

Strategies for 2nd Hand Equipment in China

Author: Weiping Ma

Contact: weiping.ma@fsi-intl.com

Among the contributors to the rapid growth of the Chinese IC industry, low-cost manufacturing has been a strong advantage, and in part the Chinese industry has been able to keep manufacturing cost low by widespread usage of used equipment. However the worldwide trend in the IC industry is continued technology innovation, with IC design and manufacturing evolving to a new technology node every two to three years, according to the International Technology Roadmap for Semiconductors. Given this fact, it is clear that the Chinese IC industry's primary challenge, in this stage of industry development, is this: How can the industry upgrade technology while maintaining low-cost advantage?

In upgrading process technology, IC fabs need the following:

- 1) An equipment set that is capable of meeting process requirements
- 2) Engineering expertise to effectively utilize such an equipment set.

The choice of equipment and how it is used affect all aspects that determine the IC fab's success: operating cost, capital productivity, and readiness for the next technology node.

Many of the fabs in China now widely use 2nd hand equipment, attracted by its low cost. However 2nd hand equipment is not without its negatives:

- 1) Risk of unknown past usage, application, and maintenance history making the equipment's future performance unpredictable.
- 2) Higher than planned COO due to lower reliability, lower uptime, and increased spending on replacement parts.
- 3) Shorter lifecycle if equipment is not compatible with the next technology node.
- 4) More engineering expertise is needed since more problems occur on 2nd hand equipment than on new equipment.
- 5) Lack of IP and software licensing.

By partnering with the Original Equipment Manufacturer (OEM) the IC fab can mitigate the negatives to a significant extent and truly benefit from the low cost of 2nd hand equipment.

The OEM can provide the following:

- 1) Audit and bring current the 2nd hand equipment, replacing parts and installing new software revision as necessary, thus resolving the issue of unknown past history.
- 2) Update and replace key components, and implement proven maintenance procedures to increase reliability.
- 3) Implement the latest recipes and processes to reduce COO and increase capital productivity.

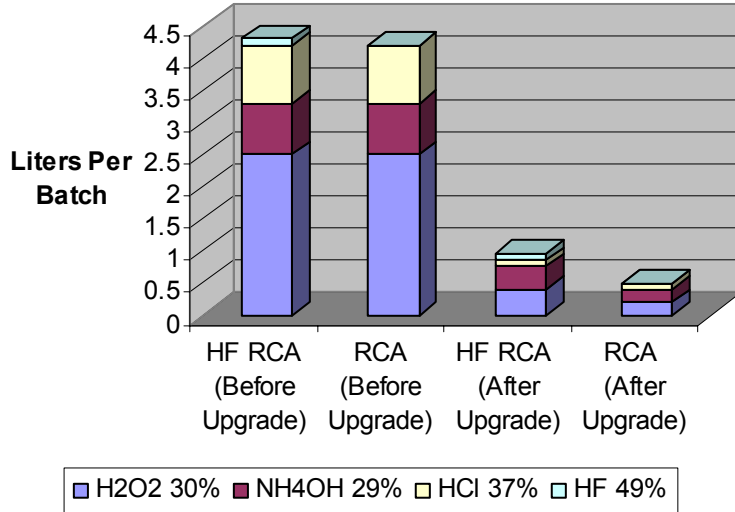
- 4) Upgrade equipment to advance to the next node and/or expand to new applications.
- 5) Provide field support, training materials, and factory training classes for process development and maintenance.
- 6) Provide required IP and software licensing.

Any and all of these services will help the IC fab get better utilization of their existing 2nd hand equipment.

We can examine the issue more closely through a case study. FSI International is a well-established provider of surface preparation equipment with over 30 years of industry experience. The MERCURY® Spray Cleaning System has been manufactured by FSI for 15 years and is particularly well-received by Chinese IC fabs, for its low COO, small footprint, high productivity, and flexibility. The MERCURY Systems have entered the China market in a variety of ways, including brokers, technology transfer, and FSI refurbishment, and they are present in a wide variety of conditions. Many of the 2nd hand units are older models, running out-dated recipes that under-utilize the systems' full capability.

For example, in pre-diffusion clean, RCA cleaning is widely used for 0.25um and greater technology nodes. First developed in 1970 by Kern and Puotinen at RCA, the original sequence included a mixture of NH₄OH, H₂O₂, and DI water (also known as SC1), in a volume ratio of 1:1:5, followed by a mixture of HCl, H₂O₂, and DI water (also known as SC2) in a volume ratio of 1:1:5.. These mixtures require large amounts of chemical. Concentrated chemical mixtures, such as these, are still commonly used in China, however leading IC makers have been using the dilute chemistry approach to RCA clean and enjoying significant reduction in chemical cost. The FSI MERCURY System can be easily upgraded to run dilute chemical processes. FSI offers a Chemical Reduction Upgrade for the MERCURY System, which results in 70% reduction in chemical cost while the process performance remains at the same level (CHART 1). This upgrade package includes the FSI low-flow pick up and control valve assembly and enhanced software. As part of the upgrade package, and FSI applications engineer will help the end user optimize their new recipe. Total cost of this enhancement varies from \$10,000 to \$100,000 depending on the current state of the system. An end user can achieve positive ROI in as little as 3 months.

