Exploiting the annealing effect of thin germanium film: interplay between crystallization and dewetting

Sonia Freddi[a,*], Michele Gherardi[b], Dominique Chatain[c], Gianfranco Sfuncia[d], Giuseppe Nicotra[d], Mohammed Bouabdellaoui[e,f], Nicoletta Granchi[g], Francesca Intonti[g], Maria Antonietta Vincenti[h], Alexey Fedorov[a], Marco Abbarchi[e,f], Monica Bollani[a]

[a] *Institute of Photonics and Nanotechnology (IFN) – CNR, LNESS, Como, 22100, Italy*
[b] *Department of Physics, Politecnico di Milano, Milan, 20133, Italy*
[c] *Aix-Marseille Univ, CNRS, CINaM, 13009 Marseille, France*
[d] *Istituto per la microelettronica e microsistemi (IMM) -CNR, Catania, Italy*
[e] *Aix Marseille Univ, Université de Toulon, CNRS, IM2NP Marseille, France*
[f] *Solnil, 95 Rue de la République, Marseille, 13002, France*
[g] *LENS and Department of Physics and Astronomy, University of Florence, Italy*
[h] *Department of Information Engineering, University of Brescia, Brescia, Italy*

Corresponding author email: sonia.freddi@ifn.cnr.it

Thin solid films are usually metastable in the as-deposited state, and, when heated at high temperature, they will agglomerate to form islands. Indeed, during thermal treatment, the thin film evolves forming at first holes, which will favor the rupture of the film, by a process known as solid state dewetting (SSD). Isolated droplets can then grow from the film breaking [1,2]. Dewetted films can be exploited in several applications: flexible photonics [3], photocatalysis [4] or dielectric Mie resonator [5]. Among the dewetting systems reported in the literature, ultra-thin crystalline silicon-on-insulator films have been largely studied and they have been considered as a model system for investigating and studying SSD. More recently, SiGe dewetting, i.e. SiGe structures directly formed on an electrically insulating and optically transparent substrate, has been efficiently exploited to realize arrays of nanostructures with size ranging from few nm up to several μm [6]. Germanium is a material of particular interest for photonic devices working at near and mid-infrared frequency. Therefore, the study and validation of a low-cost processing of Ge-based film, such as SSD, is of considerable interest for these applications. In this work [7] we studied the dewetting process of a Ge-based thin film upon annealing, highlighting the morphological and structural properties of the dewetted islands, exploiting a combination of different techniques. Beyond fundamental understanding of the Ge dewetting process, these results are relevant for the fabrication of large-scale masters for nanoimprinting lithography and novel photonic platforms. Few applications of the dewetted islands will be presented.

References

[1] F. Leroy et al., *Surface Science Reports* 2016, 71, 2, 391-409.

[2] M. Naffouti et al., *Science Advances* 2017, 3, 11, eaao1472.

[3] A. Benali et al., *J. Phys.: Photonics* 2020, 2, 015002.

[4] M. Altomare et al., *Chem Sci* 2016, 7(12), 6865-6886.

[5] N. Granchi et al., *Opt Express* 2023, 31, 5, 9007.

[6] M. Bollani, et al., *Nature Communication* 2019, 10, 5632.

[7] S. Freddi et al., *Materials Science in Semiconductor Processing* 2024, 174, 108228.

Acknowledgements

This work is supported by the PNRR project NQSTI - Spoke_7_National_Quantum Science and Technology, by the CNR “EPOCALE” project (2022-2024), and by the PRIN PNRR 2022 “ACONITE” grant n° P2022HRTYH (2023-2025).

Travel expenses to participate at ‘NanoSEA 2024’ are partially covered by the ‘Travel Award 2024’ grant sponsored by the open access journal Nanomaterials published by MDPI.