Surface Nanoripples Formation in SnTe(001)/CdTe(001)//GaAs(001) Topological Crystalline Insulator Heterostructure: a Brief Review of Selected Possible Models*

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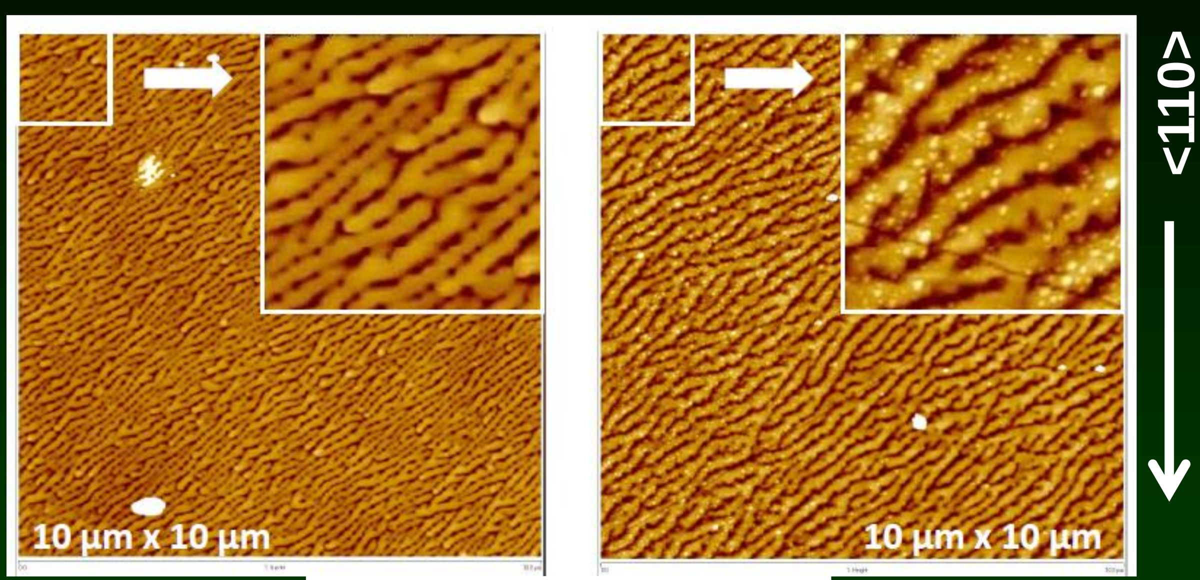
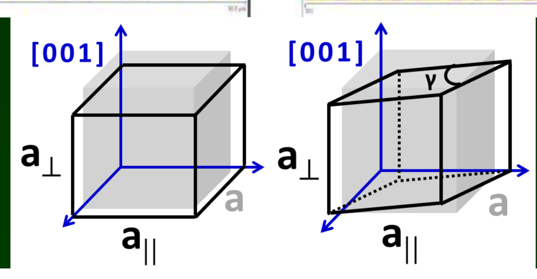
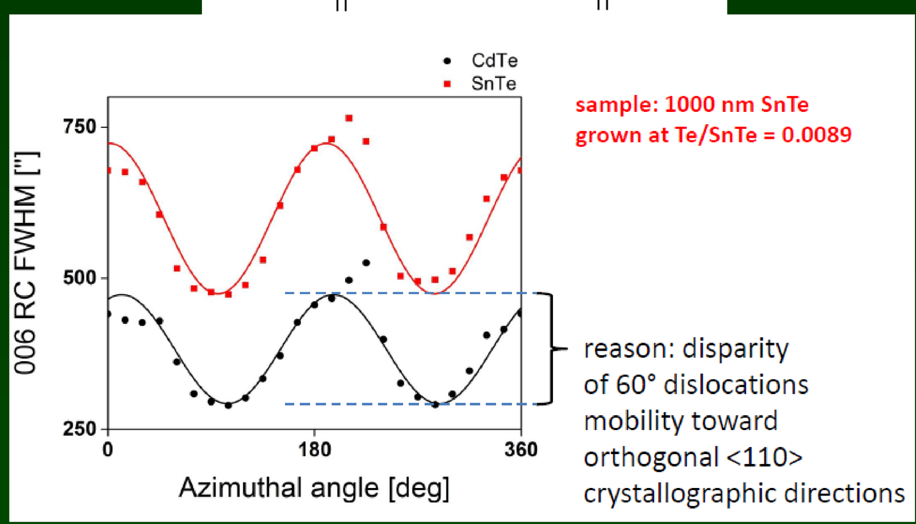
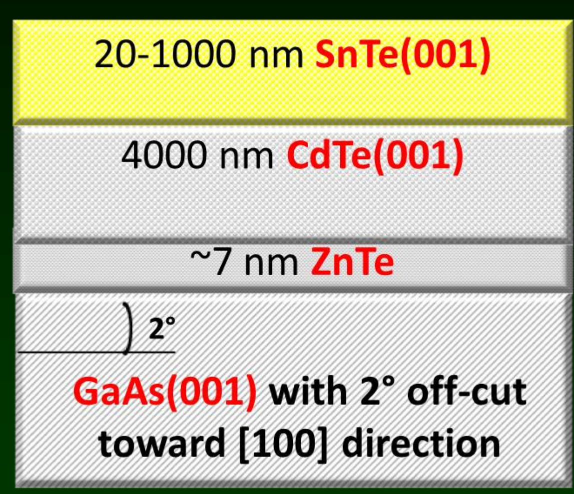


