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Asahi Glass Succeeds in Development and Mass-Production of Synthetic Quartz Photomask Substrate (QC-i) for ArF Liquid Immersion Lithography

Asahi Glass Co., Ltd.

Asahi Glass Co., Ltd. (Headquarters: Tokyo; President: Masahiro Kadomatsu) has succeeded in the development of "QC-i", a synthetic quartz photomask substrate, which complies with the liquid immersion technology used in ArF (argon fluoride) laser steppers that use ArF lasers as a light source for photolithography in semiconductor production. QC-i can be mass-produced due to substantially reduced production costs, which makes it the world's first substrate for ArF immersion photolithography to be mass-produced. This development is expected to dramatically advance the ultra-fine processing technology that is indispensable for semiconductor fabrication.

As more advanced, sophisticated integration and ultra-fine techniques for devices mounted on LSI chips are required for semiconductor manufacturers, they seek shorter wavelength light sources for the photolithography process by which semiconductor patterns are formed. These manufacturers recently have begun to use 248 nanometer[1] KrF (krypton fluoride) lasers and 193nm ArF lasers, as light sources.

Meanwhile, the semiconductor device manufacturers, aiming to further advance ultra-fine processing technologies, are developing photolithography processes using much shorter wavelength lasers such as the 157nm-F2 (fluoride dimmer) and 13nm-EUV (extreme ultraviolet) lasers. Asahi Glass in 1999 developed photomask substrate and pellicle materials for F2 lasers, and is currently developing photomask materials for EUV lasers jointly with International Sematech of the U.S. (Headquarters: Austin, Texas). Through these efforts, Asahi Glass has strived to shorten the wavelength of light sources. Although development of materials for an F2-laser photolithography process has progressed much, manufacturing costs, including equipments, are still a major barrier to commercialization. It is expected to take from four to six more years before mass-production of an EUV photolithography process is realized, considering the progress of development of peripheral materials. Therefore, the most pressing task for the industry is to develop a photolithography process that can be commercialized at an earlier date and requires less investment.

Facing such circumstances, semiconductor device manufacturers began using conventional ArF laser steppers to develop a liquid-immersion photolithography process that can improve the accuracy of ultra-fine processing, and they are nearing commercialization. In the liquid immersion photolithography process, pure water is put between the stepper lens and silicon wafer to significantly refract the light passed through the lens, so that ultra-fine processing on the wafer is made possible. Synthetic quartz photomask substrates for liquid immersion photolithography require the "low birefringence" property that minimizes irregularities in light polarization.

Leveraging development expertise in dealing with lens materials for ArF laser steppers that the Company has accumulated for years, Asahi Glass has succeeded in the development of synthetic quartz photomask substrate QC-i which can be used in the ArF liquid immersion photolithography on a commercial basis. The characteristics of QC-i are as follows:

(1) The birefringence is 1nm or less, compared with the 4 to 5nm for conventional synthetic quartz photomask substrates for ArF lithography.
(2) As production costs are remarkably reduced, QC-i can be mass-produced. (Annual production at Asahi Glass is estimated at 50,000 substrates of 6 x 6 inch square, with a thickness of 0.25 inch.)
(3) Component technologies include a high-performance planarizing technique conventionally applied in photomask materials for the F2 lithography, and a technique to reduce defects at scales of 100nm or less.

Semiconductor stepper manufacturers are expected to launch mass-produced ArF liquid immersion steppers in 2005 and 2006, and demand for photomask materials for ArF liquid immersion lithography is forecast to grow remarkably. Asahi Glass estimates sales of QC-i at 1 billion yen in fiscal 2008, by coping with the rising demand through the mass production. The Company will continue to develop and produce high quality, high performance materials matching various light sources used in the photolithography process, so that it can offer optimum solutions to its customers.

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[1] A nanometer is one billionth of a meter.

<Terms>

1. Photolithography

The general term for processes of transferring LSI circuit patterns to a silicon wafer and others. Ultraviolet and other short wavelength light sources are used to form fine circuits.

2. ArF laser stepper

Typical equipment for photographic exposure which is used to transfer photomasking patterns to wafers in IC chip manufacturing process. Also called “reduction-projection exposure device.” The ArF laser stepper uses an 193nm ArF laser for its light source.

3. Photomask

An patterned original sheet needed to transfer LSI circuit patterns to silicon wafers and others in the photolithography. A copy of the photomask pattern forms on the mask blank, which is a substrate for the fabrication of photomasks.

4. Semiconductor device manufacturers

Manufacturers of the fundamental devices that constitute electronic circuits, including transistors, ICs and LSIs.

5. Polarization of light

Polarization is occurred when light waves are aligned so that they vibrate in the same direction. In the exposing process to transfer photomask patterns to wafers, polarization of the light source improves the contrast when resist materials are exposed, enabling an easier transfer of finer patterns to the wafers.

6. Birefringence

A phenomenon in which each ray of light entering an object is split into two refractions. Quartz glass causes double refraction, birefringence, due to the distortion caused by strains in the material and other causes. Birefringence disturbs light polarization in ArF liquid immersion exposure equipment, resulting in deteriorated performance.