Clustered single wafer wet cleaning

P.W. Mertens,[1] F. Holsteyns,[1] R. Vos,[1] G. Vereecke,[1] W. Fyen,[1] J. Lauerhaas,[2] K. Xu,[1] T. Bearda,[1] I. Teerlinck,[1] S. Arnauts,[1] K. Kenis,[1] M.O. Schmidt[3] and M. Heyns[1]

[1]Imec vzw
Kapeldreef 75, B-3001 Leuven, Belgium

[2]Verteq inc.
Suite 100, 1241 E. Dyer Rd, Santa Ana, CA92705, USA

[3]Infinion
Dresden, Germany

Cleaning and surface preparation is facing a lot of major challenges in a rapidly changing environment.

SIMPLIFIED CLEANING PROCESS

Micro-electronic products today take up a significant part of the global economic volume. Therefore the growth of the semiconductor industry is directly depending to the degree in which further scaling can be achieved with cost-savings in the manufacturing processes. For decades cleaning processes in IC manufacturing were very poorly characterized and specified. At present wet cleaning takes up a significant fraction of the production cost and generates large amounts of waste. In cleaning cost savings can be achieved in various ways: reduction of the number of cleaning steps, reducing rinse water consumption, etc... Major savings have already been achieved by using simplified recipes such as the imec clean. The next challenge is the development of a *single chemistry clean* [1].

PUSH FOR SINGLE WAFER CLEANING

The IC manufacturing is characterized by the introduction of new materials at an accelerating rate: Cu, lowk, SiGe, SiGeC, SiC, FERAM, high k, MRAM, etc... This imposes an unprecedented demand for new developments in contamination control and cleaning. For this application, single wafer cleaning is largely preferred because it allows for single sided cleaning.

The threshold diameter of a particle to have a negative impact on yield is believed to be half the critical dimension of the technology generation [2]. Technologies with half pitch dimensions of 90 nm and below will therefore require efficient removal of particles of some tens of nanometers. The 2001 ITRS roadmap indicates that for technologies to be introduced as early as 2003 "no manufacturable solutions are currently known" that provide the required particle cleanliness (marked red) [2]. Single wafer wet megasonic cleaning is believed to be most promising to solve this technical issue [3, 4]. Indeed because of the better access to the wafer a more uniform and therefore better performing megasonic agitation, without creating damage to fine structures, can be applied.

In summary, in order to reduce cost and at the same time meet the stringent future requirements cleaning strategies with a higher performance have to be developed.

A lot of wet cleaning knowhow can be easily transferred to single wafer cleaning. The short wet cleaning procedures with a reduced number of steps (e.g. single chemistry clean) are particularly suited to be implemented in a single wafer cleaning. One of the major roadblocks for single wafer wet cleaning, however, was the availability of a fast (less than a few tens of seconds) and high performance (i.e. water mark free) drying technique. Therefore, Rotagoni^{TM} drying, a novel fast drying method for single wafer wet cleaning, has been proposed [5]. This method minimizes evaporation, was found to be watermark free and yields excellent particle performance [5].

CLUSTERED SINGLE-WAFER WET CLEANING

In current IC manufacturing the vast majority of the individual processes physically take place in a single wafer mode. For production on larger diameter wafers this trend towards single wafer processing is even more pronounced. Already today it has been established that for some applications, in order to avoid degradation, the time between an individual process step and the pre- or post-cleaning process needs to be minimized. This has led to the definition of critical time constraints (e.g. for pre-gate cleaning and post-CMP cleaning). Obviously, for such applications the introduction of a *single wafer clustered clean* is the most straightforward approach. Clustered single wafer cleaning eliminates timing variations, thereby reducing the standard deviation of the process control parameters. In addition, the cycle time is reduced. Clustering post-process cleans, shortens the inspection loop considerably and thus reduces scrap wafers. Clustered cleans have often been associated with dry cleaning. Currently, however, wet cleaning is largely outperforming dry cleaning [6].

Future wafer fabs are believed to look quite different than today. No longer will equipment be grouped by its functionality, but rather combined according to the process sequence. A lot of the processing is expected to occur in large single wafer clusters which comprise lean single wafer wet cleaning modules. The simplified cleaning processes using less steps will results in rather simple cleaning modules and chemical distribution systems. This allows to keep the cost down while obtaining high performance.

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Presenting Author:
Mertens, P.W.
Imec vzw

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Complete Author List:

P.W. Mertens[1]

F. Holsteyns[1]

R. Vos[1]

G. Vereecke[1]

W. Fyen[1]

J. Lauerhaas[2]

K. Xu[1]

T. Bearda[1]

I. Teerlinck[1]

S. Arnauts[1]

K. Kenis[1]

M.O. Schmidt[3]

M. Heyns[1]

[1]Imec vzw
Kapeldreef 75, B-3001 Leuven, Belgium
Phone: 32-16-281211
Fax: 32-16-281214
E-Mail: paul.mertens@imec.be

[2]Verteq inc.
Suite 100, 1241 E. Dyer Rd, Santa Ana, CA92705, USA

[3]Infinion
Dresden, Germany

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