Experimental study of craters induced under gold cluster ions

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Abstract

The study of energetic particle (cluster) impact on solid surfaces has garnered significant attention due to its ability to induce various intriguing phenomena, some of which are not yet fully comprehended. These phenomena encompass surface erosion (involving sputtering and the formation of craters) as well as implantation. Among these phenomena, the investigation of crater formation holds particular significance in the realms of space science, material modifications, surface analysis [1], and various technological applications [2].

To validate our theoretical model [3] elucidating the mechanism behind crater formation, we conducted an experimental study at the Andromede facility in France [4]. This study involved subjecting thin gold samples to individual impacts from 1.5 and 3 MeV gold clusters with an ions fluence of approximately 108 ions/cm2. These thin gold layers were deposited on silicon wafers using a magnetron sputtering process, with thicknesses ranging from 4, 20, to 40 nm.

Subsequently, we employed Atomic Force Microscopy (AFM) measurements using the NX20 Park System to analyze the irradiated samples. Our examination of the gold-irradiated samples unveiled the presence of two distinct types of surface erosion defects: simple and complex craters, with some exhibiting centrally positioned hillocks while others had laterally positioned ones. We utilized different cluster sizes in this experiment, including Au_{150}, Au_{400}, and Au_{700} clusters, and proceeded to compare the results.

The experimental data we collected included excavated atoms from the craters, crater depth, radius, aspect ratio of the craters, and crater volume. We then compared these experimental findings to the values for crater depth, radius, and volume calculated using our theoretical model.

Key words: Cluster ion, Crater, High velocity cluster impact, Theoretical approach, shock wave.

References:
[1]: Christian Anders, Eduardo M. Bringa, Fabricio D. Fioretti, Gerolf Ziegenhain, and Herbert M. Urbassek, Phys. Rev. B 85, 235440 (2012).
[2]: I. Yamada, J. Matsuo, Z. Insepov, T. Aoki, T. Seki, and N. Toyoda, Nucl. Instrum. Methods Phys. Res., Sect. B 164– 165, 944 (2000).
[3]: S. Gouasmia, M. Benguerba, Nuclear Inst. and Methods in Physics Research B 447 (2019) 43-49.
[4]: Thanh Loan Lai, Dominique Jacquet, Isabelle Ribaud, Michael John Eller, Dmitriy Verkhoturov, Emile Albert Schweikert, Luiz Henrique Galvão Tizei, Fuhui Shao, Suheyla Bilgen, Bruno Mercier, Gael Sattonnay, and Serge Della Negra, Journal of Vacuum Science & Technology B 38, 044008 (2020).