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Conductometric CO_2 Sensing Using $BaTiO_3$-CuO Composite Thin Films Grown by Pulsed Laser Deposition

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Conductometric gas sensors have certain advantages including low cost, simple design, high sensitivity and fast response which make them amenable to device miniaturization [1]. Miniaturization permits gas sensors to be used in applications where larger detection systems are not feasible. This includes sensors which can be mounted in unmanned air vehicles (UAVs) for gas detection. In this study, conductometric CO_2 sensing materials were investigated with the goal of integrating these materials into sensor devices which can be incorporated onto a UAV.

Composite thick films comprised of $BaTiO_3$ and CuO phases have previously been shown to be sensitive to variations in CO_2 gas composition at temperatures $400°C \leq T \leq 700°C$ [2-4]. While the exact sensing mechanism has not been definitively ascribed, it likely involves chemisorption of CO_2 and possibly subsequent carbonate formation at the surface and grain boundaries of the CuO and/or $BaTiO_3$ surfaces and grain boundaries of the film. This reversible interaction changes the conductivity of the film, thus providing the basis for the sensor response.

A series of thin films of different CuO/$BaTiO_3$ compositions were grown by pulsed laser deposition (PLD) onto model ~1cm^2 substrates of single crystal sapphire at deposition temperatures ranging between $400°C \leq Tdep \leq 650°C$. The resulting thin films ($d < 1$ μm) were characterized by X-ray diffraction (XRD), chemical analysis using energy dispersive spectroscopy (EDS) and SEM. This confirmed that $BaTiO_3$-CuO composite films with different CuO/$BaTiO_3$ ratios could be grown by PLD using sintered composite targets comprised of these same two phases.

These films were then evaluated for their sensitivity to CO_2 in a synthetic air mixture of 20% O_2 and 80% N_2. Some films, notably those prepared from sintered targets of 1% CuO/ 99%$BaTiO_3$ exhibited high sensitivity to 100 ppm CO_2 (Figure 1).

Using the most promising $BaTiO_3$-CuO compositions and deposition conditions, some films were then grown directly onto sintered 3 mm^2 alumina sensor substrates with interdigitated Au electrodes and a Pt heater on the backside (Figure 2). These were again characterized by XRD, SEM EDS and tested for CO_2 sensitivity.

References

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Figures

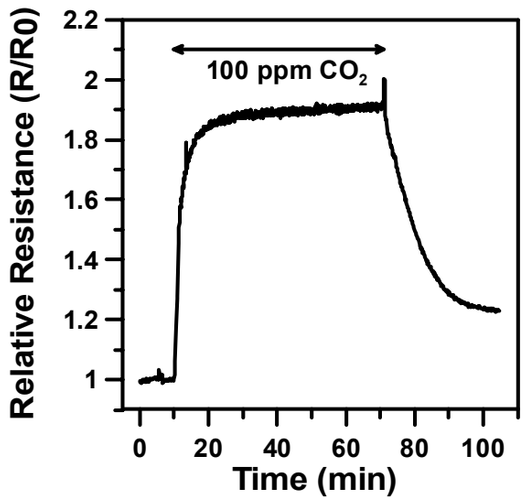

Figure 1: Dynamic sensor response to 100 ppm CO_2 in a 20% O_2/ 80% N_2 gas mixture for a $BaTiO_3$-CuO film prepared by PLD.

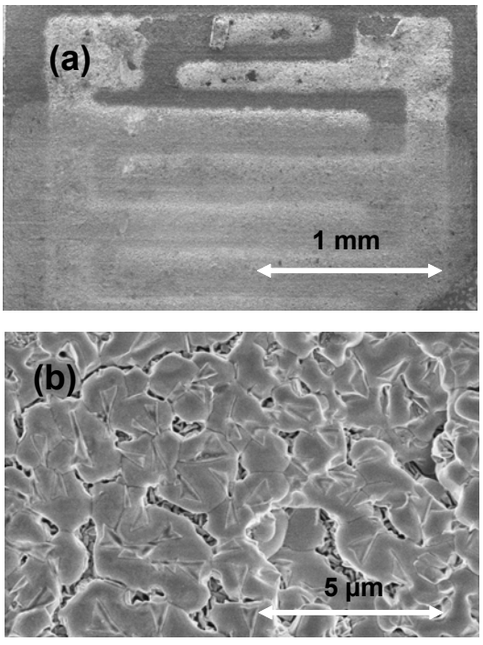

Figure 2: SEM images of the sensor device: (a) low magnification showing the Au gold interdigitated electrodes with the film covering the lower part; (b) higher magnification showing the morphology of the $BaTiO_3$-CuO film on the sintered alumina substrate.