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Nanolithography Equipment for it, Electronics and Photonics – a Technology, Industry and Global Market Analysis

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Abstracts

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Nanoscale lithographic apparatus are indispensible tools used to manufacture integrated circuits (ICs), flat panel displays, optoelectronic and photonic devices as well as micro-electromechanical systems (MEMS), all involving nanoscale structures. The advancement in photolithography technology has been the key to the rapid development of the semiconductor industry. Countless innovations and progress in this field will continue to drive technological development in the semiconductor industry.

Semiconductor chip manufacturers use many different types of equipment in the making of integrated circuits. There are 300 to 500 process steps, utilizing over 50 different types of process tools, required in the making of a single device like a microprocessor. Semiconductor chip manufacturers seek efficiency improvements through increased throughput, equipment utilization and higher manufacturing yields. Capacity is added by increasing the amount of manufacturing equipment in existing fabrication facilities and by constructing new fabrication facilities. Historically, every seven or eight years, the semiconductor industry adopts a larger silicon wafer size to achieve lower manufacturing costs; the ability to produce more chips on a larger wafer reduces the overall manufacturing cost per chip. For example, the use of 200mm wafers in production began at the end of the 1980s. The migration from 200mm to 300mm began at the end of the 1990s. Today, most wafer fabrication facilities use wafers with a diameter of 300mm, and there are plans to move to 450mm wafer diameters.

As wafers became larger, the integrated circuits on the wafers became increasingly smaller and more densely integrated, moving from below the sub-micron range (1000nm, or 1 micron, to 100nm, or 0.1 micron) to the nanometer range, which was considered to be 100nm or less in 2002, when computer and memory chip manufacturers moved from working in the 120nm range to 65 nm. Nanofabrication equipment is now used to create integrated circuits in the 65nm to 45nm range, and in 2009, companies such as Intel and Sandisk have started to move to manufacturing computer chips and memory chips in the 32nm range. Intel has announced that it will spend $7 billion dollars over the next two years for equipment to manufacture computer chips in the 32nm range in the U.S. The cost of setting up a factory, known as a foundry, for producing microprocessors and data storage is between $1 billion and $3 billion depending on the desired capacity of the foundry.

The continuing worldwide economic slowdown has driven sharp reductions in semiconductor manufacturers’ capital budgets, and nanofabrication equipment manufacturers are experiencing a greater-than-expected decline in orders and revenue as a result.

Nevertheless, the introduction of non-optical lithography will be a major paradigm shift, required in order to meet the technical specifications and complexities that are necessary for continued adherence to Moore’s Law at 32nm half-pitch and beyond. This shift will drive major changes throughout the lithography infrastructure and will require significant resources for commercialization. These development costs must necessarily be recovered in the costs of exposure tools, masks and materials.

STUDY GOAL AND OBJECTIVES

Photolithography has been a key patterning step in most integrated circuit fabrication processes. Resist, a photosensitive plastic, is spun on a workpiece, baked, and exposed in a pattern through a reticle, usually by ultraviolet (UV) light. After development and a second bake, the surface is left partially covered by an inert organic film that resists various treatments to which the workpiece is subjected. Such treatments include material removal by wet chemical etch or by gaseous plasma etch, doping by ion implantation (e.g., broad beam implantation), and addition of material (e.g., lift-off). The preparation, exposure, development, cleaning, caring, and stripping of resist can increase the number of fabrication steps tenfold, requiring expensive equipment and facilities to establish stable, qualified, and high yield fabrication.

Photolithography has been the main lithographic tool for processing patterns of resist down to 45nm. However, present and future microelectronics will require minimum feature sizes below 45nm. While advances in a number of lithography techniques (e.g., ultraviolet (UV), enhanced ultraviolet (EUV) emersion, maskless emersion, laser, phase-shift, projection ion, and electron beam lithography (EBL)) may enable high-scale production at these dimensions, they are all nearing their theoretical limits with respect to wavelength, overlay accuracy, and/or cost. Pushed to the limit, the weaknesses of each process present difficult problems, and the resulting patterning defects can result in significant yield loss. The study examines the state of the art and emerging technologies.

This study focuses on nanofabrication equipment for information technology (IT) and electronic devices. The study provides market data about the size and growth of nanofabrication application segments, industry trends, new developments including a detailed patent analysis, and company profiles. Another goal of this report is to provide a detailed and comprehensive multi-client study of the market for nanofabrication equipment in North America, Europe, Japan, China, India, Korea and the world for IT and electronic devices and potential growth opportunities in the future.

The objectives include a thorough coverage of the underlying economic issues driving nanofabrication for IT and electronic devices, as well as assessments of improved nanofabrication materials and techniques that are being developed. Another important objective is to provide realistic market data and forecasts for nanofabrication equipment nanotechnology. This study provides the most thorough and up-to-date assessment that can be found anywhere on this subject. The study also provides extensive quantification of the many important facets of market developments in nanofabrication systems and hydrogen energy use all over the world. This, in turn, contributes to the determination of the kind of strategic responses companies may adopt in order to compete in this dynamic market.

The goal of the study was to determine the current and future financial and technological state of the nanofabrication equipment industry for the IT and electronics businesses, as well as the influence of related nanotechnologies. One of the objectives was to determine how many organizations in each nation were involved in different types of nanofabrication equipment. The study provides a review of the activities of the top organizations developing nanofabrication equipment and techniques for IT and electronics.

