Advances in Low Temperature Processing in a Hot Wall RTP system

Jeffrey Hebb, James Willis, Peter Frisella, and Aditya Agarwal
Axcelis Technologies, Inc.
Ion Implantation and Rapid Thermal Processing Division
108 Cherry Hill Drive
Beverly MA 01915-1088

The trend toward reducing thermal budget during IC processing is putting more stringent requirements on low temperature performance of RTP. The most important application for mainstream IC processing is advanced silicidation, which may require processing temperatures less than 500ºC. In this paper, we describe advances in low temperature RTP processing in the Summit hot wall RTP system [1].

Temperature Measurement and Control

Temperature measurement and control of processes at temperatures below 450ºC is challenging for RTP systems. Pyrometry is the preferred method for temperature measurement, but the emitted signal at a typical pyrometer wavelength of 950 nm is very weak. One of the main potential sources of error is "stray light", where radiation from the heating source is collected by the pyrometer, when it is only the emitted signal that is desired for the accurate measurement of wafer temperature. The nature of the heat source and processing environment is critical for this issue. Two factors minimize stray light issues on the Summit: 1) The Summit has a continuous large area heat source, which allows the maximum source temperature to only be a few hundred degrees hotter than the wafer processing temperature. The peak wavelength for source radiation is approximately 3 µm, far away from the pyrometer wavelength. 2) The processing environment is non-reflective (SiC and Quartz), further suppressing any issues with stray light. The simple nature of the heat delivery system (stable furnace gradient plus elevator position) coupled with temperature measurement and model based allows temperature control starting at 275ºC. Process control of 300ºC has been demonstrated in the system with steady-state control within ±1ºC[1].

Low Temperature Monitoring

The ability to monitor the low temperature thermal performance of an RTP system in a production environment is essential. Day-to-day wafer temperature repeatability and within wafer temperature uniformity are two critical parameters that are monitored to ensure process control. Thermocouple wafers are intrusive and not suitable for a production environment. Using silicide formation as a monitor can useful, but the resulting sheet resistance is a combination of RTP and metal deposition performance, and it can be difficult to separate the effects of each. In this work, we investigate the use of ion implantation above the amorphous threshold for monitoring low temperature performance. Solid phase re-growth of the amorphous layer can occur at low temperatures, causing both activation and damage repair. The activation can be measured by sheet resistance, and the level of crystal damage can be measured by Thermal Wave Technology. Both of these measurements yield useful information that can be related to thermal performance. Monitor evaluation data and RTP low temperature thermal performance data will be presented.

Nickel Silicide Processing

The system was used to form nickel silicide on blanket wafers. Figure 1 shows preliminary results for 200Å Ni film, which suggests the transformation to the low resistivity phase completion of NiSi phase at temperatures > 350ºC. Net added non-uniformities of < 1 % (1σ) are achieved for the low resistivity phase.

References

[1] J. Willis and J. Hebb, "Cutting Edge Temperature Measurement and Control Over a Wide Range of Process Temperatures in a 300mm RTP System," Proceedings of the 202nd Electrochemical Society Meeting, Philadelphia, PA (2002).

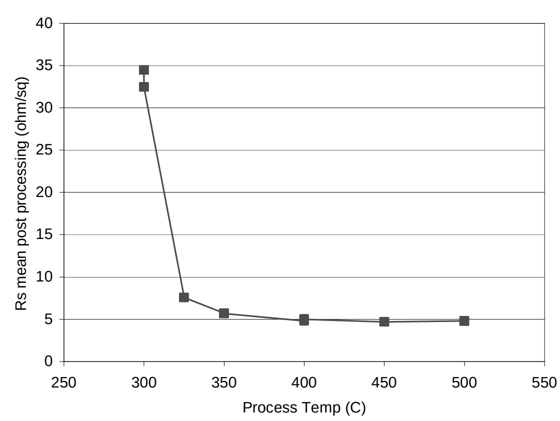

Figure 1: Rs sensitivity for 200Å Ni on blanket wafers. Initial Rs of the wafers was approximately 13 ohms/sq.