Deposition of Low-k Materials/Dielectric Barrier by spin-on and CVD on industrial low-k spin-on and CVD-tools

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Transfer of laboratory preparation process to a specified spin-on tool

In the last few years at ZfM a SiO_2-Aerogel spin-on process has been developed for preparation at laboratory and was described in detail in previous papers. In year 2000 a BMBF project together with the equipment suppliers SÜSS MicroTec and APPLIED MATERIALS was started to transfer this lab process to a prototype of an industrial equipment. A spin on tool was developed for deposition of the dielectrics provided by SÜSS MicroTec (see figure 1) and a CVD unit was adapted for requirements of post-treatment of the dielectrics and deposition of dielectric barriers and provided by Applied Materials (see figure 2). At the beginning of 2002 the full equipment was available at ZfM and the experiments for the process transfer could be started. The goal of this research is to provide a full dielectric stack for integration in Cu-Damascene technology.

Figure 1 *Spin on tool for deposition of dielectrics provided by SÜSS MicroTec*

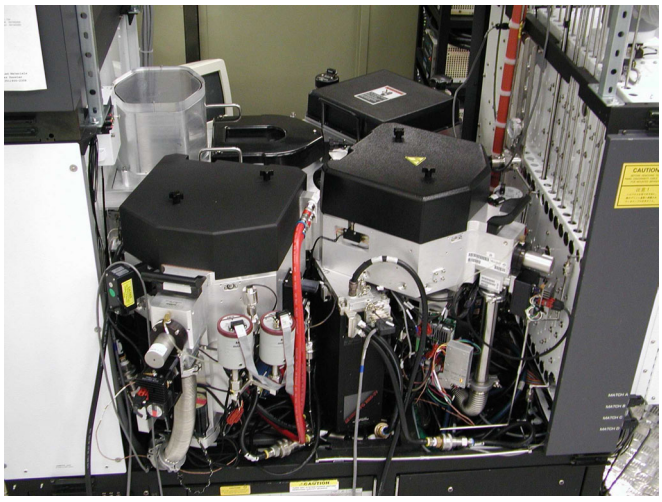

Figure 2 *CVD-tool P5000 with chambers for post-treatment of dielectric and cap deposition*

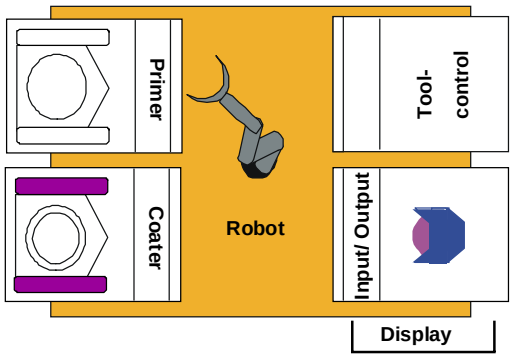

Figure 3 (on the top) *Scheme of module arrangement of the spin-on tool*

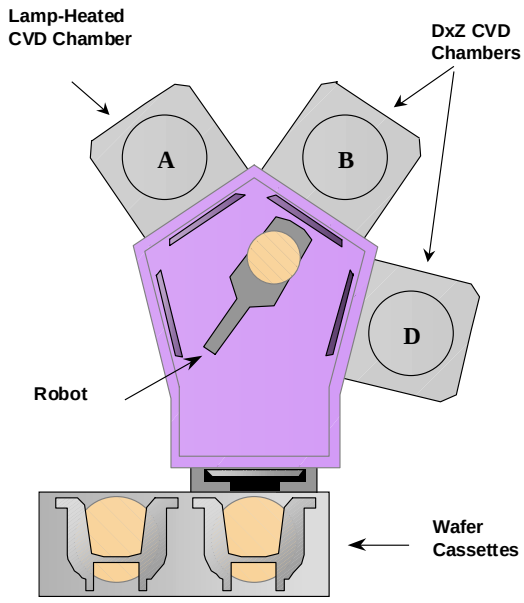

Figure 4 (on the right) *Scheme of the chamber arrangement of the CVD tool P5000, chamber A is configured for hydrophobisation of aerogel low-k films*