REASONS FOR DOING THE STUDY

Nanofabrication equipment is the enabling technology for IT and electronic devices now being sold and this will continue to be so. There is no other technology on the horizon that can compete with nanofabrication equipment in the ability to create the most powerful microprocessors and memory chips for computers, electronic devices and other applications. The industry is considered critical to continued economic development in the U.S. as well as Japan, China, Korea and the member states of the European Union.

CONTRIBUTIONS OF THE STUDY

The study gathers into one place current information related to the technology of nanolithography and the application markets where this technology is used to manufacture products, amounting to over $850 billion dollars.

As nanolithographic methods are key to increasing the speed and capacity of computers and communication lines, as well as a host of other products in every field of human endeavor, more than 200 recent patents and patent applications were examined to insure that the study contains the latest technological information.

The study will benefit existing manufacturers of lithography and nanofabrication equipment that seek to expand revenues and market opportunities by expanding and diversifying the use of their equipment in manufacturing semiconductor, photonic, optoelectronic and MEMS devices.

SCOPE AND FORMAT

The study examines the companies that provide equipment to semiconductor and electronics manufacturers to enable them to produce not only microprocessors and memory chips, but also display technologies such as plasma screen TVs and computer screens as well as the screens on cellular telephones. Microprocessors and memory chips with nanoscale architecture are found in computers, cellular telephones, MP3 plays, DVD players, plasma TVs, cars and airplanes of all sizes and makes – in fact, in virtually any device that contains a microprocessor or computer chip manufactured after 2006. The “Digital Age” is very much the “Age of Nanofabrication.” At 1976 transistor prices, an IPod® would cost 3.2 billion dollars, according to Applied Material calculations. That fact highlights the importance of lithography at the nanoscale, as it it the technology that makes printing millions of transistors in a space measured in less than a few square inches possible and affordable.

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This study focuses on nanofabrication techniques and apparatus, their state of development, their costs, and the markets for nanofabrication equipment. The broad categories of nanofabrication machinery and techniques covered include: deposition processes, lithography techniques, beam technologies, etch & clean processes, assembly and test equipment and services, metrology on the nanoscale and other wafer processes. Many of the nanofabrication processes used in semiconductor manufacturing are beginning to be adopted by the solar power manufacturers, who use silicon to form the solar power collector panels. The solar power industry represents a growing market for manufacturers of nanofabrication apparatus.

The materials, manufacturing methods and machinery used in producing nanomaterials for IT and electronic applications are examined.

TO WHOM THE STUDY CATERS

Process engineers working in EUV lithography process development, photomask engineers working on EUV masks, and lithography equipment engineers working on the development and evaluation of exposure tools may find this report of interest.

REPORT SUMMARY

Nanofabrication equipment has been used to create integrated circuits in the 65nm to 45nm range, and companies are now moving to manufacturing computer chips and memory chips in the 32nm range.

In 2008, nanofabrication apparatus enabled semiconductor manufacturers to transform more than $11.4 billion worth of silicon wafer material into more than $425 billion worth of semiconductor, photonic, opto-electonic and MEMS material devices for use in computers and electronic devices, which in turn constituted a global market valued in excess of $1.38 trillion dollars, plus related services valued at $5 trillion dollars globally.

Semiconductor and electronics manufacturers spent roughly $80 billion in 2007 and $74 billion in 2008 for silicon wafers, materials and equipment which allowed them to manufacture integrated circuits at scales to 45nm, and they are now beginning to buy equipment to manufacture integrated circuits at the scales of 32nm and 22nm.

The overall market for wafers and nanofabrication equipment is expected to grow at nearly 10% a year for the next five years and grow from an estimated $65.8 billion in 2009 to $105.6 billion in 2014.

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Companies involved in nanofabrication materials, apparatus, metrology and testing for the IT and electronics industry had sales in excess of $80.013 billion in 2007 and more than $73.558 billion in 2008, reflecting the worldwide economic downturn.

Research and development (R&D) spending for improved nanofabrication techniques and equipment exceeds $7 billion a year at the corporate level. Research and development of manufacturing equipment for 45nm technology for semiconductors, which began in 2003, is now the manufacturing standard, and the new standard under development is 32nm architecture, beginning to be implemented in 2009. Each reduction in size results in more powerful microprocessors, memory chips and silicon-based solar power collectors, in which creates new demands. Lithography, including masks and resist, and associated metrology currently comprises 30% to 40% of the entire cost of semiconductor manufacturing. This fraction depends strongly on the product mix, volume of integrated circuits in demand per design, and age of equipment in the factory.

The iRAP study identified over 200 companies and institutions involved in as manufacturers and developers as well as researchers. These companies are driving the technology to the next generation of nanofabrication in the semiconductor industry.

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Controllable Crystal Oscillator
Frequency Synthesizer With Acoustic Resonance VCO
Temperature Stabilized Voltage Controlled Oscillator
List of Patents Granted by the European Union
Method for Producing Polycrystalline Silicon Germanium Suitable for Micromachining
Method for Encapsulating a Device in a Microcavtiy

COMPANY PROFILES

Abracon Corporation
Dalsa Semiconductor
VTI Technologies OY
VTT Technical Research Centre of Finland

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