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Self-organized surface nanopatterns induced on silicon by low-energy ion-beam irradiation

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Self-organized surface nanopatterns induced by ion-beam irradiation were firstly observed in the early 60's but it was not until the late 90's when the field gained further attention. Since then, this intriguing process has been successfully reported in a broad variety of materials ranging from metals, semiconductors or insulators where, typically, mound, pit or ripple nanostructures are produced in rather short processing times and over relatively large areas. This 'universal behavior' has also been inspired by macroscopic analogies such as the formation of sandy dunes. However, despite the intense research, the underlying mechanisms are still under debate, especially for the particular case of amorphous or amorphizable materials (i.e., excluding metals). In this niche, silicon is the most studied material due to its paradigmatic character and technological relevance. Here, the unclear situation has been partially motivated by controversial findings and lack of reproducibility. However, the scenario has recently changed since the elucidation of the critical role played by concurrent (metal) impurities and the eventual emergence of phase-separation (due to silicide formation). Hence, under impurity-free conditions, irradiations above a certain critical incidence angle (~45º) are required to effectively induce (ripple) nanopatterns. On the contrary, metal-assisted irradiation extends the processing window (lowering or eradicating the need of a critical angle) and introduces a novel parameter for pattern designing. Compositional driven mechanisms may also have broader implications since they have also been observed in nanopatterning compound semiconductors. This paper will present a brief historical overview in the field of ion-beam nanopatterning followed by the most recent theoretical and experimental findings, with a special mainline on silicon surfaces. Finally, some of the approaches in the quest for potential applications will also be highlighted.

Keywords
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