O_2 and CO induced alterations of noble metal clusters on carburized tungsten: An in-situ STM-study

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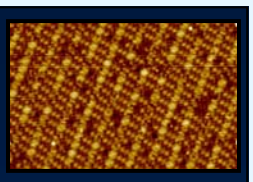
Gold as a catalyst?

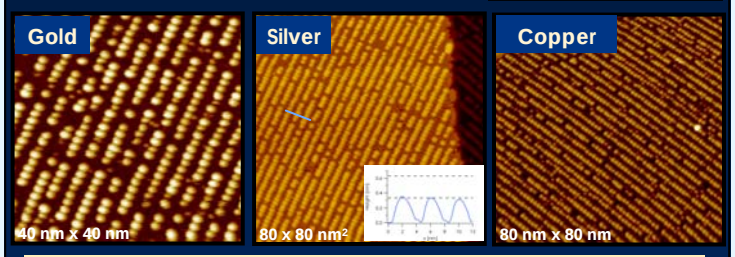
Albeit known for its inert nature as a bulk metal, dispersed gold particles on oxide and inert supports have turned out to exhibit a surprisingly high catalytic activity and selectivity for a number of oxidation reactions at low temperatures.[1] Since this promising behaviour of nanoscopic gold particles has first been observed, many different methods to produce gold catalysts on various support materials have been developed. This allows addressing a remarkable amount of potential applications. Despite high efforts in exploring the factors controlling the activity of the gold catalysts, the origin of the reactivity is still not clear at all. Even though there is general agreement that the size of the gold particles plays a considerable role for the catalytic reactivity, the results of several investigations carried out in order to determine the underlying physical explanations are quite controversial.[2]

Here we present a novel template for fabrication of ordered metal cluster arrays: Two different carburized W(110) surfaces are used to generate small Au, Ag and Cu clusters, which exhibit high potential for catalytic application. Since the proposed substrates are rather different to templates known from literature, we expect illuminative results concerning support effects on CO and O_2 adsorption over noble metal clusters. In a first step towards the final goal the influence of the reactants deposited on the cluster systems as well as on the templates themselves was investigated by in-situ STM-measurements.

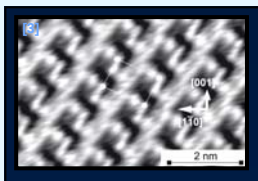
Substrates

Low carbon coverage:
R(15x12)C/W(110)

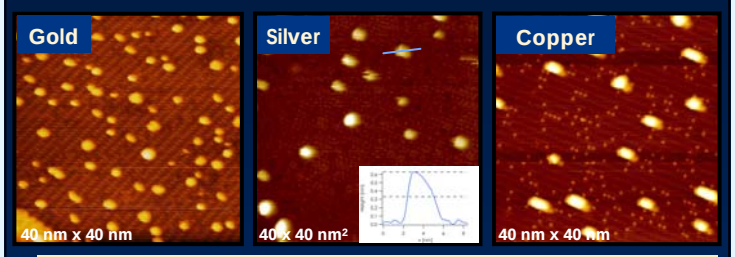




7 atoms per cluster, 1 ML high

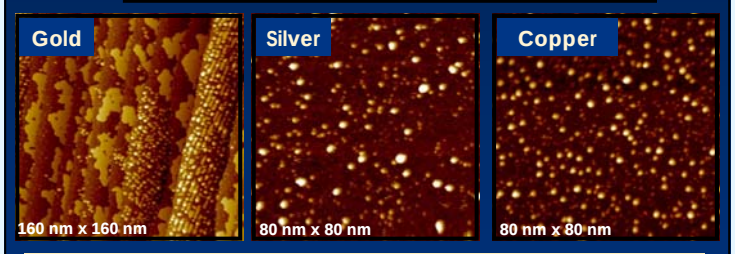


High carbon coverage:
R(15x3)C/W(110)



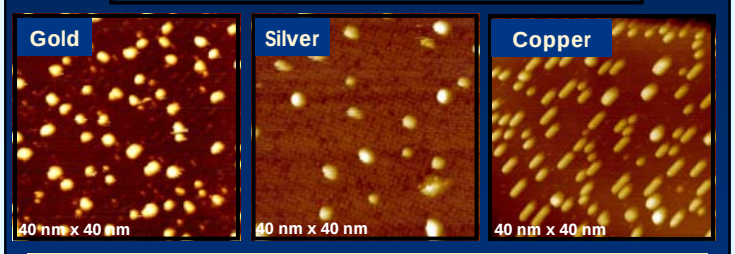
Larger clusters (D ≈ 2 nm), 2 ML high

Exposure to O_2



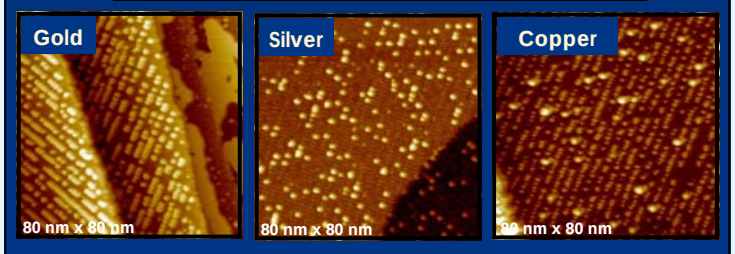
Increasing influence of O_2 ⟹

Exposure to O_2



Clusters hardly affected by O_2

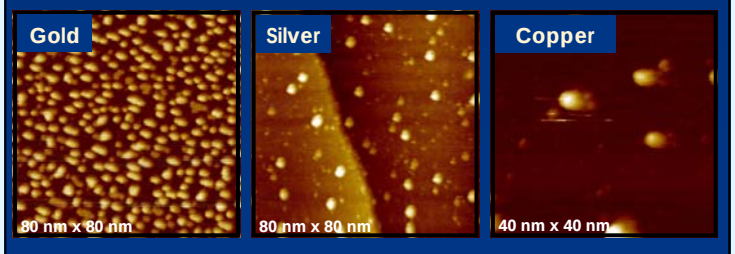
Exposure to CO



No influence of CO

Slow formation of 2 ML– islands

Exposure to CO



No visible CO-induced changes

Condensed Information

	(15x12)	Au (15x12)	Ag (15x12)	Cu (15x12)	(15x3)	Au (15x3)	Ag (15x3)	Cu (15x3)
O_2	Temporary loss of ordering, **periodicity preserved**	**Slow** alteration	**Corrosion,** but slower than Cu	**Immediate corrosion**	**Slow loss** of periodi-city	✓	✓	**Quite stable,** diffusion of small clusters
CO	?	✓	✓	Agglomera-tion of 2 ML clusters	✓	✓	✓	✓

Outlook

- Temperature Programmed Desorption (TDS) measurements on all cluster types
- CO and O_2 co-exposure: TDS and TPR (Temperature Programmed Reaction) experiments

References

[1] M. Haruta, T. Kobayashi, H. Sano, N. Yamada, Chem. Lett. (Jpn) **16**, 405 – 408 (1987).
[2] B. K. Min, C. M. Friend, Chem. Rev. **107**, 2709 – 2724 (2007).
[3] A. Varykhalov, O. Rader, W. Gudat, Phys. Rev. B **77**, 035412 (2008)