**Sample preparation:** A clean Cu(110) surface was obtained following cycles of Ar sputtering (1 keV, 15 min) and annealing (770−820 K, 10 min). To study the oxygen covered surface the clean sample was exposed to 10 L (Langmuir, 1 L = 10−6 Torr × sec) of O2 at 600 K,26 which produced a Cu(110)- (2 × 1)-O structure, also referred to as the 'added-row structure', where Cu−O chains are formed in the [001] direction, with a coverage of 0.5 monolayers (ML) of atomic oxygen. The CO gas was leaked into the chambers starting from a base pressure of ∼1 × 10−10 Torr in the APSTM chamber, ∼ 5 × 10−10 Torr in the APXPS chamber, and ∼8 × 10−10 Torr in the IRRAS chamber. No nickel contamination (from potential Ni-carbonyls) was detected after the experiments.

**APSTM Measurements:** APSTM measurements were performed at 298 K with a custom-built STM scanner using Pt−Ir tips.18 The STM was operated in the constant current mode by applying a bias to the sample. Imaging parameters are indicated in the figure captions.

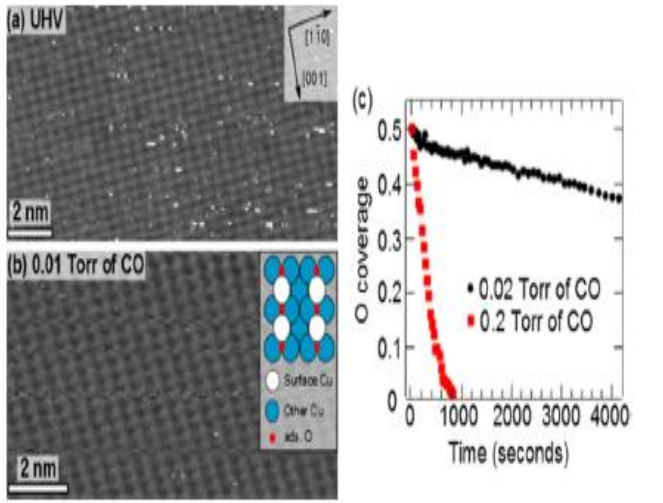
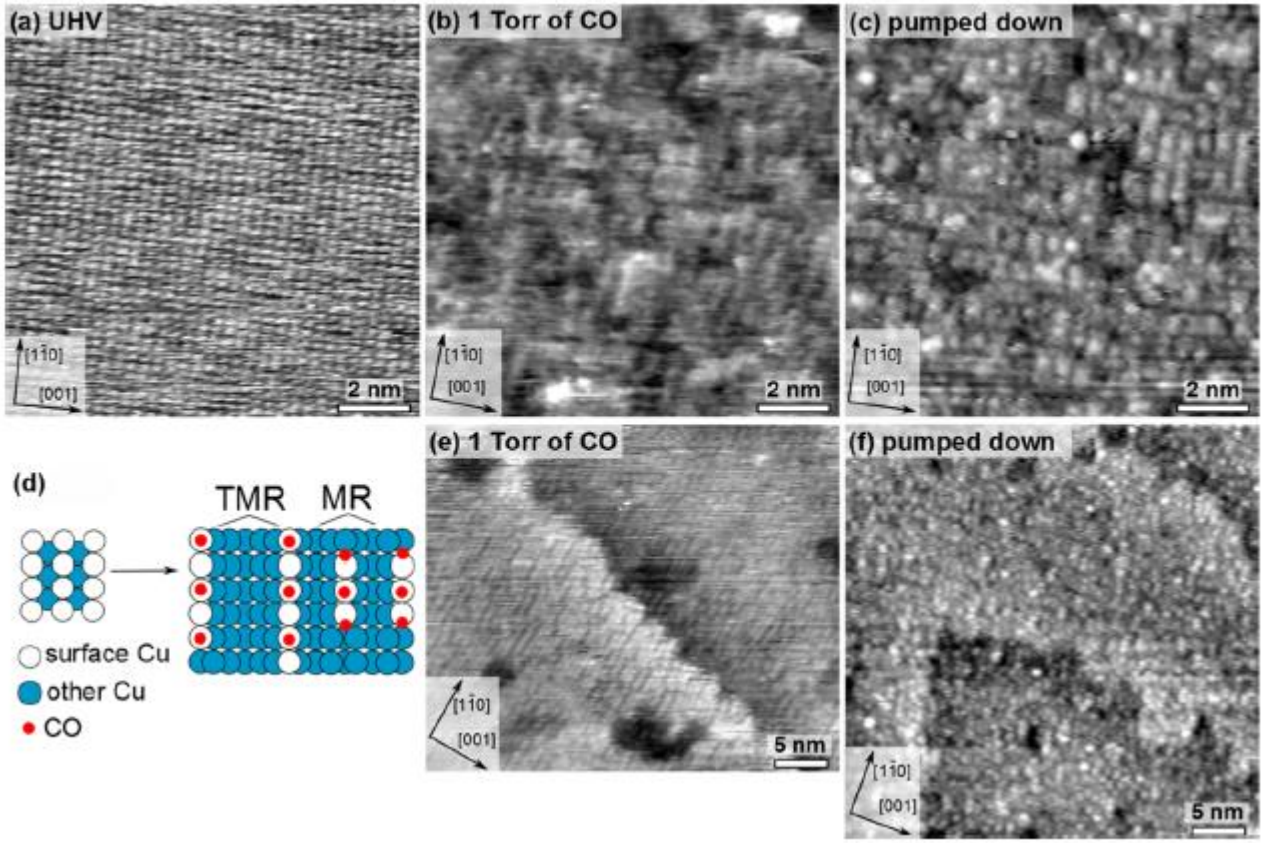



Figure 3. STM images of the Cu(110)-(2 × 1)-O surface (a) in UHV and (b) after ∼1 h in 0.01 Torr of CO. Imaging parameters: $I_t$ = 0.8 nA, $V_b$ = 1.4 V. (c) Variation of the atomic oxygen coverage due to reaction to form $CO_2$ in the presence of 0.02 and 0.2 Torr of CO measured with APXPS.[10]




**Cu(110):** The images in Figure 1 show the structural changes of the surface that occur in the presence of 1 Torr of CO at 298 K. The initially flat surface (Figure 1a) restructures into short (1−3 nm) linear clusters along the [1−10] direction (Figure 1b and e) separated by 2 lattice distances along the [001] direction, although a few rows can also be seen spaced 3 lattice distances. These are called single, double, or triple missing rows. The latter has two missing rows in the first layer and one missing row in the second layer, and it is difficult to distinguish it from a double missing row in APSTM images. This structure remains kinetically unchanged after pumping the chamber down to 2 × 10−9 Torr, which causes desorption of all CO from the surface (Figure 1c and f). As we showed recently, the CO restructured (111) surface becomes very active and react readily with background gases, in particular water. The same is true on the present (110) surface. Differences in the image contrast before and after CO evacuation can be attributed to both the lack of adsorbed CO on the surface and on the tip, and to the presence of small amounts of dissociated water from background adsorption. Figure 1d shows proposed models of the surface forming linear nanoclusters.