tetragonal distortion



monoclinic distortion





Investigated heterostructure with SnTe layer at its top is a promising material for spintronic devices due to the fact that it has topological electron states, protected by crystal symmetries. Thus, it is important to control its crystallographic quality as well as surface morphology.

Molecular beam epitaxial growth of such heterostructures leads to formation of surface nanoripple-like structures, visible in the atomic-force-microscopy images.
The detailed mechanism of this process is still unknown. Numerous models of it, based on literature concerning related tin telluride-based and other materials, can be proposed. Below, some selected models are presented.

High resolution X-ray diffraction and atomic force microscopy data enable to propose a working hypothesis for our samples.

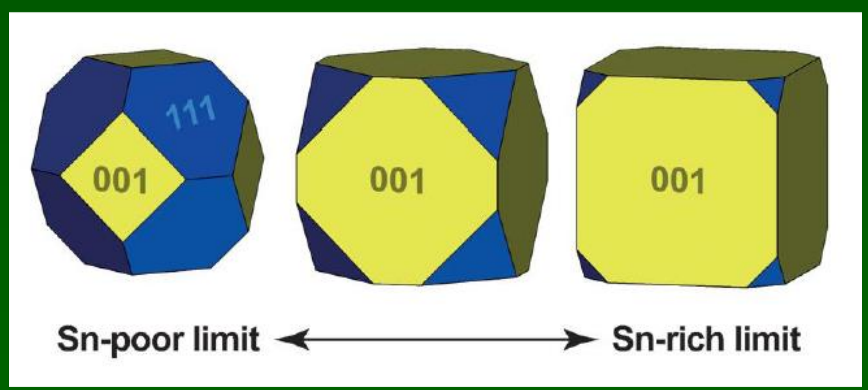
Firstly, we detected anisotropy of azimuthal defects' distribution in cadmium telluride buffer, mapped by tin telluride layer. It is caused by a disparity of sixty-degree dislocations mobility toward orthogonal 110 crystallographic directions.
This anisotropy can be quite large what results in a monoclinic distortion of tin telluride unit cell, observed in some investigated samples. Other, less distorted samples exhibits tetragonal tin telluride.

Secondly, we have observed a correlation between a surface nanostructures' size and the tin telluride unit cell distortion type. For the tetragonal one the nano-ripples are significantly narrower than for the second one.

