Semiconductor Technology from A to Z

Dry Etching

Compound Semiconductors and High-k Materials 3
Why These Materials Are a Special Case 3
III-V Compound Semiconductors (GaAs, InP, GaN) 3
Silicon Carbide (SiC) 3
High-k Dielectrics (HfO_2 and Others) 3

Compound Semiconductors and High-k Materials

Why These Materials Are a Special Case

The gas overview in the Dry etch processes chapter covers the standard materials of silicon manufacturing: silicon, silicon dioxide, silicon nitride, polysilicon and aluminum. Some material systems, however, cannot be etched well – or at all – with the same chemistries, either because they are too chemically inert, or because the resulting reaction products are not volatile enough at process temperature.

III-V Compound Semiconductors (GaAs, InP, GaN)

III-V semiconductors such as gallium arsenide, indium phosphide or gallium nitride cannot be etched with fluorine chemistry – the resulting fluorides are not volatile enough at process temperature. Chlorine chemistry (BCl_3, Cl_2) is used instead, forming volatile chlorides with the group III elements.

One challenge is that the different elements of a compound react at different rates – for GaAs, for example, the chemistry must be tuned so that gallium and arsenic are removed at comparable rates. Otherwise the surface becomes depleted of one element, and etching stalls or the surface roughens.

Silicon Carbide (SiC)

Silicon carbide is chemically extremely inert – the very property that makes it valuable for high-temperature and power applications makes it significantly harder to pattern. Dry etching SiC requires fluorine chemistry, usually SF_6-based, with considerably higher ion energy than for silicon, in order to break the strong Si-C bonds.

Etch rates are correspondingly lower, and the mask erodes faster – for deep structures, the mask thickness must therefore be more generous than for comparable silicon processes.

High-k Dielectrics (HfO_2 and Others)

Hafnium oxide (HfO_2) and related high-k materials, which replace classic silicon dioxide as the gate dielectric in modern gate stacks, form only poorly volatile reaction products with fluorine or chlorine compounds. Etching is usually done with BCl_3-based chemistries, often assisted by a stronger physical component – i.e. ion bombardment – to mechanically remove the reaction products from the surface rather than relying purely on chemical volatilization.

The process windows are narrow, since the extremely thin high-k layers – often just a few nanometers – do not tolerate over- or under-etching.