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Layered CU-based Electrode for High-Dielectric Constant Oxide Thin Film-based Devices (ANL-IN-03-013)

Copper offers better performance at a lower cost

The Invention

A multi-layer, thin film device containing copper layers protected by amorphous TiAl oxide and devices incorporating TiAl.

Argonne's layered device comprises a substrate of or containing silicon and/or a compound thereof or of or containing diamond, an adhering layer on the substrate, an electrical conducting layer on the adhering layer, a barrier layer of an oxide of TiAl and a high dielectric layer forming one or more of an electrical device and/or a magnetic device (see figure).

The successful use of Cu in thin-film devices requires the solution to critical issues such as adhesion of Cu layers to Si, SiO2 and ferroelectric layers, Cu diffusion, and elimination of oxidation of the Cu during growth of oxide films. A significant problem is that Cu oxidizes at relatively low temperatures at a significant rate, which results in degradation of the electrical conduction properties of the Cu electrode layers. Thus protection against oxidation is necessary when growing ferroelectric or high permittivity oxide films on Cu electrode layers, since synthesis of those layers requires high temperature and oxygen ambient or oxygen plasmas.

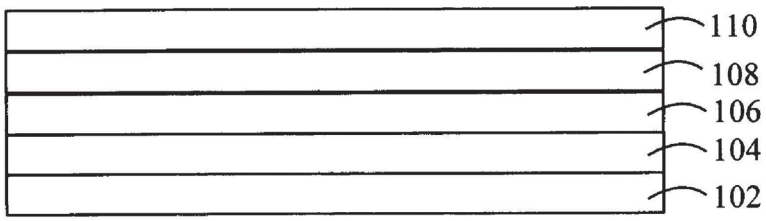
To prevent oxidation of the copper layer during growth of the oxide layer on the copper layer, a TiAl oxygen diffusion barrier is put on top of the copper layer before growing the oxide layer. The TiAl layer absorbs oxygen preferentially binding it to the constituent elements (Ti and Al) of the layer and inhibiting the diffusion of oxygen atoms towards the copper layer while growing the oxide film in an oxygen environment at high temperature. The TiAl oxygen diffusion barrier layer can be deposited by MOCVD (metalorganic vapour phase epitaxy), atomic layer deposition or physical vapor deposition or any other method suitable for growing oxide thin films.

Benefits

- Low cost
- High conductivity
- Offers protection against oxidation

Applications and Industries

- Electrodes
- Circuit technologies
- Electrical and magnetic devices



Simplified schematic representation of a layered device where 102 is the substrate, 104 is the adhering layer, 106 is the electrical conducting layer, 108 is the barrier layer and 110 is the high dielectric layer.

Developmental Stage

Ready for commercialization

Availability

Available for licensing

Argonne Invention Number

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Patent Information

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Inventor

Orlando Auciello

Contact

Terry Maynard
Argonne Technology Development and Commercialization
www.anl.gov/techtransfer

U.S. DEPARTMENT OF ENERGY

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