Our observations suggest that the tin telluride surface nano-ripples formation is strongly influenced by the relaxation processes in mismatched layers and by the spatial distribution of extended defects in the topological insulator layer.

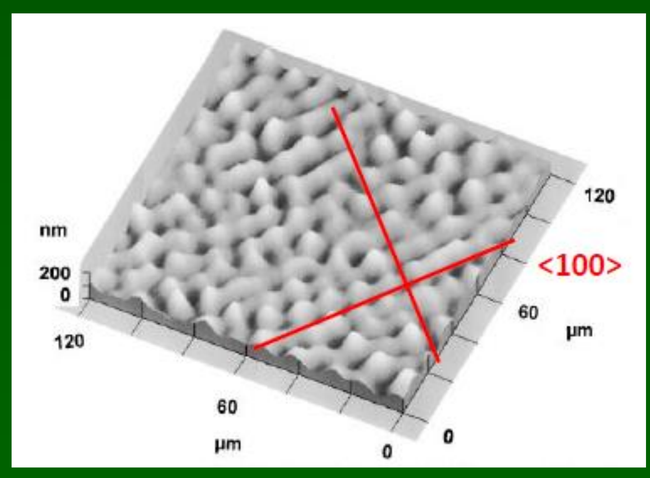
Models proposed in literature for possible mechanisms of the surface nanoripples' formation

Termodynamics-driven mechanism: equilibrium shape of a crystal surface, energetically favoured in given growth conditions



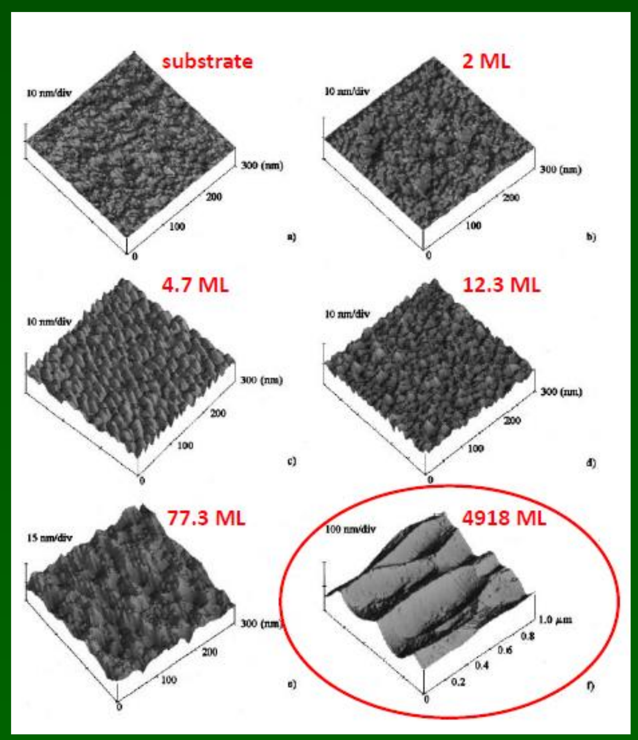
Deringer, Volker L. and Richard Dronskowski, ChemPhysChem 14.13 (2013): 3108-3111.

Kinetics-driven mechanism: local improvement of a growth rate of a layer above the dislocations*



