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# Understanding of mechanism of Cu reduction induced by photon beam in Cu thin films

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X-ray absorption spectroscopy is a technique that finds numerous applications in materials research providing key information for understanding the chemistry of investigated structures. Its high sensitivity is advantageous in study of thin films and nanostructures. Unfortunately, during investigation of nanoscale objects with XAS, artifacts can appear due to irradiation with intensive X-ray beam, such as evaporation of the film due to local heating [1] or reduction of effective charge of some elements [2,3]. Although often reported and effectively circumvented during regular measurements understanding these effects is still incomplete.

In XAS study we have observed that shape of L-edge of copper in thin films exposed to focused synchrotron beam shows a strong reduction in the intensity of Cu-II feature and increase in the intensity of spectral features corresponding to Cu-I and metallic copper (Figure 1). Our measurements showed that this effect is strongly associated with the intensity of photon beam, but can also depend on the film thickness, substrate, and morphology dependent on deposition method. On the other hand it seems to be independent from the energy of photon beam. As long as in the typical measurement procedure the signal is collected from the same spot for different elements/edges, this reduction effect will play significant role and can lead to misinterpretation of the results. Better understanding of the mechanism of Cu photoreduction shall help providing procedures for preventing or minimizing X-ray induced effects in XAS study of nanostructures.

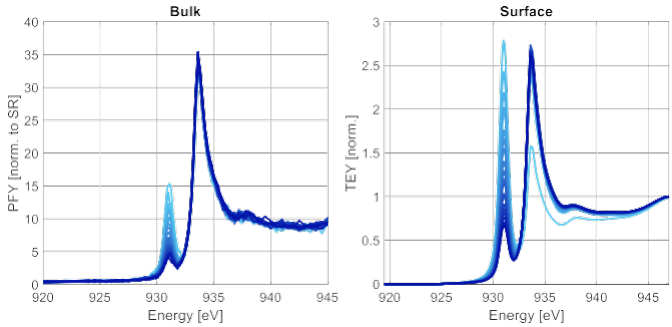


Figure 1. Consecutive Cu L3-edge spectra of thin film collected with FY (left) and TEY (right). Early scans (light blue) shows the spectral shape corresponding to high amount of Cu-II, opposite to the late ones (dark blue).

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**References**

1. E.L. Bright, et al., J. Synchrotron Rad. 28 (2021) 1377–1385.
2. L. Monico, et al., Anal. Chem. 92 (2020) 14164–14173.
3. F. Stellato, et al., Metallomics 11 (2019) 1401.