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2000s

ALD (Atomic Layer Deposition)

~ Process Technology ~

ALD is a method of film formation by, ① exposing a precursor having an element X to do replacement adsorption of the terminal group on the substrate surface, and then ② exposing a precursor having an element Y for the replacement adsorption of reactive group of the X element to the Y element, and this process is repeated to deposit an XY compound in each atomic layer. Here, since the replacement adsorption of each of ① and ② is a saturated reaction, the film deposition is almost completely reaction rate limited process, and it is not limited by the supply of the reacting elements in sufficient exposure time. As a result, it is possible to form a uniform film on a three-dimensional structure with a pattern of varying fineness (Fig. 1).

In the field of silicon semiconductors, this feature solved the problem of uneven growth of a film in a high-aspect groove in the traditional LPCVD method, in which the film becomes thinner at the bottom than at the top, caused by the supply limited growth mechanism of reacting elements (Fig. 2).

As for the ALD film forming equipment for silicon semiconductors, ASM International(Dutch company) first commercialized a single wafer type machine, then Hitachi Kokusai Electric commercialized a vertical type batch equipment to improve productivity.

The ALD film forming method was first applied to the high-k film of a 256 Mbit DRAM stacked capacitor with the high aspect ratio, and further developed for the applications to the main structure film formation of LSI, such as high-k gate film and metal gate film of the transistor. In addition, due to the feature that the film thickness can be precisely controlled by the number of cycles ① and ② in the atomic layer level, it has been applied to double pattering technology in the lithography which realizes the fine pattern exceeding the limit of optical wavelength (Fig. 3). The double patterning method is now an indispensable CD control technology because of the enormous increase in the cost of the advanced exposure machine that determines the CD (critical dimension).

Reference:

A Short History of Atomic Layer Deposition: Tuomo Suntola’s Atomic Layer Epitaxy, Wiley Online Library

http://onlinelibrary.wiley.com/doi/10.1002/cvde.201402012/full

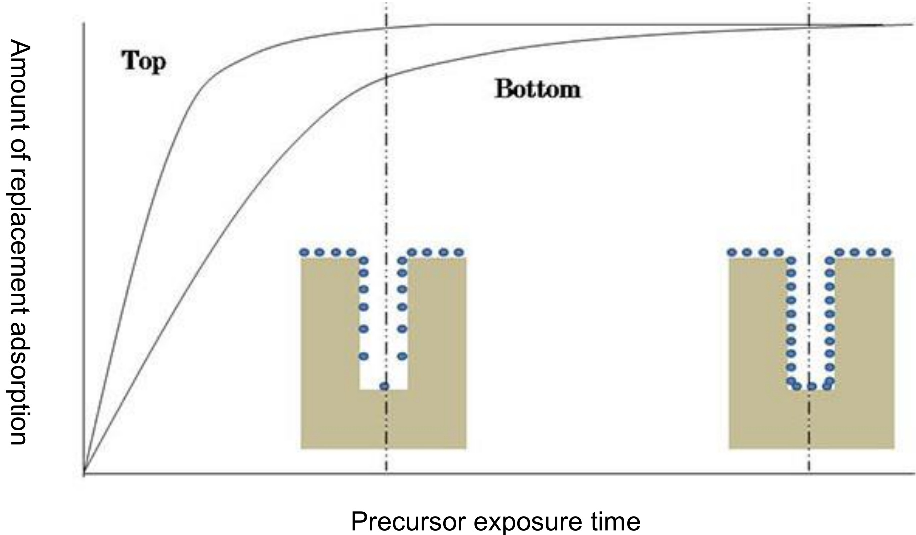

Fig.1: Uniform film formation by ALD on different pattern fineness

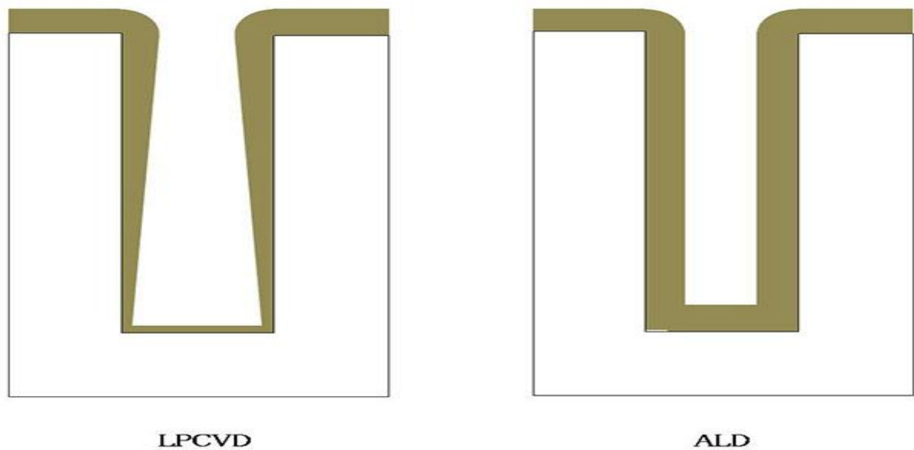

Fig.2: Step coverage comparison of LPCVD and ALD

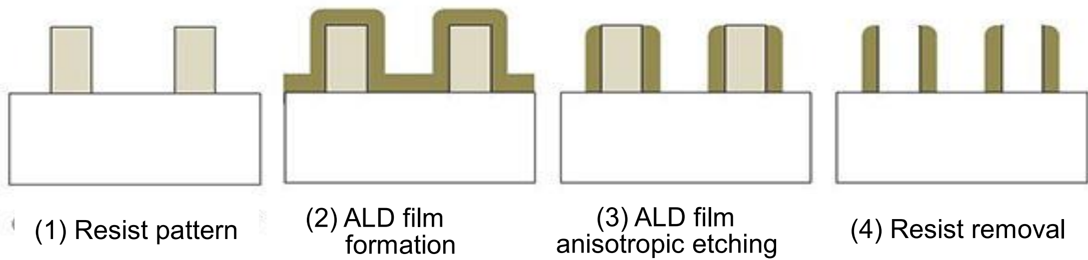

Fig.3: Double patterning