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Investigation of copper conditioning and deconditioning processes for particle accelerators

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The electron cloud phenomenon is currently one of the main limitations to the operation of high intensity positively charged particle accelerators as the LHC. The Secondary Electron Yield (SEY) of the inner surface of the beam vacuum chamber steers the multiplication of primary electrons produced by both synchrotron radiation and ionization of residual gases. For several materials used in accelerator vacuum systems, the SEY decreases under electron bombardment and accelerators rely on this effect, called conditioning, to operate the beam in stable conditions. The understanding of the conditioning and deconditioning processes is essential to interpret the present LHC heat load to the cryogenic system and predict the LHC operation for future more intense beams.
To investigate these phenomena, chemically cleaned Cu OFE samples (material of the inner beam screen surface in the LHC arcs) were conditioned down to different SEY values in the lab, using an electron gun. The surface modifications induced by the electron bombardment were followed by X-Ray photoelectron spectroscopy. The results show Cu(OH)2 removal, vanishing of high binding energy components of the C1s line, and carbon graphitization. These samples were then stored in different atmospheres to study the impact of the environment on the deconditioning process: vacuum, desiccator, saturated vapour pressure of water. The results of SEY and surface chemistry evolution for different deconditioning atmospheres will be presented. In parallel, the fundamental mechanisms of the conditioning process are investigated on well characterized model surfaces of copper and the related results will be presented.

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