ANALYSIS



- Terraces separated by single-atomic steps due to the miscut of the Si substrate.
- The entire surface is reconstructed and exhibits equivalent 90°-rotated domains on neighboring terraces.



- One-dimensional (1D) chains run along two perpendicular directions on neighboring terraces.
- The vacancies along the 1D chains correspond to missing Sr atoms and appear as depressions.



These images agree well with a model for the Sr/Si(001) (2x1) surface proposed by Kuzmin et al¹:

- The backbone of the (2x1) structure is produced by Si dimer rows. The Sr atoms sit in-between these dimer rows. Each Sr atom has two s electrons that donate the valence charge to the dangling bonds of neighboring Si atoms.
- In the filled electron state STM image the tunneling current is related to the Si dangling bonds participating in bonding with Sr atoms.

CONCLUSIONS

- This study represents the first local structural analysis of a PLD prepared Sr-buffered Si surface.
- The structural features of the PLD grown Sr-buffer layer are analog to MBE prepared surfaces.
- PLD can be used for the growth of a high quality buffer layers necessary for achieving epitaxial growth of complex oxides on silicon surfaces.