

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

<https://marketpublishers.com/r/NCDCD2BFDC1EN.html>

Date: November 2009

Pages: 444

Price: US\$ 3,950.00 (Single User License)

ID: NCDCD2BFDC1EN

## Abstracts

**Print Copy** - US\$3,650.00

**Single User License** - US\$3,950.00

**Multi-User License at the Same Location** - US\$4,950.00

**Enterprise License** - US\$5,950.00

Nanoscale lithographic apparatus are indispensable 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, curing, 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 is the technology that makes printing millions of transistors in a space measured in less than a few square inches possible and affordable.

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-electronic 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.

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.

## Contents

### INTRODUCTION

Study Goal and Objectives  
Reasons for Doing the Study  
Contributions of the Study  
Scope and Format  
Methodology  
Information Sources  
Whom the Study Caters To  
Author's Credentials

### EXECUTIVE SUMMARY

Summary Table Summary of Global Market for MEMS Oscillators by Market Domain Through 2013 (\$ Millions)  
Summary Figure Summary of Global Market for MEMS Oscillators by Market Domain Through 2013 (\$ Millions)

### INDUSTRY AND TECHNOLOGY OVERVIEW

MEMS Oscillator Basics  
Table 1 Comparison of Oscillators by Technologies  
Materials  
Different Structures of MEMS Resonators  
Table 2 MEMS Resonator Structures Commercialized in 2008  
Performance Parameters of a Typical Oscillator  
Table 3 Explanation of Oscillator Performance Parameters  
Table 4 Explanation of Oscillator Performance Parameters and Achievable Values in MEMS Oscillators  
q Factor of MEMS Oscillators  
MEMS Oscillator Electric Circuit Details  
Frequency Trimming Procedures in MEMS Oscillators  
Table 5 Comparison of Frequency Trimming Techniques  
Laser Trimming  
Electronic Frequency Compensation  
Fabrication and Integration of Cmos and MEMS Resonators to Create Oscillators  
Table 6 Technologies Used by Manufacturers of Surface Mountable, Chip-size Package

## MEMS Oscillators

Table 7 Explanation of Technical Terms for Packaging Micro-electromechanical Systems Based Oscillators

Table 8 Explanation of Technical Terms for Manufacturing MEMS- Based Oscillators

MEMS Oscillator Product Categories

Clock Oscillators

Table 9 Frequency References in Computer Buses (> 1-133 MHZ)

Table 10 Frequency References in CPU (>1-3600 MHZ)

Table 11 Frequency References Used in Consumer Electronics Products (> 1-500 MHZ)

Clock Generators

Table 12 Desired Frequency Accuracies in Wireless Systems

Table 13 Commonly Used Clock Frequencies

Real-time Clocks

MEMS Oscillator Applications and Markets

Computers and Networking Market Domain

Table 14 Applications of MEMS Oscillators in the Computer and Networking Market Domain

Consumer and Communication Products Market Domain

Table 15 Applications of MEMS Oscillators in Consumer and Communication Products Market Domain

MEMS Oscillator Market Penetration and Challenges

Technical Barriers

Commercial Barriers

Commercially Available Products

Table 16 Typical Sizes of MEMS Oscillator Devices and Equivalent Conventional Quartz Crystal Oscillator Makes Used in Market in 2008

Table 16 Typical Sizes of MEMS Oscillator Devices and Equivalent Conventional Quartz Crystal Oscillator

Emerging Technologies and Developments in MEMS Oscillators

Quartz MEMS

new Market Entrants

Micro-resonators

Nano-resonators

Other Developments

## **GLOBAL MARKETS FOR MEMS OSCILLATORS**

Market by Product Category



Clock Oscillators

Real-time Clocks

Table 17 Global Market for MEMS Oscillators by Product Category, Through 2013 (\$ Million)

Figure 2 Global Market for MEMS Oscillators by Product Category Through 2013 Market by Technology

Table 18 Global Market for MEMS Oscillators by Technology, Through 2013 (\$ Millions)

Figure 3 Global Market for MEMS Oscillators by Technology, 2008 and 2013 (\$ Millions) Market by Domain

Table 19 Summary of Global Market of MEMS Oscillators, by Market Domain, Through 2013 (\$ Millions)

Figure 4 Global Market for MEMS Oscillators by Market Domain, 2008 and 2013 (\$ Millions)

Market by Region

Table 20 Global Market for MEMS Oscillators by Region, Through 2013 (\$ Millions)

Figure 5 Global Market for MEMS Oscillators by Region, 2008 and 2013 (\$ Millions)

## **INDUSTRY STRUCTURE AND MARKET DYNAMICS**

Market Dynamics

Status of Technology Development

Sitime Corp.