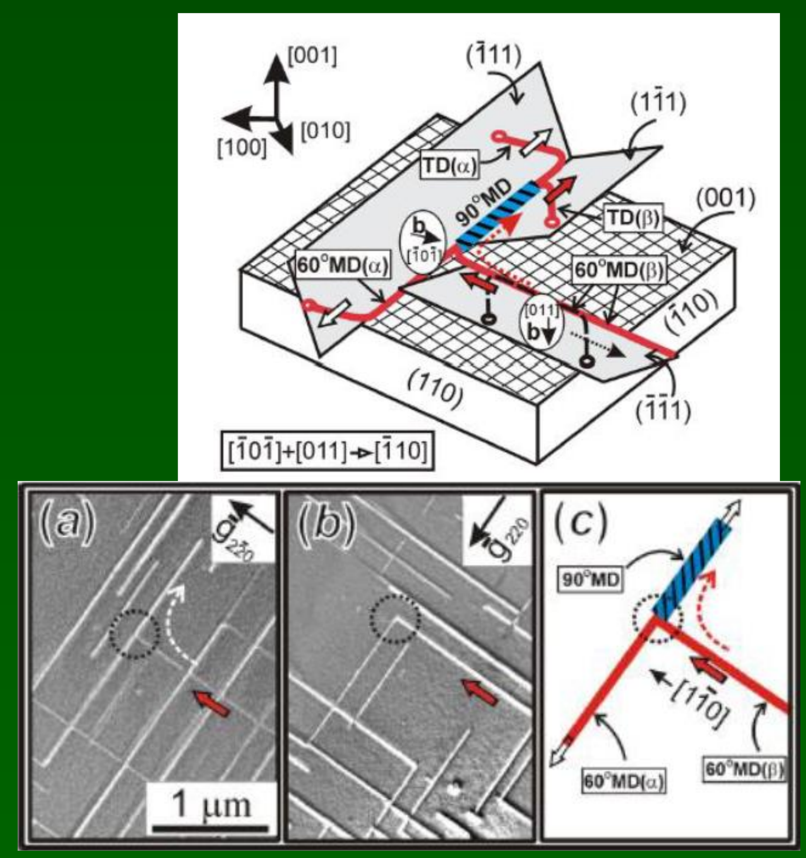
Albrecht, M., et al., Appl. Phys. Lett. 67.9 (1995): 1232-1234.

Growth-mode-driven mechanisms: switching of 2D-3D growth modes as the layer's strain is relieved*



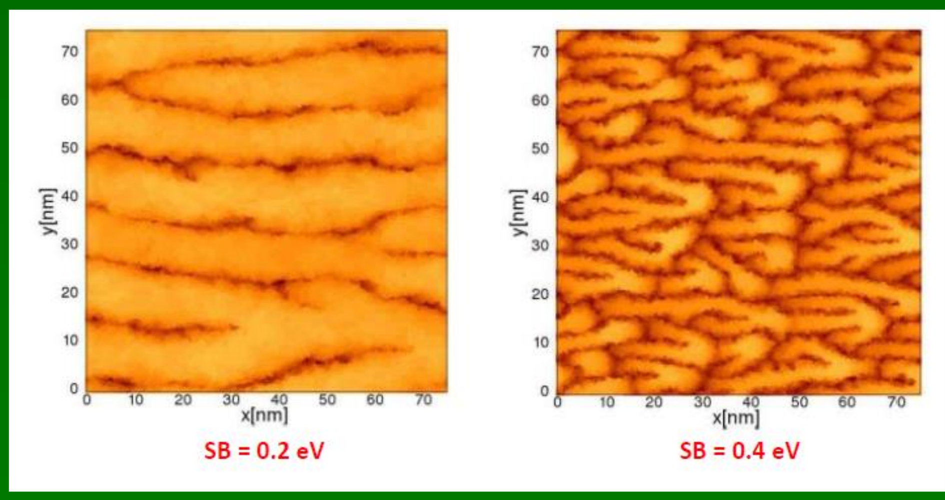
Longo, M., et al., J. Vac. Sci. Technol. B 16.5 (1998): 2650-2655.

