Technical-Report

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. In particular, the Bosch process for Deep Reactive Ion Etching (DRIE) has been widely applied to the manufactruing of accelometers and gyroscopes in automotive components, Micro Total Analysis Systems(μTAS) for medical diagnostics , and Through Silicon Via (TSV) for 3D-IC. 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 having an SF_6 flow rate of 1,000 sccm, to enable high-speed Si etching. Its optimized gas flow design enables a high rate of gas flow; moreover, its high-speed switching valves for etching gas/ deposition gas minimizes scallops.
Additionally, the SAMCO RIE-800iPBC has temperature-controlled reaction chamber wall to reduce 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 Ø430 mm
Sample Stage	Al, Ø221 mm, ESC
ICP RF Power	13.56 MHz, crystal oscillation Max. 500 W automatching
BIAS RF Power	13.56 MHz, crystal oscillation Max. 500 W automatching
Gas Lines	5 mass flow controoled lines
Vacuum System	R.Chamber：turbo molecular pump + dry pump L.L. Chamber : dry pump
Dimensions	1200(W)×2270(D)×2270(H) mm

Fig.1 Appearance of RIE-800iPBC

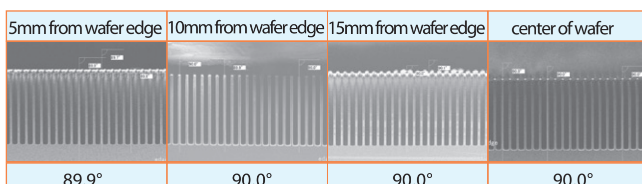

Fig.2 The tilt angle of grating on the 8" silicon wafer

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 μm thick TSV by as much as 3 μm. 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 8"wafers.

2. Scallop Reduction and Removal

The scallops on the etched sidewalls of TSV by the Bosch Process can result in lack of uniformity in the seed layers, and may result in lack of uniformity in the seed layers and copper filling with gaps. We worked on this issue by using two approaches. One is to minimize scallops and the other is to remove scallops on the sidewalls. To minimize the scallops, the SAMCO RIE-800iPBC is equipped with high-speed gas switching of 0.1 sec. In the recipe for alternating CF_x 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 μm/min. In the recipe for switching CF_x passivation film deposition (0.2 sec.) and silicon etching (0.2 sec.), etch rate was 1 μm/min, and the scallop was reduced to less than 5 nm, which was below the resolution of a Scanning Electron Microscope(SEM). SAMCO has also developed its sidewall smoothing technologies. Please refer our Technical Report Vol. 82, for more details on this subject.

Summary

SAMCO has sold many Si DRIE systems to universities and manufacturers since 2003. The RIE-800iPBC, based upon our accumulated experiences and process knowledge, can provide the etching processes suitable for our customers' varous applications. One of SAMCO's advantages is a wide range of systems for MEMS device manufacturing. We can provide not only the Si DRIE systems, but also PE-CVD systems for low-temperature deposition and XeF_2 dry etching systems for the process of Si sacrificial layers, to meet the variety of our user's needs. As the pioneer of thin film technologies, SAMCO continues to provide cutting-edge process solutions.