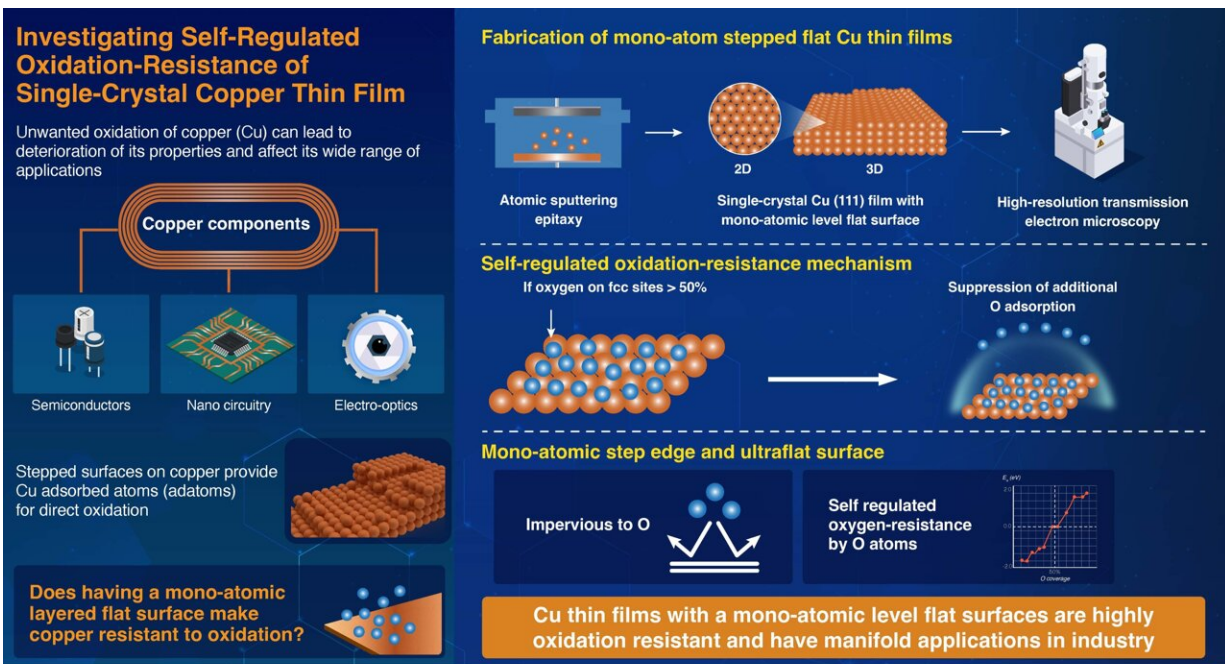


Researchers develop 'corrosion-free' copper thin films

March 21 2022



Flat-surface-assisted and self-regulated oxidation resistance of Cu(111)
Kim et al. (2022) | Nature | DOI: 10.1038/s41586-021-04375-5

Lab website:
<https://syjeong.pusan.ac.kr/syjeong/index.do>
ORCID id: 0009-0003-1019-4403



PUSAN NATIONAL UNIVERSITY

The copper thin film was grown using atomic sputtering epitaxy and then the mechanism behind its strong oxidation-resistance was revealed using theoretical models. Credit: Pusan National University

Copper (Cu) is of fundamental importance to our daily lives due to its excellent electrical conductivity, as well as other valuable physical properties, such as the ability to draw copper into thin wires. Cu is the

metal that is at the heart of the electronics, semiconductor and electro-optics industry. But oxidation and unwanted corrosion on its surface can limit the lifespan and increase the electrical resistance of Cu. Now, a team of researchers led by Prof. Se-Young Jeong from Pusan National University have developed a way to fabricate oxidation-resistant thin films of copper. "Oxidation-resistant Cu could potentially replace gold in semiconductor devices, which would help bring down their costs. Oxidation-resistant Cu could also reduce electrical consumption, as well as increase the lifespan of devices with nanocircuitry," says Prof. Jeong. The study has been published in *Nature*.

Previous studies have shown that Cu oxidation occurs due to microscopic "multi-steps" on the surface of copper. These steps provide a source of Cu adatoms (adsorbed atoms), which interact with oxygen and provide a place for oxides to grow. This is why single-crystalline Cu is resistant to oxidation. "We used a method called atomic sputtering epitaxy to grow tightly coordinated flat single-crystal copper films. By using noise reduction systems to reduce electrical and mechanical noises, we were able to keep the Cu surfaces nearly defect-free and fabricate atomically flat films," explains Prof. Jeong.

The research team then used high-resolution transmission electron microscopy (HR-TEM) to study the Cu films. They found that the film grew in the [111] direction and had an almost [flat surface](#) with occasional mono-atomic steps. They then compared the single-crystal Cu (111) films (SCCFs) with other Cu films which had higher surface roughness and found that unlike with the other films, the SCCFs were oxidation-resistant, i.e., it is very difficult for oxygen to penetrate the mono-atomic step edge.

The researchers then used a microscopic model of Cu oxidation based on "density functional theory" to investigate how the SCCF interacts with oxygen. They found that the surface of the SCCF was protected by

oxygen itself, once 50% of its surface was covered with oxygen atoms. Additional absorption of oxygen atoms on the SCCF was suppressed by the high energy barrier they, themselves, created.

"The novelty of our research lies in the realization of atomically flat surfaces, i.e., surfaces that are flat on the atomic level, as well as an elucidation of the oxidation-resistance mechanism of ultraflat metals," concludes Prof. Jeong.

The findings of this study make major contributions not only to the electronics and semiconductor industry, but also go a long way towards helping protect priceless bronze sculptures from damage.

More information: Su Jae Kim et al, Flat-surface-assisted and self-regulated oxidation resistance of Cu(111), *Nature* (2022). [DOI: 10.1038/s41586-021-04375-5](https://doi.org/10.1038/s41586-021-04375-5)

Provided by Pusan National University

Citation: Researchers develop 'corrosion-free' copper thin films (2022, March 21) retrieved 30 June 2024 from <https://phys.org/news/2022-03-corrosion-free-copper-thin.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.