Protective Layer Formation during Oxidation of $Cu_3Au(100)$ using Hyperthermal O_2 Molecular Beam

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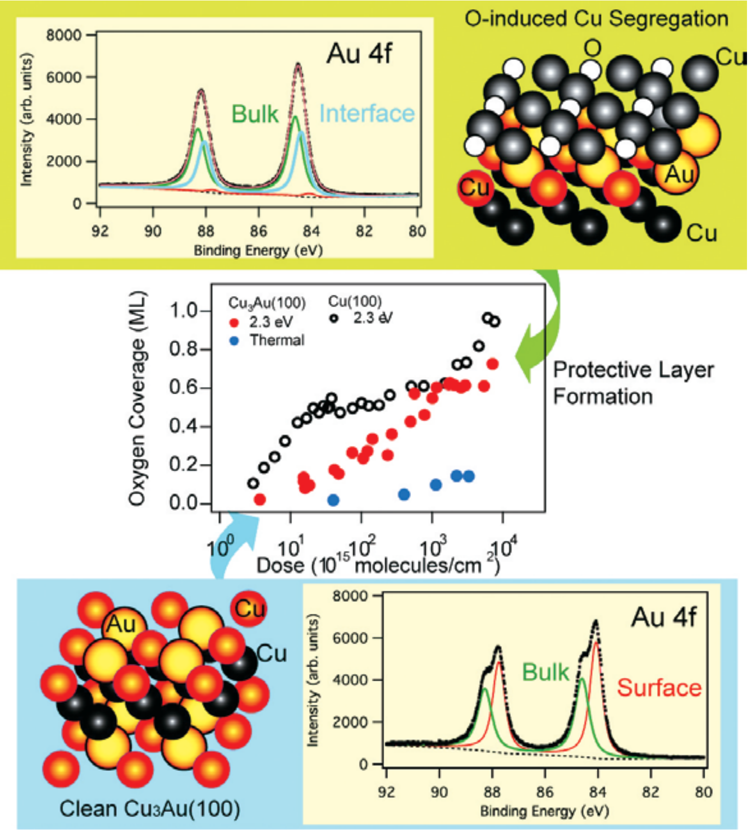
Corrosion wastes more than a few percent of the world's GDP. The initial stage of the corrosion is one of the central topics in material science. The oxidation is a major corrosion process of metals. The growth of a protective thin surface layer, which prevents further oxidation into bulk of a metal, requires the formation of a homogeneous film. One simple way for the protection of underlying metals is surface alloying, combining different substances to form multi-component surfaces.

We report results of our detailed studies on the initial oxidation process of Cu_3Au (100) with a hyperthermal O_2 molecular beam (HOMB) with varying its incident energy. From the O-uptake curves (middle of Figure), which were determined from a series of O-1s X-ray photo-emission spectroscopy (XPS) measurements in conjunction with synchrotron radiation (SR), it was found that the dissociative sticking probability of O_2 is much lower on Cu_3Au than on Cu. Low-energy electron diffraction (LEED) observations and surface core-level shift (SCLS) measurements suggest that the dissociative adsorption of O_2 occurs accompanied with the Cu segregation on the surface. No obvious growth of Cu_2O was observed even for the prolonged doses of 2.3 eV HOMB on Cu_3Au (100) (Compare the top and bottom of Figure). The combination of the surface Cu-O layer and the second Au-rich layer works as a perfect protective layer even for the energetic O_2.



Single Gadolinium Atoms Observed by Aberration-Free TEM

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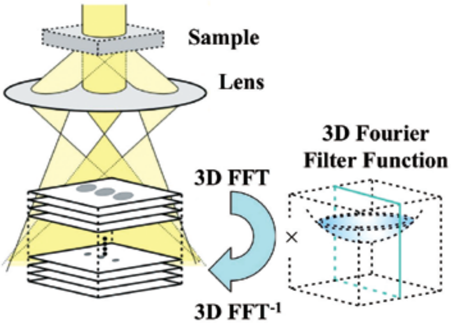

Fig. 1. Three dimensional Fourier filtering method.

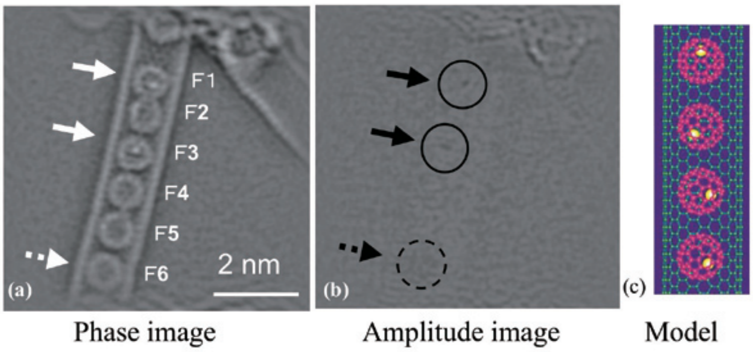

Fig. 2. Aberration-free (a) phase and (b) amplitude images of ($(Gd@C_{82})_n@SWCNTs$) together with (c) molecular model

Recent electron microscopic methods using aberration correction techniques have led to revolutionary improvement in understanding structural and compositional details on a single atomic scale on surfaces, interfaces, and even in bulk crystals. Among them, aberration-free transmission electron microscopy (TEM) based on wave field restoration techniques has great potential for determining localized atomic structures because complex wave fields on the exit surface of the sample can be restored without image delocalization due to the correction of lens aberrations.

In the present paper, single gadolinium atoms in fullerenes encapsulated in a single-wall carbon nanotube ($(Gd@C_{82})_n@SWCNT_s$) are observed by wave field restoration processing based on three-dimensional Fourier filtering method as schematically shown in Fig. 1. In the imaginary part image (phase contrast image) of Fig. 2(a), the single gadolinium atoms encaged in fullerenes F1 and F3 can clearly be seen with sharp spot-like contrast, as indicated by the white arrows. Surprisingly, dark spots are also slightly visible in the real part image (amplitude contrast image), which is due to an improved signal-to-noise ratio by Fourier filtering and resolution enhancement by correcting spherical aberration and two-fold astigmatism. These reconstructed images correspond to aberration-free TEM images observed with and without an ideal phase plate, respectively. This result indicates that the present method has high potential to clarify compositional details of the sample on a single atom level by using their image contrasts.