Supervising nano-construction:
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 Zn monolayer of strontium (Sr) on Si is known to passivate the Si surface and is structurally compatible with the oxide films. 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-buffered 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 (1300°C) in UHV-High Vacuum (UHV) environment (2x10^-8 mbar).
2. Growth of ½ 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 system.

RESULTS OF STM ANALYSIS

- Terraces supported 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 (1×2) chains run along two perpendicular directions on neighboring terraces.
- The vacancies along the 1×2 chains correspond to missing Sr atoms and appear as depressions.
- These images agree well with a model for the Sr(001) (2×1) surface proposed by Kämäräinen et al.
  - The backbone of the (2×1) structure is produced by Si dimer rows. Each Si atom is in between these dimer rows, each Sr atom has two 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-buffered 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.