Highlights

RESEARCH AREA 2 - Functional and Complex Materials for Innovative Electronics and Sensing - 2023

Laser-induced periodic surface structuring for secondary electron yield reduction of copper: dependence on ambient gas and wavelength

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APPLIED SURFACE SCIENCE

One of the main limitations for future high-performance accelerators operating with positively charged particles is the formation of an electron-cloud inside the beam vacuum chamber, giving rise to instabilities. The Secondary Electron Yield (SEY) of the beam-facing surfaces gives a measure of the mechanism which drives this phenomenon. The laser-induced periodic structure formation on Cu surfaces has been demonstrated as a promising process to reduce SEY. We studied the laser process influence on SEY for 515 and 1030 nm wavelength femtosecond pulses on copper in different ambiences (air, nitrogen, vacuum). Depending on used process conditions, the surface composition differs, structures with varying aspect ratio are formed, i.e., periodic ripples and large-scale channels. Treatment in air at 515 nm is the most efficient for the formation of deeper structures allowing SEY maximum reduction first down to 1.6–1.7 and then below unity upon electron irradiation, thereby totally suppressing electron-cloud. Increasing the laser fluence, SEY will further reduce due to surface roughness enhancement via nanoparticle re-deposition. This study reveals the crucial role of laser induced periodic surface structures (LIPSS) treatments to enable surface treatment in large-scale accelerator installations, where particle-free components are desired, and paves the way to potential future applications.

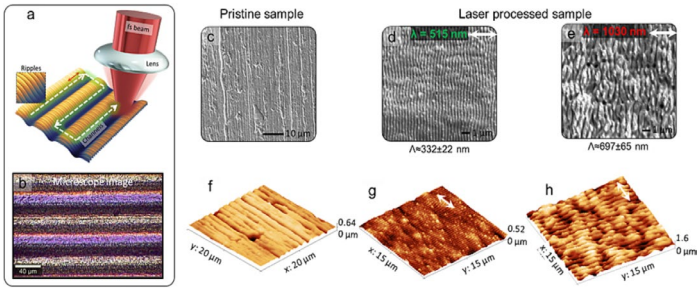

Fig. 1: (a) Graphical representation of the structural surface changes induced by the implemented laser treatment, (b) optical micrograph of a Cu sample processed at sample scanning velocity v=1 mm/s with 515 nm fs pulses. SEM images of the copper surface before laser processing (c), after irradiation in ambient air and v=1 mm/s with at 515 nm (d) and 1030 nm (e). AFM images of the copper surface before (f) and after laser processing at 515 nm (g) and 1030 nm (h).

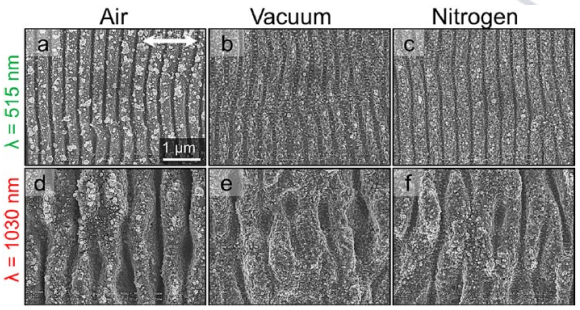

Fig. 2: SEM images of LIPSS generated with two different laser wavelengths (515 and 1030 nm) in three different environments (air, vacuum, and nitrogen ambience) at v=1.5 mm/s. The white double-headed arrow in (a) indicates the laser beam polarization direction.

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