Discera, Inc.

Silicon Clocks

Foundries Specific to MEMS Oscillators

Competition

Merger Deals

Table 21 Alliance/partnership/acquisition Deals Among Manufacturers of MEMS Oscillators From 2003 to 2008

## **PATENTS AND PATENT ANALYSIS**

List of Patents Granted

MEMS Oscillator Drive

Temperature Compensation for Silicon MEMS Resonator

Fabrication of Advanced Silicon-based MEMS Devices

Method for the Closure of Openings in a Film

Temperature Controlled MEMS Resonator and Method for Controlling Resonator Frequency

MEMS Resonator Array Structure and Method of Operating and Using Same  
Frequency And/or Phase Compensated Micro-electromechanical Oscillator  
Method for Adjusting the Frequency of a MEMS Resonator  
Frequency And/or Phase Compensated  
Micro-electromechanical Oscillator  
Temperature Compensation for Silicon MEMS Resonator  
Method and System for Generating a Temperature-compensated Control Signal  
Temperature Compensated Oscillator Including MEMS Resonator for Frequency  
Control  
High-Q Micromechanical Resonator Devices and Filters Utilizing Same  
Method of Fabricating Silicon-based MEMS Devices  
Method and Apparatus for Frequency Tuning of a Micro-mechanical Resonator  
Method for Adjusting the Frequency of a MEMS Resonator  
Temperature Compensation for Silicon MEMS Resonator  
Temperature Controlled MEMS Resonator and Method for Controlling Resonator  
Frequency  
Temperature Compensation for Silicon MEMS Resonator  
Frequency And/or Phase Compensated Micro-electromechanical Oscillator  
Wafer Level MEMS Packaging  
MEMS Resonator and Method of Making Same  
Radial Bulk Annular Resonator Using MEMS Technology  
Method for Producing Micromachined Devices and Devices Obtained Thereof  
MEMS Resonators and Method for Manufacturing MEMS Resonators  
Reduced Size, low Loss MEMS Torsional Hinges and MEMS Resonators Employing  
Such Hinges  
Tunable MEMS Resonator and Method for Tuning  
Frequency Sensitivity Analysis and Optimum Design for MEMS Resonator  
Patent Analysis  
Table 24 Number of U.S. Patents Granted to Companies Manufacturing MEMS  
Oscillators From 2004 Through April 2008  
Figure 6 Companies by Number of Patents Granted for MEMS Oscillators From 2004 to  
April 2008  
International Overview of Patent Activity in MEMS Oscillators  
Table 23 U.S. Patents Granted by Assigned Country/region for MEMS Oscillators From  
Jan. 2004 to April 2008  
List of Patents Granted by WIPO  
MEMS Type Oscillator, Process for Fabricating the Same, Filter, and Communication  
Unit  
Low-voltage MEMS Oscillator

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 Microcavity

## **COMPANY PROFILES**

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

## **APPENDIX I COMMONLY USED FREQUENCY SYNTHESIZERS**

Table 24 Commonly Used Frequency Synthesizers Frequencies (100 to 650 MHz)

## **APPENDIX II FREQUENCY REFERENCES IN WIRELESS**

Table 25 Frequency References in Wireless (1-100 MHz)

## **APPENDIX III - BASIS OF MARKET ESTIMATION OF MEMS OSCILLATORS IN 2008**

Table 26 Basis of Market Estimation of MEMS Oscillators in 2008 -2013

## I would like to order

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

Product link: <https://marketpublishers.com/r/NCDCD2BFDC1EN.html>

Price: US\$ 3,950.00 (Single User License / Electronic Delivery)

If you want to order Corporate License or Hard Copy, please, contact our Customer Service:

[info@marketpublishers.com](mailto:info@marketpublishers.com)

## Payment

To pay by Credit Card (Visa, MasterCard, American Express, PayPal), please, click button on product page <https://marketpublishers.com/r/NCDCD2BFDC1EN.html>

To pay by Wire Transfer, please, fill in your contact details in the form below:

First name:  
Last name:  
Email:  
Company:  
Address:  
City:  
Zip code:  
Country:  
Tel:  
Fax:  
Your message:

**\*\*All fields are required**

Customer signature \_\_\_\_\_

Please, note that by ordering from marketpublishers.com you are agreeing to our Terms & Conditions at <https://marketpublishers.com/docs/terms.html>

To place an order via fax simply print this form, fill in the information below and fax the completed form to +44 20 7900 3970

