February 19, 2007

Toshiba Corporation
Shibaura Mechatronics Corporation
Chlorine Engineers Corp., Ltd.

# Toshiba, Shibaura Mechatronics and Chlorine Engineers Together Establish New Chemical-reuse Environment-conscious Semiconductor Resist Stripping Technology

-- Practical Application of Industry's First Electrolyzed Sulfuric Acid Method --

Toshiba Corporation, Shibaura Mechatronics Corporation and Chlorine Engineers Corp., Ltd. today announced co-development of an innovative semiconductor resist stripping technology that employs electrolyzed sulfuric acid. The technology draws on Toshiba's cutting-edge semiconductor process technology, Shibaura Mechatronics' expertise in semiconductor manufacturing equipment and Chlorine Engineers' know-how in high durability electrolyzer technology for high-purity chemicals. It is the first time that electrolyzed sulfuric acid has been applied to resist stripping.

Resist is a masking material used in the lithographic process that forms semiconductor circuits on a chip substrate. Once circuits are etched, the resist must be removed, which is typically done with peroxymonosulfuric acid, produced by mixing sulfuric acid with hydrogen peroxide. However once the process is completed, it is difficult to recycle the sulfuric acid because of dilution by the water released as a by-product of the breakdown of the hydrogen peroxide in the mixture. The new technology allows sulfuric acid to be recycled, as electrolyzing sulfuric acid generates peroxymonosulfuric acid without producing water.

The new technology reduces the volume of sulfuric acid used in resist stripping by 70 percent and totally eliminates use of hydrogen peroxide. As a result, it reduces the overall environmental burden of the semiconductor wet process and adds to the efficiency of wastewater treatment. The new process is also more efficient, and contributes to improved productivity by shortening resist stripping time by 20%.

Toshiba, Shibaura Mechatronics and Chlorine Engineers have already developed a single-wafer resist-stripping system that will be integrated into the resist-stripping process at Toshiba's Yokkaichi Operations in April. Shibaura Mechatronics Corporation and Chlorine Engineers Corp., Ltd. also plant to market the overall system and an electrolyzed sulfuric acid generation unit that can be integrated into the current resist-stripping process. The new technology can be applied to overall process of circuit formation on wafers, and the companies intend to promote such application.

## Outline of Development

The new technology was developed as a substitute for the current sulfuric acid hydrogen peroxide Mixture (SPM) technology applied to the "wet process" of resist stripping.

### 1. Co-development

Development combined Toshiba's cutting-edge semiconductor technology; Shibaura Mechatronics' industry-leading capabilities in semiconductor production systems and Chlorine Engineers' specialist expertise in electrolytic technology.

- Toshiba: new process technology for stripping resist with electrolyzed sulfuric acid.
- Shibaura Mechatronics: system technology for the new process and electrolytic tank.
- Chlorine Engineers: high durability electrolyzer technology for direct electrolysis of concentrated sulfuric acid.

### 2. Comparison with current method

Current method

The current SPM resist-stripping method activated sulfuric acid by mixing it with hydrogen peroxide, accelerating the reaction with the resist. The chemical reaction formula is as below.

| $H_2SO_4$ | + | $H_2O_2$ | → | $H_2SO_5$ | + | $H_2O$ |
|---|---|---|---|---|---|---|
| (sulfuric acid) | | (hydrogen peroxide) | | (peroxymono-sulfuric acid) | | (water) |

* Peroxymonosulfuric acid is activated sulfuric acid, a strong oxidizer that facilitates resist stripping.

Reuse of sulfuric acid is difficult in the current method as sulfuric acid is diluted by water.

New method

The new technology achieves the same reaction and result as SPM but uses electrolyzed sulfuric acid. This is achieved by exciting the acid, as shown below.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $H_2SO_4$ | + | $H_2O$ | → | $H_2SO_5$ | + | $2H^+$ | + | $2e^-$ |
| (sulfuric acid) | | (water) | | (peroxymono-sulfuric acid) | | (hydrogen ion) | | (electron) |

* Peroxymonosulfuric acid production and resist stripping match that of SPM.

The new method allows reuse of sulfuric acid, as the water is also electrolyzed and does not dilute the sulfuric acid.

3. Impact (estimate)

- Impact on resist-stripping process (pattern rework process):
  - sulfuric acid use reduced by approximately 70%
  - hydrogen peroxide use reduced to zero

Customer Contacts:

Toshiba Corporation
Corporate Manufacturing Engineering Center
Technology Planning & Coordination Dept.
Phone: +81 (45) 759-1513
URL: http://cmc.toshiba.co.jp/en/contact.htm

Shibaura Mechatronics Corporation
Semiconductor Manufacturing Equipment Division
Sales Department
Phone: +81 (45) 897-2443
URL: http://www.shibaura.co.jp/e/inquiry/semicon.html

Chlorine Engineers Corp., Ltd.
Puretron dept.
Sales section
Phone: +81 (3) 5245-8131
URL:http://www.chlorine-eng.co.jp