A mathematical equation that explains the behavior of nanofoams

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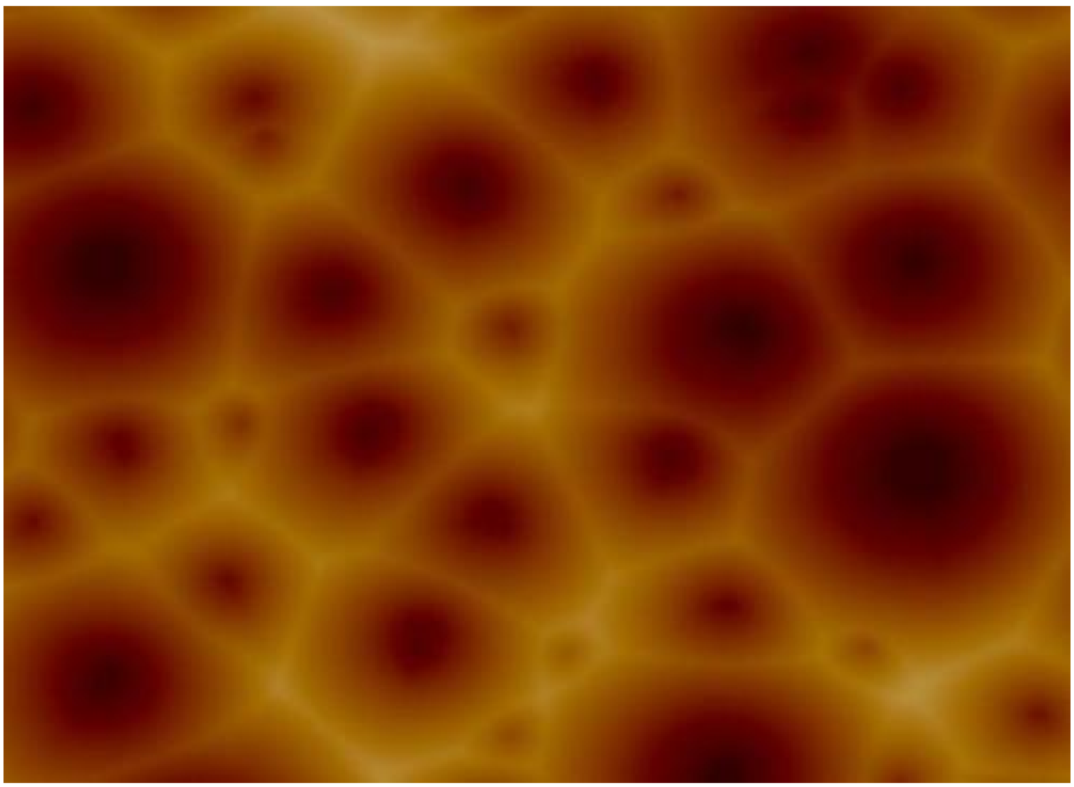

This is nanofoam. Credit: UC3M

A research study, participated in by Universidad Carlos III de Madrid (UC3M), has discovered that nanometric-size foam structures follow the same universal laws as does soap lather: small bubbles disappear in favor of the larger ones.

The scientific team, made up of researchers from the Consejo Superior de Investigaciones Científicas (Spanish National Research Council) - CSIC, the Universidad Pontificia Comillas de Madrid- UPCO, and UC3M, reached this conclusion after producing and characterizing nanofoam formed by ion radiation on a silicon surface. This study, recently published in the journal, *Physical Review Letters*, describes the evolution of these nanostructures during the time of irradiation.

For this purpose, the scientists carried out an experiment that consisted in "bombardment" of a small silicon plate with energetic particles from a plasma. The objective was to observe how the surface of this crystal reacted to these different "attacks" from this type of ion radiation (ions are used: atoms of a gas that have lost an electron). "At the outset, we were studying other methods of erosion and looking for a rippled structure at the edge of our sample after applying this technique, but when we looked at its center we observed a cellular structure that got our attention because of its similarity to many other natural and artificial systems," one of the authors of the study, Mario Castro, UPCO Professor, revealed.

Cellular structures that are more or less disordered can be found in many natural systems: from the hides of animals, such as a giraffe, to bath froth or beer foam, to microscopic fluid convection, basalt column landscapes or diverse crystalline materials. This particular order is also evident in artificial structures and even political ones, such as modern architecture or demarcation of provinces on maps.

"It is of interest to confirm that the same universal laws which regulate the cellular structures in other systems are also regulating at the nanoscale," Rodolfo Cuerno from the UC3M Mathematics Department noted. "Furthermore," he added "it is the first time that the evolution of a system of this kind is reproduced quite well by a single differential equation," which also is applied to other systems. The validity of the model in this study means that the formation of certain self-organized patterns and the dynamics of the foam would be different manifestations of a same principle.

"The results of this study help us to understand how certain material systems evolve in the presence of an external agent, as in this case of ion radiation. In addition, there exists interest of a practical nature because of the importance of the technological applications of silicon as well as for the nanometric dimensions in which the phenomenon unfolds," explained Luis Vázquez, from the Instituto de Ciencia de Materiales (Materials Science Institute) de Madrid at the CSIC.

The experimental observations have been carried out using an atomic force microscope, a machine with great precision. This type of microscope has enormous spatial resolution: it distinguishes variations in height up to a nanometer (the millionth part of a millimeter) and movements on a horizontal plane of up to 10 nanometers.

This research could have further future applications, since in general, methods are being sought to produce structures with nanometric dimensions for diverse uses, according to the scientists: for example, in order to obtain favorable conditions in certain catalytic chemical reactions, to optimize displacement of fluids in circuits on such small scale or in optoelectronics, to generate laser light if certain structures are sufficiently ordered.

More information: Pattern-Wavelength Coarsening from Topological Dynamics in Silicon Nanofoams, M. Castro, R. Cuerno, M. M. García-Hernández y L. Vázquez, *Physical Review Letters* 112, 094103. Published March 7, 2014. DOI: 10.1103/PhysRevLett.112.094103

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