

Preface

The International Symposium on Ultra Clean Processing of Semiconductor Surfaces (UCPSS) is a bi-annual conference organized by IMEC since 1992. Since the first editions of the symposium the scope includes contamination, cleaning and surface preparation in mainstream large-scale semiconductor IC manufacturing with typically silicon as the main semiconductor of interest. Over subsequent editions, the scope was broadened to cleaning of surfaces of all other materials used in micro-electronic circuits and devices, such as dielectric insulators, metal-based interconnects and other semiconducting materials, such as Ge, SiGe, SiC etc. Over the last 50 years, the industry of integrated circuit fabrication has steadily grown to a large major mature economic activity. The application of IC technology has diverged into new applications besides digital logic and memory IC's, such as: power devices, various types of sensors and large-area electronics, that are all in the scope of the conference.

Early on, Gordon Moore defined the trend for reducing the cost per function (or per transistor) over time. The economic drive of reducing the cost per function is continuing. At first, more channel width (area) is fit on the area of the chip by folding or stacking the transistor channel area into thin lamellae in different ways (e.g. Fins or other configurations) resulting in rather complex geometric shapes. These geometric configurations present new challenges to get chemical action effective in all corners and space, with high yield. At the same time progress is made on process simplifications that can lead to saving on patterning steps. For instance, replace deposition or etching steps by selective processes or patterning at once multiple stacked layers like in NAND-flash memory circuits. All these processes come with challenging cleaning and selective etch requirements. Beyond mere chip fabrication itself, breaking down circuits in smaller chips and advanced packaging schemes can further help to enhance overall yield and hence drive the cost down.

In parallel with purely economic aspects that drive the future trends, environmental and sustainability aspects play an increasingly important role. Often both aspects match as they rely on a reduction of required resources (e.g. self-aligned additive processing replacing subtractive processing), re-use and recycling. In this subject the current edition of UCPSS nicely reconnects with the activities in this field in the late 1990s, some of which got published in earlier editions of UCPSS.

The individual contributions to this conference are often specific and specialized, but the fundamental and technological aspects can be applied in many other fields. The knowledge can be extended to cleaning and surface preparation of other materials and for different applications (numerous consumer cleaning applications, optical surfaces, medical applications, life science, food industry etc.). It can even be extended much broader to any field where the interface between a fluid and a solid surface plays an important role (electro-plating, surface modification, surface wetting, lubrication, corrosion, adhesion, coating, ...).

During the previous edition of the symposium, the world was facing a pandemic spreading of the dangerous COVID19 virus. As a result, the 15th edition got postponed by 1 year and finally converted to an on-line format, in April 2021. Although this internet-based edition was well received, many participants experienced the lack of informal contacts of a real life edition of UCPSS. During the preparation of this 16th edition it became clear that all participants are eager to meet in time & space in a life edition of UCPSS and celebrate the symposium's (30 + 1)th anniversary. This additional 1-year slip was introduced during the COVID19 pandemic. As we all appreciate to be relieved from the pandemic and accompanied restrictions, the world faces new challenges such as man-induced environmental issues, and build-up of geopolitical tensions and even a war in Eastern Europe, which in turn generate new barriers and challenges for international symposia like UCPSS.

Indeed, the UCPSS symposia are characterized by an informal character with strong interactions between experts which stimulate and contribute to progress of the field. The sixteenth international symposium on Ultra Clean Processing of Semiconductor Surfaces has been scheduled to take place in Bruges, Belgium on 12th till 14th September 2023. The symposium is preceded by a tutorial session on 11th September 2023.

In addition to the informal and interactive character of the physical symposium, a major and lasting result of an edition of UCPSS is its proceedings. It is the collective recording of the entire conference, available for consultation in the future by a much larger community beyond the mere symposium participants. The structured format of the proceedings allows one to quickly find information on any specific subject. The proceedings of all editions of UCPSS are a rich source of specialized information on the subject matter. As such these proceedings provide the benchmark and foundation for new developments.

This symposium proceedings volume covers all presentations and consists of 55 papers, comprising 4 invited papers. The manuscripts are arranged according to their main topic in 12 chapters. The first 6 chapters concentrate on advanced (logic and memory) devices and in particular the use of liquid and gas phase chemical cleaning and etching processes. The surface chemistry and removal of contaminants from the surface is treated in these chapters: dealing first with Front-End-of-Line (FEOL) processes. Then, any surface treatment involves the exposure to a fluid. Such fluids may contain contaminants. Prevention is preferred over curing. Therefore, reducing the density of defects on the surface requires tight control of undesired trace impurities in fluids to enable ultra-clean processing. These aspects are treated in chapters 7 and 8. Chapter 9 covers fluid dynamics aspects of single wafer liquid processes. Chapter 10 focuses on removal of particle-shaped contaminants. In view of global environmental challenges, we are particularly delighted that we have a chapter (11) dedicated to aspects of sustainability. This volume concludes with interconnect processes in chapter 12.

At this symposium experts from all over the world gather with a representation from most of the leading cleaning chemical suppliers, the equipment manufacturers and almost all leading integrated device manufacturers as well as staff from academia and R&D-centers. The attendance is an indication of the interest in the topic and the huge cleaning challenges in new technologies. The symposium fosters the participation of students, which resulted in 10 student presentations.

A conference is organized with the commitment and efforts of many. Particularly with respect to this proceedings volume we would like to thank all the authors for submitting their results for publication in this conference and for their diligent follow-up in the peer review process. We thank the program committee members for their great job in paper selection. Finally, we would like to thank all reviewers to provide constructive feedback in a timely manner that resulted in significant improvements of the papers in this volume.

We believe UCPSS and similar symposia contribute to the search for new solutions to new challenges. In this perspective we invite you already to the 17th edition of this symposium to be held in 2025. Updated information concerning future editions of this symposium will be posted on www.ucpss.org.

Leuven 10th July 2023,

Paul Mertens, Antoine Pacco, Quoc-Toan Le and Kurt Wostyn, Proceeding editors

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