Dislocations-driven mechanisms: various types of reactions of 60° dislocations



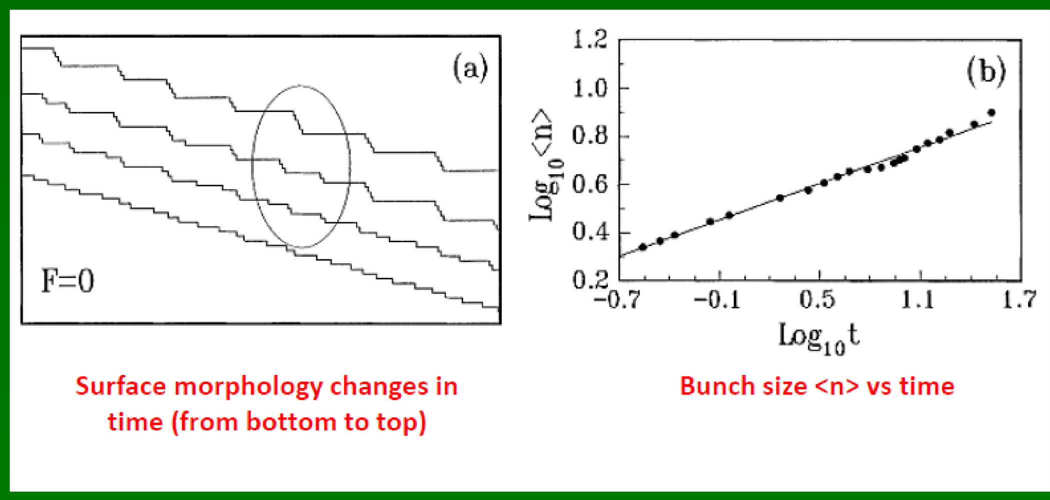
Bolkhovityanov, Yu B., et al., J. Appl. Phys. 109.12 (2011): 123519.

Diffusion-driven mechanism: meandering process, driven by diffusion and Schwöbel barrier*



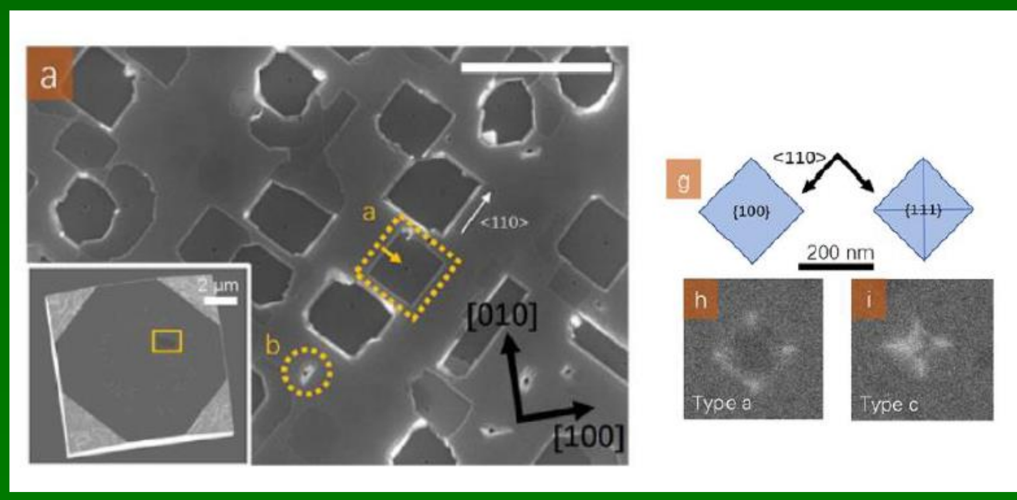
F. Krzyżewski, et al., 47th "Jaszowiec" Conference, 2018, contributed lecture.

Growth-mode-driven mechanisms: step-bunching*



Tersoff, J., et al., Phys. Rev. Lett. 75.14 (1995): 2730.

Dislocations-driven mechanisms: surface pits creation, migration and coalescence



Liu, Pengzi, et al., J Phys Chem Solids 128 (2019): 351-359.

*Red shapes and fonts represent own modifications added to the original figures.

Summary

- **Literature**: there are various physical factors potentially involved in the nano-ripples formation in SnTe layer;
- **Our results**: the real mechanism is probably complex, with a significant contribution of relaxation processes;
- **Prospects**: an extended overview of the models proposed in literature to explain the origin of the surface nano-ripples could be an interesting topic for a review work.