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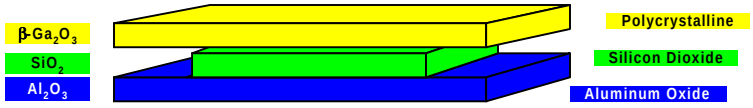
Application Note

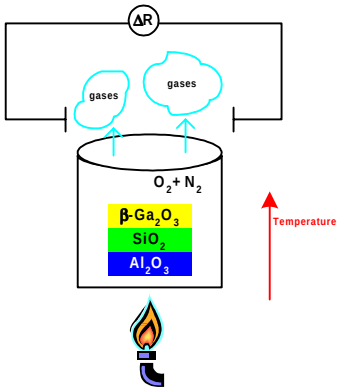
1689 Digibridge Used In Gas Sensor Materials Testing

In the material testing of polycrystalline (β-Ga_2O_3) we find another application in which the 1689 Digibridge has been employed. This particular research analyzes the oxygen/oxide-semiconductor interaction of bulk and grain boundary phenomena in a thin layer of β-Ga_2O_3 (grain size = 30nm). Knowing the conduction of the material at varying temperatures allows the differentiation of its resistive properties. Polycrystalline is a compound used in the manufacture of chemical gas sensors operated at high temperature.

How is a material tested?



This particular experiment formed a sandwich structure out of the polycrystalline. First a silicon dioxide diffusion barrier layer is formed on an aluminum oxide substrate. Then a 2µm thick polycrystalline film is sputtered on the substrate. The sample is then cured for 10 hours at 900°C in air to achieve the desired grain size equal to 30nm. The sample is placed in a 20% (O_2 + N_2) gas mixture at temperatures varying from 567°C to 790°C. The 1689 Digibridge is used to measure the impedance as a function of temperature. AC frequencies vary from 12Hz to 100kHz. The change in resistance (ΔR) is indicative of the thickness of the depletion layer of the material. The sample's absorption of oxygen changes its bulk resistance.



What is a gas sensor?

Chemical gas sensors do just that, sense the presence of hydrogen, hydrocarbons, and nitrogen oxide gases. Gas sensing technology has great promise in aeronautics and aerospace applications such as hydrogen sensors on the space shuttle launch pad. Hydrogen & hydrocarbon sensors are also used in commercial automotive applications. Think about it. What kind of device would be incorporated into an automotive State Inspection Emissions Tester? Ford Motor Company uses hydrogen gas sensors on its NGV assembly line (natural gas vehicle). Another commercial application for chemical gas sensors is in a hand-held gas-sensing device used by HAZMAT teams.

Gas Sensor Materials and Processes

Since temperature plays a major factor in the stability of a chemical compound's characteristics, materials chosen for sensing applications are evaluated for specific properties over specific temperature ranges. The precise sensitivity of the semiconductor-oxide material determines its application. Certain types of semiconductor-oxides are more adept at detecting the presence of specific gases. Refer to Table 1.

Table 1: Semiconductor Oxides and Targeted Gases[1]

Oxide	Detectable Gas
SnO_2	H_2, CO, NO_2, H_2S, CH_4
TiO_2	H_2, C_2H_5OH, O_2
FeO_3	CO
$Cr_{1.8}Ti_{0.2}O_3$	NH_3
WO_3	NO_2, NH_3
In_2O_3	O_3, NO_2
$LaFeO_3$	NO_2, NO_X

Knowing the certain oxide that will sense the presence of the target gas, the materials scientist must then decide the semiconductor oxide's material properties. Film thickness, gas absorption, surface reaction kinetics and electron transfer in the conduction band of the semiconductor are all considerations. Combining metals and oxides proves beneficial in some applications to increase sensor sensitivity to reduce gases like CO_2. Without getting into a discussion of chemical properties, semiconductor doping levels and metal oxide combinations, we can observe that the science of chemical gas sensing is a very necessary and valuable technology. For more in-depth information, use an Internet search engine and the keywords "chemical gas sensors".

For complete product specifications on the 1600 Series Precision Digibridge instruments or any of QuadTech's products, visit us at http://www.quadtech.com/products. Call us at 1-800-253-1230 or email your questions to info@quadtech.com.

1. "Materials and Processing Issues in Nano-structured Semiconductor Gas Sensors", Frederic Cosandey, Ganesh Skandan & Amit Singhal, 10/2000, JOM: http://www.tms.org/pubs/journals/JOM/0010/Cosandey/Cosandey-0010.html.

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