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Method and reactor configuration for the production of oxide and oxynitride thin layers

Offer of invention

The present invention describes a new process and reactor configuration for the preparation of thin oxide and oxynitride films utilizing inorganic compounds at ambient conditions.

Prior-art surface coating processes that are known for the formation of thin oxide/nitride films from reactants in the gas phase at ambient conditions raise numerous challenges. First and foremost, intermediate products form upon the substrate surface because of the gas-phase diffusion phenomenon, resulting in a low-quality film. Second, inhomogeneous reactions can occur making the deposited films non-stoichiometric and nonuniform. Third, a high thermal budget is required to assure functional film stability. Last but not least, various types of hazardous material precursors are used and by-products must be selectively removed by exhaust stream.

The purpose of the current invention is to provide a novel method and a reactor design for the production of resilient oxide and/or oxynitride films at ambient pressure and room or sub-room temperature, yet by altering the gas-phase diffusion kinetics.

The process according to the present invention is called "Surface Reaction Controlled Ambient Chemical Vapor Deposition" (SRA-CVD). The layers are stoichiometrically deposited by the hydrolysis/oxidation of inorganic compounds. This is preferably done at room- or sub-room temperature, depending on the desired film characteristics.

The deposited layers consist, for example, of dielectric or electrically conductive materials. The properties of the layers can vary depending on the intended application and can be used as an insulating layer, anti-reflection coating, passivation layer for quantum devices and micro-nano-optics, and much more.

With the present process it is possible to realize a high deposition rate with low costs and negligible thermal budget. The associated reactor is vacuum- and plasma-free as well as it is durable and safe to operate since no flammable or toxic precursors are utilized.

Solution approach

- Hydrolysis/oxidation of inorganic compounds, preferably halogen-containing groups, at ambient conditions and with heterogeneous surface-reaction control. The used compound materials are known to not condensate as thin films at ambient conditions, but rather as dust, which is refuted in this invention

Advantages

- Highly resilient films with negligible thermal budget
- Wide range of film structures, from porous to quite dense
- High deposition rate while maintaining film durability
- Inexpensive and safe-to-use material precursors
- The reactor/process is vacuum and plasma-free as well as compact and safe to operate, hence cost-effective technology

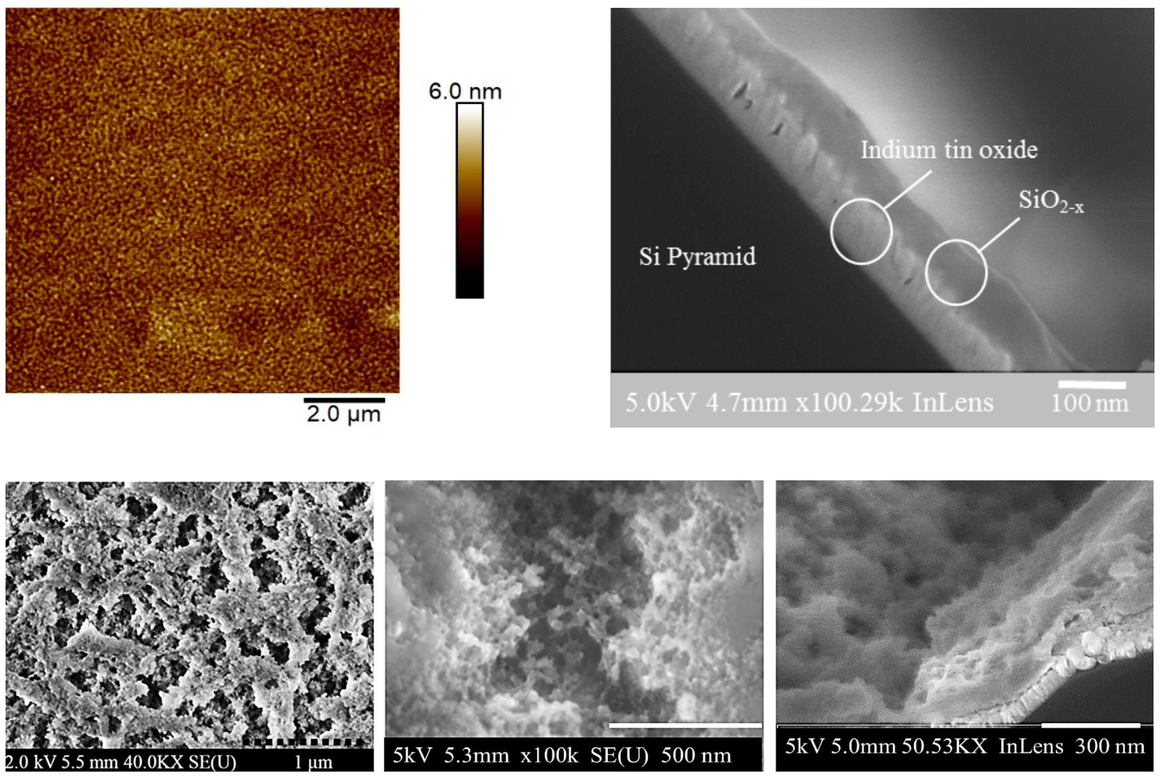

Figure: Characterizations of films deposited using the current invention. **Upper left:** Surface roughness measurement of 200 nm thick SiO_2 film deposited on planar Si wafer. **Upper right:** Cross-sectional SEM image of dense SiO_2 film adhered intimately on indium tin oxide-coated Si pyramid. **Middle:** SEM image of various film materials deposited firmly porously on different surfaces. **Bottom:** Photos of 100 nm of various oxide films deposited firmly densely on planar Si wafers

Target group and target applications

- The target group includes, for example, manufacturers of reactors for the production of oxide and oxide nitride coatings.
- Areas of application can be, by way of examples but not limitation, in the semiconductor industry, glass industry, optical fibers, photovoltaics, quantum devices, microsystem technology, automotive industry, etc.

Development status & property rights

- Experimental proof, laboratory-scale setup
- German patent certificate: DE102022108150B3
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