Enhanced Imaging of Nanoscale Changes in Alloy Chemistry

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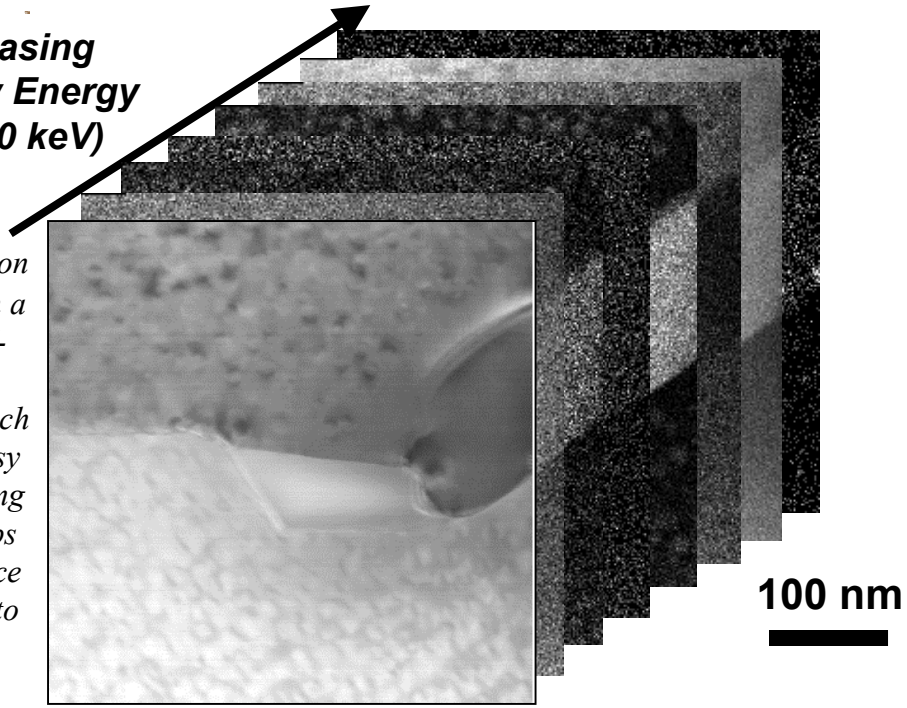
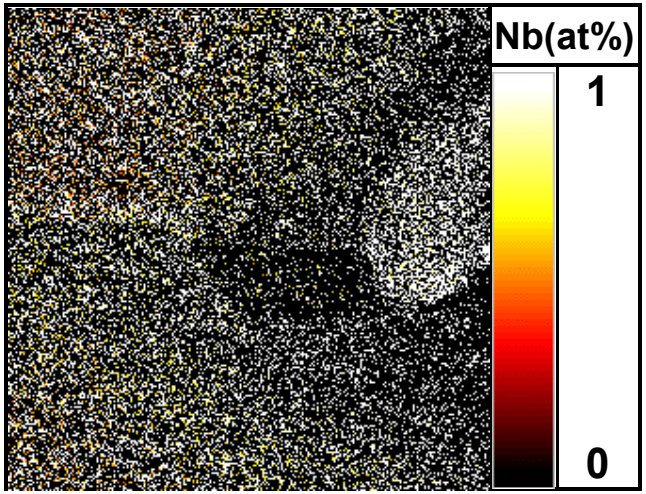


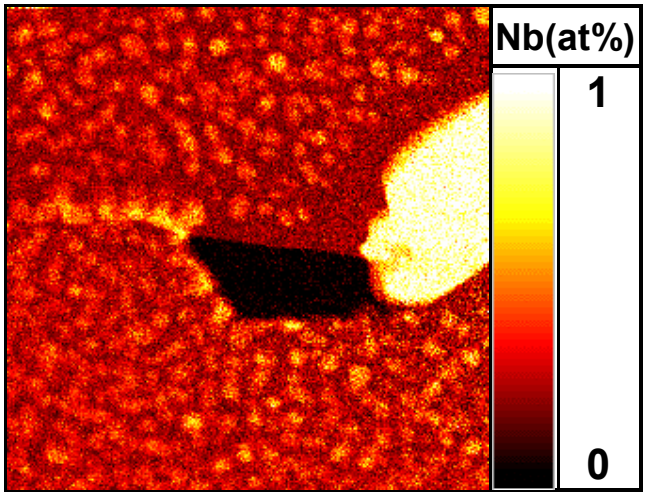
(a) *Electron image with a series of X-ray maps behind. Each map is noisy but summing all the maps can enhance the signal to noise*

(b) *A standard X-ray map of the Nb distribution is masked by the noise in the signal.* **(c)** *A quantitative Nb map produced by summing all the X-ray maps in* ***(a)*** *and removing the noise components, gives an enhanced image revealing the variation of Nb content in the particles.*



(b)

We are mapping the distribution of elements associated with defects in engineering alloys such as crystal (grain) boundaries. Small changes in local chemistry can transform otherwise ductile alloys into brittle, unsafe materials. X-ray mapping creates chemical images from elemental X-rays emitted when a high-energy (300 keV) beam strikes the specimen in an electron microscope. **(a)** is a high-magnification electron image of a Ni-base super-alloy showing nano-scale particles in the grains and coarser particles on the grain boundary. An X-ray map **(b)** created by collecting only Nb K X-rays of a specific energy is very noisy because of the small signal intensity (the maximum Nb concentration is 1 at. %). Use of new computer hardware permits the collection of an image at each X-ray energy (several are shown in **(a)**). New software permits removal of the noise from all these images resulting in enhanced signal collection and reduced-noise maps shown in **(c)**.



(c)