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Controlled growth of atomic layer SiO₂ films at room temperature

Background

 SiO_2 is one of the most important materials on earth by virtue of its abundance in the earth's crust. SiO_2 is used for many applications including optical fiber communication, microelectronics, protective coatings, electroluminescent displays, and chromatography to name a few. The development of low-temperature ultra thin film deposition techniques will facilitate the development of many new technologies. Specifically, future silicon microelectronic devices will require multilevel fabrication techniques with components having nanoscale sizes in order to achieve ultra large scale integration. The reduction of component size and tolerances to the nanometer level will require extremely precise control over thin film properties such as film thickness, morphology, crystallinity, conformality and electrical properties.

Prior to this patented invention, Si0₂film deposition techniques required elevated temperatures ranging from 200°C. to 1000°C. Lower deposition temperatures will be needed because the interlayer diffusion of just a few atoms caused by high temperature can destroy the electrical and optical properties of such nanoscale devices.

Technology

Dr. Steven George of the University of Colorado developed the first process in which SiO₂ films can be grown at room temperature with inexpensive, widely available precursors. The room temperature growth of the SiO_2 films is accomplished by catalyzing the reactions on the growing SiO_2 surface. The presence of a catalyst lowers the deposition temperature from 200-600°C down to room temperature (25°C).

Briefly, this method involves exposing a functionalized substrate to a catalyst that is a Lewis base or Lewis acid, and a first molecular precursor which includes the primary element of the film to be grown and a second functional group. The catalyst first interacts with the first functional

Summary

- Method for growing Si0₂ films at room temperature
- Process utilizes inexpensive, widely available precursors
- May be applied to any functionalized substrate to which a thin film may be bonded.

group of the functionalized substrate; then the first molecular precursor reacts with the first functional group which is activated by the catalyst, resulting in a displacement of the catalyst and a bond between the first functional group of the substrate and the primary element of the first molecular precursor. The substrate is then exposed to additional catalyst and a second molecular precursor. The catalyst interacts with the second functional group and the second molecular precursor resulting in a displacement of the second functional group and resulting in a bond between the primary element of the first molecular precursor. Then, the second molecular precursor reacts with the bond between the element of the first molecular precursor, which is activated by the catalyst resulting in a displacement of the catalyst and the deposition of the first functional group, i.e. the same group which was used to functionalize the substrate. At this point, the first atomic layer of film has been grown.

The use of a catalyst which serves as a Lewis base to activate the first functional group of the functionalized substrate enables the first functional group of the functionalized substrate to be linked or bonded to the first molecular precursor at a low temperature and low flux.