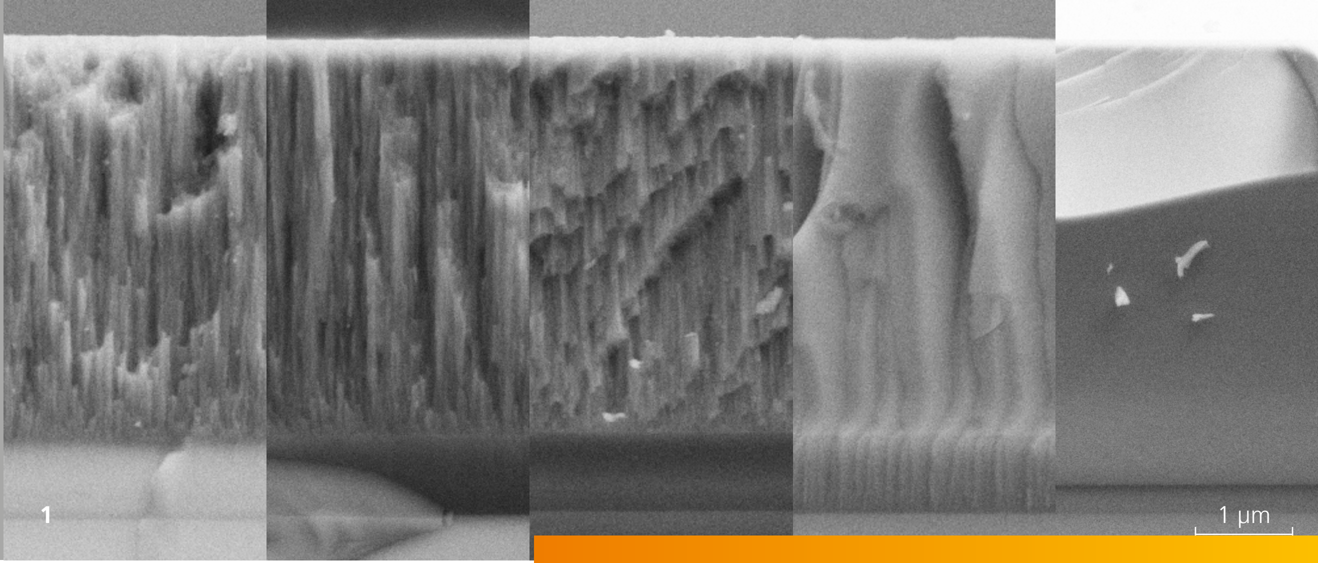


Extract from the annual report 2017
To the website: www.ist.fraunhofer.de/en.html

GAS FLOW SPUTTERED SILICON LAYERS

For decades pure silicon has been the main element of microelectronics and therefore has significant technological and economic importance. In current projects researchers are attempting to extend microelectronics with systems that interact with the environment. For example these can be sensory, actuating, chemical, or electrochemical components. In this area as well silicon is an extremely attractive source material, however the traditional deposition processes for semiconductor silicon, such as chemical vapor deposition (CVD), are not always suitable in this regard. As part of a Fraunhofer-internal research program, a new generation of silicon deposition processes is being developed and investigated. One of these processes uses the hollow cathode gas flow sputtering (GFS) developed at Fraunhofer IST.

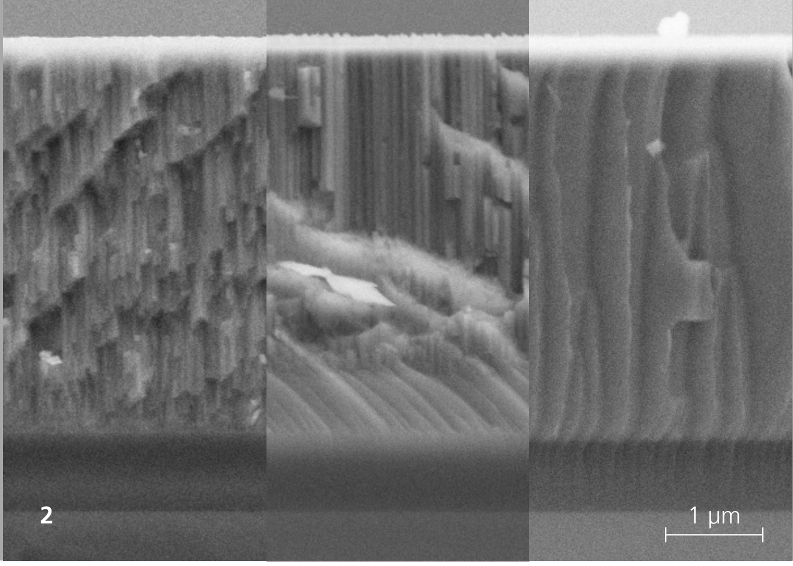
Gas flow sputtered silicon layers

Gas flow sputtering (GFS) is a high rate sputtering process in which an intensive hollow cathode glow discharge is used for atomization. The atomized species are transported to the component via a directed gas flow. In the research project cited above, highly-doped silicon (n-type, phosphorus) is atomized in a plasma discharge and deposited on level silicon substrates at moderate temperatures. As a representative of physical vapor deposition (PVD) gas flow sputtering uses non-toxic starting materials, and through plasma support, enables an outstanding layer adhesion on the substrate. For deposition, process parameters can be selected in such a manner that the layers either have a columnar, i. e. porous, microstructure or a compact, i. e. dense, microstructure (see Fig. 1). In addition to the structure, the inherent stresses of the occurring layers can be controlled to a certain extent. Typical layer thicknesses here are on the order of 10 µm. However, in principle GFS layer thicknesses of 100 µm and more can be achieved.

Silicon PVD with hydrogen added

Plasma-supported PVD processes are based on purely physical procedures and as a rule use argon as the process gas. On the other hand, in chemical gas vapor deposition (CVD) processes that are conventionally used for silicon deposition, chemical processes are used for mobilization of the particles and layer formation. Often hydrogen plays a decisive role in this regard. However, Fig. 2 shows that hydrogen can also influence the layer properties in PVD processes. Different quantities of hydrogen were added to the gas flow sputtering process in what otherwise were the same conditions. Here the addition of hydrogen increases the mobility of the layer-forming particles on the surface and thus favors a compact layer structure.

Fraunhofer Institute for Surface Engineering and Thin Films IST | Bienroder Weg 54 E | 38108 Braunschweig | Germany



Outlook

In the future silicon layers produced with PVD processes could even be bonded lightly in the same process with metallic electrode layers or passivated with barrier layers, such as silicon oxide. The variable microstructure also makes GFS silicon attractive as an anode material for lithium ion batteries, or for catalytically active surfaces, e. g. for gas sensors.

The project

This work was funded by the Fraunhofer Society in the framework of internal programs.

1 *Scanning electron micrograph of silicon fracture edges. Depending on process parameters silicon layers can be generated with a microstructure that varies in porosity or density. In the figure, the substrate bias voltage increases from left to right.*

2 *The density of the forming layers can also be influenced through an addition of hydrogen in the gas flow sputtering process. In the figure the addition of hydrogen increases from left to right.*

CONTACT

Dr. Kai Ortner
Phone +49 531 2155-637
kai.ortner@ist.fraunhofer.de