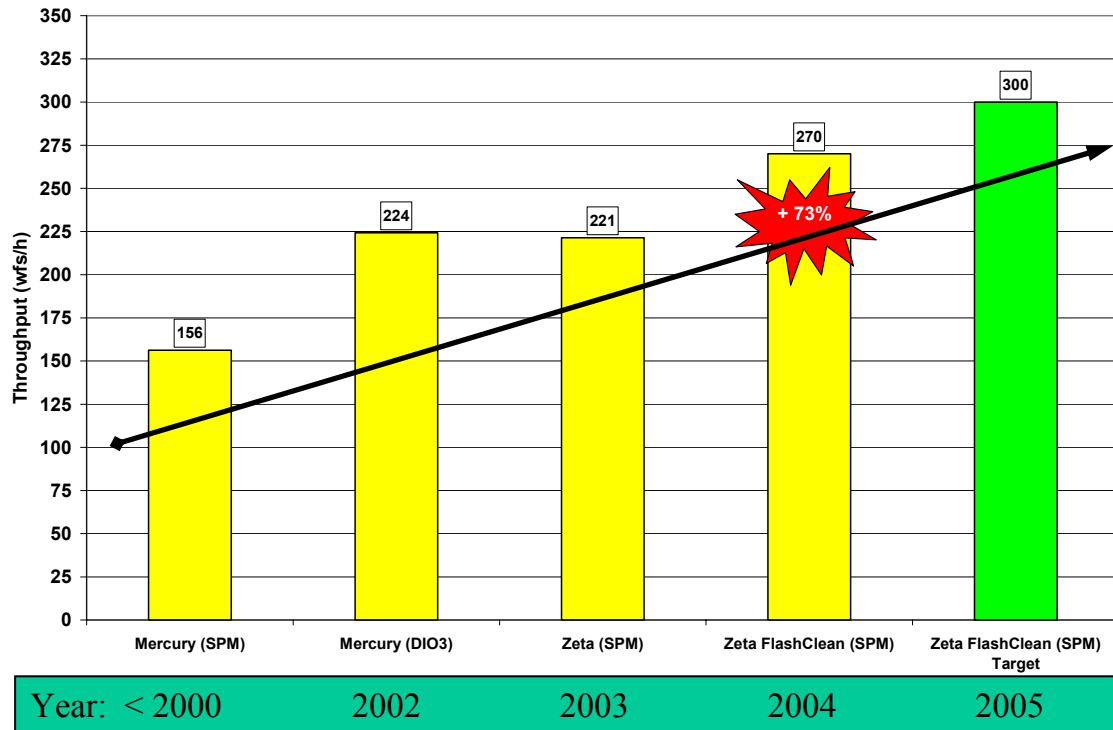
CHART 1. Sample chemical reduction for RCA-based processes on FSI MERCURY® Spray Cleaning System. Each batch consists of 100 wafers at 8 inch or 150 wafers at 6 inch or below.



The Chemical Reduction Upgrade is only one of the many upgrade services available through the FSI MERCURY System Refresh Program. In general, IC makers should be aware of the benefits of continuous improvement, available through OEM suppliers. For example, CHART 2 shows the history of throughput improvement experienced by a leading European IC maker on a post-ash cleaning application using FSI equipment and upgrades.

- 1) Phase I (Pre-2000): Customer used MERCURY System with SPM (sulfuric acid – hydrogen peroxide mixture) recipe for throughput of 168 wafers/hour.
- 2) Phase 2 (2002): Customer replaced SPM with an ozone recipe for throughput of 224 wfrs/hour. The ozone upgrade also provided benefits of lower chemical consumption and lower environmental impact.
- 3) Phase 3 (2003): Customer replaced semi-automated MERCURY System with the fully-automated ZETA® System. However, at the same time, new resist requirements caused the customer to go back to SPM recipe. The throughput took a slight dip.
- 4) Phase 4 (2004): To improve throughput, FSI's Research and Applications Lab developed the FlashClean™ Advantage upgrade. The customer installed this upgrade on their ZETA Systems and reached 270 wfrs/hour throughput. The FlashClean Advantage upgrade also improves particle performance for advanced technology nodes and has also been adopted by leading IC makers in the U.S. and Asia.
- 5) Phase 5 (2005): Continuing improvement programs in partnership with the customer, FSI will introduce further field upgrade packages this year, with the goal of helping customers reach 300 wfrs/hour throughput.

CHART 2. History of post-ash clean throughput improvement at a European IC maker using FSI equipment, recipes, and upgrades. All on 8 inch wafers.



There are several equipment suppliers who offer OEM services for 2nd hand equipment. While the FSI program is unique in the extent of application enablement, while other suppliers primarily concentrate on increasing hardware reliability, all of these programs significantly add value to 2nd hand equipment and prolong their useful life. However, it would be incorrect to conclude that such programs extend equipment life infinitely. In particular, for the vast majority of 2nd hand equipment in China, there are three primary limitations:

- 1) Factory automation requirements.
- 2) Process technology limitations, such as process control.
- 3) Obsolescence of replacement parts, primarily the electronic components.

While these limitations can be overcome with additional upgrade programs, they would be very expensive. Thus there is a point in the life of 2nd hand equipment when the ROI is no longer attractive, and the IC fabs must look to new equipment to satisfy their needs. Once again the IC fab should partner with the equipment supplier in order to enjoy significant leverage in terms of lab facilities and expertise for process development, on-site support, and best-known methods.