A Universal Process for Reducing Secondary Electron Yield

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Laser Engineered Surface Structures (LESS) are a material independent method to reduce the secondary electron yield (SEY) of a surface. SEY is the ratio of secondary electrons emitted to the number of primary electrons incident upon a surface. When high SEY surfaces are exposed to high energy electrons, e.g. in particle accelerators, it can cause damage from electron clouds, surface charging, heating and multipactor events [1].

It is well known that high aspect ratio surface features reduce SEY, as it allows emitted electrons to be re-absorbed [2]. LESS processing uses sub 10 picosecond laser pulses to remove material through ablation. This creates a nested structure of micro-scale trenches coated in a dense, 'cragged' nanostructure. Numerical modelling of surface profiles from real processed samples demonstrates that SEY reduction is primarily from this topographic change, particularly the nanostructure. Its formation is dependent on operating in the two-temperature regime ensuring ablation and minimising melting. Here we show that LESS processing can reduce the SEY of any material capable of being ablated by a pulsed laser.

We have experimentally demonstrated these structures on both metals and ceramics (copper and alumina), both materials commonly exposed to high energy electrons. This has been done with a variety of pulse lengths, pulse energies, wavelengths, scan speeds and spot sizes. Notably this shows we can produce SEY reducing nested structures in materials with different chemistry and light matter interactions. These parameters can be optimized for minimal SEY or for a compromise with other important parameters such as surface resistance or processing time. Measurements on samples in Fig. 1 show LESS created a dramatic decrease in SEY of Al_2O_3 from a maximum of 8.63 to 1.74 and of copper from 2.33 to 1.17. Our processing on copper is currently being applied for use in the LHC after passing vacuum and chemical stability testing [3].

LESS is therefore a highly flexible technique for SEY reduction that can applied to almost any material through ablation.

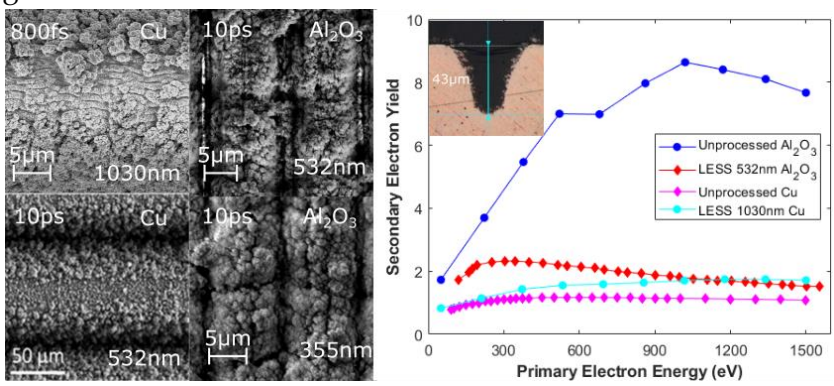

Fig. 1: SEM images of Cu and Al_2O_3 LESS processed samples with key laser parameters. The graph shows their SEY curves. The insert is a cross section from the 1030nm Cu sample.

Ref.: [1] P. Costa Pinto *et.al.* "Carbon coatings with low secondary electron yield" Vacuum **98**, (2013). [2] M. Ye *et.al.* "Suppression of secondary electron yield by micro-porous array structure" J. Appl. Phys. **113**, (2013). [3] S. Calatroni, *et.al.* "First accelerator test of vacuum components with laser-engineered surfaces for electron-cloud mitigation" Phys. Rev. Accel. Beams **20**, (2017).