

# Si DRIE System for MEMS Devices Manufacturing

## RIE-800iPBC

Nowadays, MEMS devices can add high value in many products, and can be applied to a wide variety of products. Nanofabrication processes for MEMS device manufacturing are also used in various applications, such as biotechnologies, medical and optical communications. The Bosch process for Si Deep Reactive Ion Etching (DRIE) is one of such nanofabrication processes, and has been widely applied to the manufacturing of accelerometers and gyroscopes in automotive components, medical applications such as Micro Total Analysis Systems ( $\mu$ TAS) for diagnostics, and Through Silicon Via (TSV) for three-dimensional LSI. SAMCO obtained the first Bosch Process license in Japan from Robert Bosch GmbH, and has been providing the process solutions to customers worldwide. This report describes the specifications of SAMCO's production DRIE system, the RIE-800iPBC, and its processes.

### Specifications

The SAMCO RIE-800iPBC has a small footprint of 1200×2270×2190 mm (not including dry pumps and a chiller for stage cooling), yet it has a powerful 5 kW RF generator as its ICP source, plus a high-volume turbo molecular pump capable of more than 1000 sccm SF<sub>6</sub> flow, to enable high-speed Si etching. Its optimized gas flow design enables a high rate of gas flow; moreover, its high-speed valves switching of etching gas and deposition gas minimizes scallops.

Additionally, the SAMCO RIE-800iPBC has temperature-controlled reaction chamber wall and reduces contamination of by-products. These capabilities largely contribute to the highly reproducible Bosch process. The RF generator, with its Bias power source, is capable of pulsing, and prevents notches at the boundary of the SOI substrates.

#### Summary of the specifications

Reaction Chamber	Al, inner diameter $\varnothing$ 430 mm
Sample Stage	Al, $\varnothing$ 221 mm, ESC
ICP RF Power	13.56 MHz, crystal oscillation Max. 5 kW automatching
BIAS RF Power	13.56 MHz, crystal oscillation Max. 1 kW automatching
Gas Lines	5 mass flow controlled lines
Vacuum System	R.Chamber : turbo molecular pump + dry pump L.L. Chamber : dry pump
Dimensions	1200(W)×2270(D)×2190(H) mm



Fig.1 Appearance of RIE-800iPBC

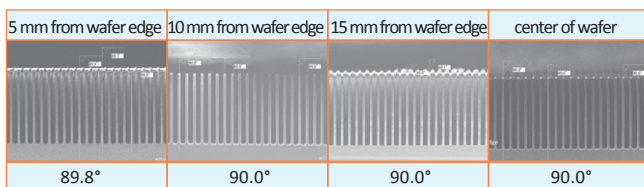


Fig.2 The tilt angle of grating on the  $\varnothing$ 8" silicon wafer

### Process Advantages

#### 1. Tilt Prevention

Precise tilt control is critical in the TSV process, because tilt angle of just 1° could result in the misalignment of a 200  $\mu$ m thick TSV by as much as 2  $\mu$ m. An absolutely vertical Si DRIE process can be achieved with uniform plasma discharge, and the SAMCO RIE-800iPBC creates the highly uniform plasma by means of its lower electrode design for uniform electric field, and its optimized process recipe. As shown in Fig. 2, the etched profiles are vertical on the whole  $\varnothing$ 8" wafers.

#### 2. Scallop Reduction and Removal

The scallops on sidewalls of TSV can result in nonuniformity of the seed layers and ends up with gaps in the copper fillings. SAMCO resolved this issue by two approaches. One is to minimize scallops in the Bosch process and the other is to remove scallops after the Bosch process. The SAMCO RIE-800iPB is capable of high-speed gas switching of 0.1 sec and minimize the scallops. In the recipe for alternating CF<sub>x</sub> passivation film deposition (0.2 sec), passivation film etching (0.2 sec) and silicon etching (0.2 sec), the scallop size was reduced to less than 50 nm, while maintaining the etch rate of 9  $\mu$ m/min. In the recipe for switching CF<sub>x</sub> passivation film deposition (0.2 sec) and silicon etching (0.2 sec), etch rate was 1  $\mu$ m/min, and the scallop was reduced to less than 5 nm (below the resolution of a Scanning Electron Microscope). SAMCO has also developed the sidewall smoothing technologies. Please refer our Technical Report Vol. 82, for more details on this subject.

### Summary

SAMCO has delivered many Si DRIE systems to universities and device manufacturers since 2003. The RIE-800iPBC, along with our accumulated experiences and process knowledge, can provide the etching processes suitable for our customers' various applications. One of SAMCO's advantages is a wide range of systems for MEMS device manufacturing. SAMCO provides not only the Si DRIE systems, but also low-temperature plasma deposition systems and XeF<sub>2</sub> dry etching systems for Si sacrificial layer etching, and can meet the variety of our user's needs. As the pioneer of thin film technologies, SAMCO continues to provide cutting-edge process solutions.