Epitaxial Rules for van der Waals Epitaxy from $(GeTe)_m(Sb_2Te_3)_n$ Phase Change Material Alloys

F. Arciprete[1,2*], J. E. Boschker[2,3], S. Cecchi[2,4], E. Zallo[2,5], V. Bragaglia[2,6], F. Righi Riva[1], S. Prili[1], and R. Calarco[2,7].
*lead presenter: fabrizio.arciprete@roma2.infn.it
1 Department of Physics, University of Rome Tor Vergata, Italy
2 Paul-Drude-Institut für Festkörperelektronik, Berlin, Germany
3 Present address: Ferdinand-Braun-Institut gGmbH, Berlin, Germany
4 Present address: Department of Materials Science, University of Milano-Bicocca, Italy
5 Present address: Walter Schottky Institut and Physik Department, Technische Universität München, Germany
6 Present address: IBM Research, Zürich, Switzerland
7 Present address: Istituto per la Microelettronica e Microsistemi (IMM), Consiglio Nazionale delle Ricerche (CNR), Rome, Italy

van der Waals (vdW) epitaxy represents a powerful way for growing heterostructures made of stacked sequences of two-dimensional (2D) crystals, potentially exhibiting new phenomena and peculiar properties.

In this study we aim at identifying the key parameters to predict the interaction between 2D layered materials and the substrate surface. In particular, we present the case of $(GeTe)_m(Sb_2Te_3)_n$ (GST) layered materials on InAs(111). GST alloy is a key Phase Change Material, widely studied for its cutting-edge technological applications. It is a prominent material for phase change memories, and, very recently, it has attracted new interest as the most advanced emerging non-volatile memory technology for neuromorphic applications [1,2]. In the GST/InAs(111) system the substrate can be efficiently prepared into self- and un-passivated surfaces to clarify the role of the surface interaction. Furthermore low-lattice mismatch conditions are fulfilled. Those are necessary to avoid relaxation due to formation of misfit dislocations and allow to correctly identify vdW epitaxy. It is known that GST exhibits two different highly ordered 2D structures and a three-dimensional disordered structure, allowing to directly infer the nature of the epitaxy. We will give evidence of the key role played by the substrate surface in vdW epitaxy. We will show that substrate symmetry influences the symmetry of the growing film and we will give indications for which vdW epitaxy can be fully achieved [3,4]. Our study paves the way for mastering and design of vdW epitaxial growth of 2D heterostructures as well as hybrid 2D and non-layered materials.

This project has received funding from the European Union's Horizon 2020 research and innovation program under Grant Agreement No. 824957 (“BeforeHand:” Boosting Performance of Phase Change Devices by Hetero- and Nanostructure Material Design).

References

[1] A. Sebastian, M. Le Gallo, G. W. Burr, S. Kim, M. BrightSky, and E. Eleftheriou. Tutorial: Brain-inspired computing using phase-change memory devices. J. Appl. Phys. 2018;124;111101.
[2] W. Zhang, R. Mazzarello, M. Wuttig, and E. Ma, Designing crystallization in phase-change materials for universal memory and neuro-inspired computing, Nat. Rev. Mater. 2019;4;150.
[3] F. Arciprete, J. E. Boschker, S. Cecchi, E. Zallo, V. Bragaglia, and R. Calarco. Hints for a General Understanding of the Epitaxial Rules for van der Waals Epitaxy from Ge-Sb-Te Alloys. Adv. Mater. Interfaces 2022;9;2101556.
[4] V. Bragaglia, F. Arciprete, A. M. Mio, and R. Calarco. Designing epitaxial GeSbTe alloys by tuning the phase, the composition, and the vacancy ordering. J. Appl. Phys. 2018;123;215304.