CO gas sensing of Cu_xO nanostructured thin films grown by pulsed laser deposition

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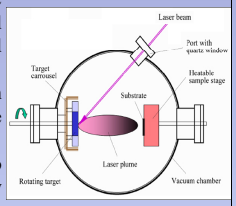
Abstract

➢Cu_xO nanostructured thin films were tested as potential carbon monoxide (CO) sensing layers towards 3000ppm maximum concentration in air flow at selected working temperatures between 120-200 ºC.
➢Au nanoparticles were additionally deposited on the surface of the Cu_xO nanostructured thin films.
➢The influence of Au nanoparticles on the morphological and gas sensing properties of the obtained films was also examined.

Films Preparation

• Undoped p-type Cu_xO thin films were grown under a dynamic oxygen pressure of 40Pa for 90 min deposition time on heated SiO_2 substrates at two different temperatures of 120 ºC and 200 ºC by pulsed laser deposition.
• An Nd:YAG laser (λ = 355 nm (THG)) source at 10Hz repetition rate was focused on a metallic Cu target. The laser fluence incident on the target surface was set at ~2 J/cm^2.
• After the film deposition, the chamber was evacuated down to 10^{-4} Pa pressure and an Au target (99,998% purity) was ablated by the focused laser beam for about 2 min.

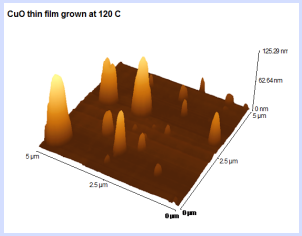


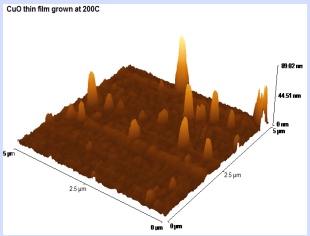
Films characterization

Hall-effect measurements were carried out at room temperature by using a magnetic field of 0.7 T

Deposition Temperature (º C)	ρ(Ω.cm)	μ_H (cm^2/V.sec)	p_H (cm^{-3})	Dominant carrier type
120	32	19.9	9.8E+15	P
200	166.3	132.7	2.8E+14	P

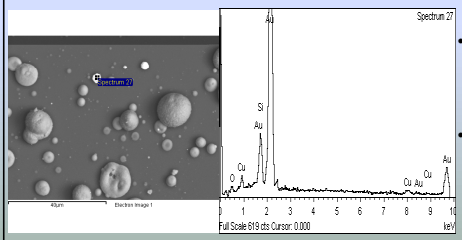
Thin film grown at 120 ºC deposition temperature is characterized by a lower resistivity and higher carrier concentration.





Deposition Temperature (º C)	Nanoparticles	Area Ra (nm)	Area RMS (nm)	Avg. Height (nm)	Max. Range (nm)
120	-	4.02	11.34	4.10	188
120	Au	4	12	2.62	164
200	-	2.91	6.68	4.52	89
200	Au	2.83	7.22	5.86	142

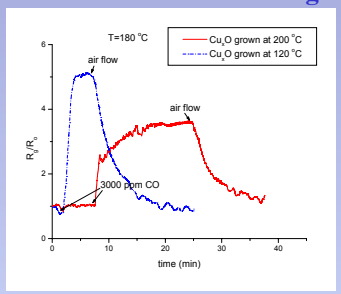
The film grown at temperature of 200 ºC was smoother than the one grown at 120 ºC.
Higher surface roughness of the film grown at 120 ºC lead to low Hall mobility[1]

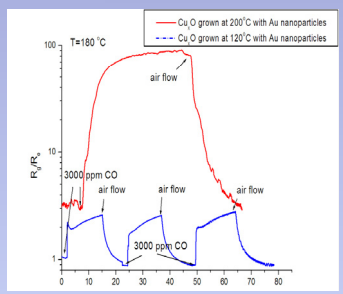


• A typical micrograph of SEM showing the surface grain structure of the sample grown at 120 ºC with Au nanoparticles on surface.
• The EDS spectra confirm that the large round particles are mainly copper oxide and the small "white" ones are gold.

[1] "Nanotechnology: An Introduction to Nanostructuring Techniques", Michael Köhler,Wolfgang Fritzsche, Wiley-VCH

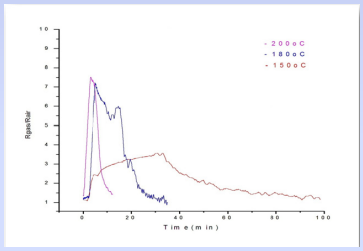
Carbon monoxide Sensing Tests

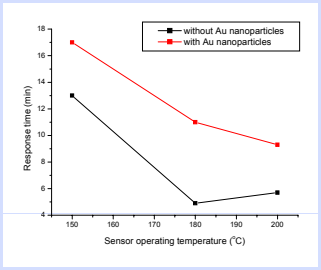


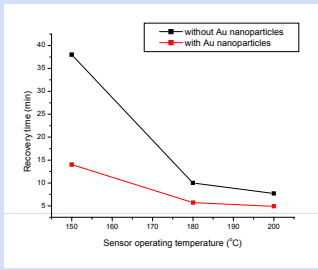


The Cu_xO film grown at 120 ºC deposition temperature exhibited higher relative response than Cu_xO film grown at 200 ºC, at sensor working temperature about 180 ºC.

Response and recovery time for both samples tend to decrease as sensor working temperature increase







The response time of the Cu_xO thin films increased with the presence of Au nanoparticles on their surface, while the recovery time decreased.

Conclusions

✓Undoped copper oxide (Cu_xO) thin films were grown by reactive pulsed laser deposition under two different deposition temperatures of 120 ºC and 200 ºC.
✓ The influence of deposition temperature on the films surface morphology, structure, electrical and carbon monoxide sensing properties has been investigated.
✓ The response time of the Cu_xO thin films increased with the addition of Au nanoparticles on their surface, while the recovery time decreased.
✓The optimum working temperature of both samples as potential CO sensing layers was 180 ºC.
✓Further sensing measurements down to a few ppm CO concentration are in progress.