1 Dry etching

1.1 Overview

1.1.1 Abstract

In wet etching film stacks are generally etched isotropic, however, at small feature sizes an anisotropic profile is neccesary. Therefore dry etch processes are applicable which have a sufficient selectivity. Such methods allow reproducible uniform etching of almost all materials which are used in semiconductor manufacturing. Besides anisotropic processes, isotropic processes are possible as well. Despite the expensive production facilities and the single wafer processes, dry etching has established itself.

1.1.2 Major values in dry etching

Etch rate r: the etch rate is the abrasion per time and for example can be specified in nanometers per minute or Angstrom per second.

$$r = \frac{\text{Etch removal } \Delta z}{\text{Time } \Delta t}$$

Anisotropism f: The anisotropism gives the ratio of horizontal etch rate r_h and vertical etch rate r_v.

$$f = 1 - \frac{r_h}{r_v}$$

For structuring high anisotropic processes are desired, which means an etching only in vertical direction, so that the resist mask is not underetched. For anisotropic etch processes $f \to 1$, and accordantly for isotropic processes $f \to 0$.

Selectivity S_{jk} of layer j and layer k: the selectivity is the ratio of the etch rates of two films, e.g. of the layer which should be structured (j; e.g. oxide) and the layer which should not (k; e.g. resist).

$$S_{jk} = \frac{r_j}{r_k}$$

The value of the selectivity depends on the process. For structuring the value should be as high as possible, which means that the layer one wants to structure is etched much faster than a masking resist layer. In reflow back etching the selectivity should be about 1 to ensure a uniform surface.

1.1.3 Dry etch processes

In dry etching gases are stimulated by high frequency, which is primarily 13.56 MHz or 2.45 GHz. At a pressure of 1 to 100 Pa the mean free path is some millimeters to centimeters.

Primarily there are three types of dry etching:

- **physical dry etching:** physical abrasion of the wafer surface by accelerated particles
- **chemical dry etching:** chemical reaction of gas and wafer surface
- **chemical physical dry etching:** physical etch process with a chemical character