Most important requirements regarding aerogel film deposition consist in sufficient solvent-saturated ambient and fast handling between coating chamber and primer chamber. Solvent atmosphere is necessary to avoid prematurely drying of the film surface causing high roughness. Solvent atmosphere is produced before

deposition is started and remains until the chamber will be opened at the end of the deposition step. The integrated Genmark™ robot is a fast modern component, which realises the wafer transport from chamber to chamber in less than 8 seconds. This time is short enough to avoid film drying during transport. Wet films are then post-treated in the primer chambers. The primer chambers are configured for application of various atmospheres, containing for instance basic catalyst for dielectric post-treatment, and heating until 270°C. Although there exists no automatically transport between spin-on tool to CVD-tool, both tools are located in close proximity to each other. This fact facilitates the post-treatment/ barrier deposition immediately after film deposition. At the CVD-tool hydrophobisation of the low-k material and cap layer deposition are carried out. Until now PE-CVD-SiN_x and -SiO_y- cap layers are favoured for aerogel low-k films, but SiC-like cap layers (for instance BLOk) will be investigated for this application, too. The general process flow for the deposition of the whole dielectric stack is shown in figure 5, below.

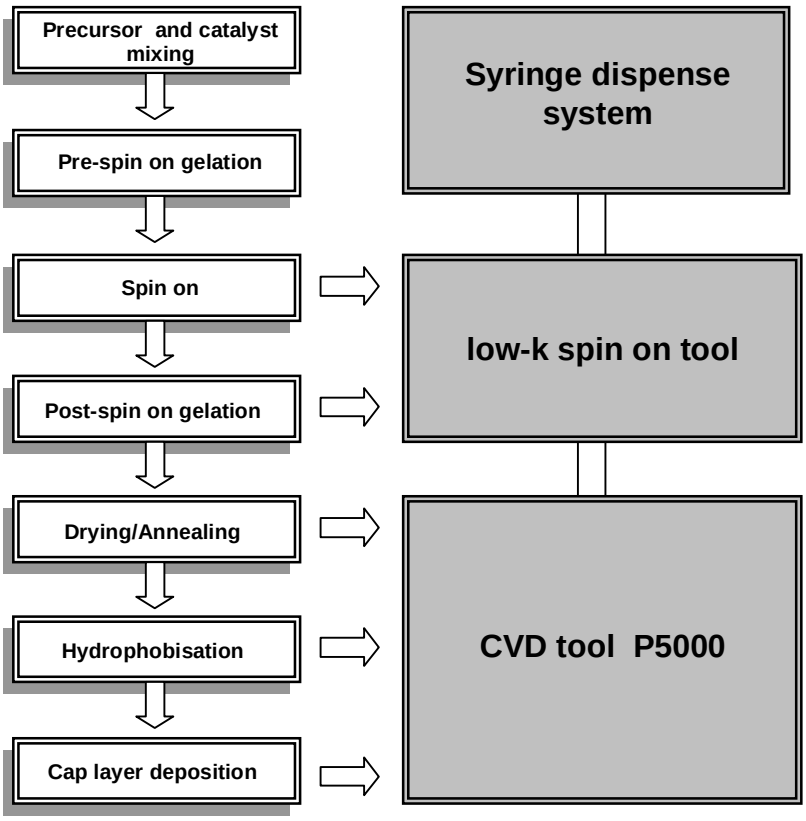

Figure 5 *General process flow of aerogel deposition, post-treatment and cap layer deposition with respect to the tool, where the processing steps are carried out*

The sol prepared by precursor mixture and pre-gelation is filled in syringes of the dispense system. The syringe dispense system is integrated in the spin on tool and the applied nitrogen pressure evoking the dispense is controlled by the spin on tool system controller. This enables one to refill or to change the precursor in short time and with small effort.
After few modifications of both the tools and the process, the transfer of the spin on deposition of the aerogel shows promising results. The films are homogenous and smooth. Electrical behaviour of the aerogel layers made on the spin-on tool by the so called “air-dried” process are comparable to those of the lab process. The standard process has not yet reached the excellent results known from the films prepared in lab. Especially leakage current density due to short throughput-driven hydrophobisation treatments using hexamethyldisilazane at the P5000 is slightly above the limit. Investigations are ongoing and will be finished at the beginning of 2003.

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