RF sensing method to detect low open area end point – Chunhua Song

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RF Sensing has played a role in monitoring plasma processing. Despite its historical significance, the widespread adoption of this technology has been hindered by certain challenges. One significant hurdle is the expertise required for proper interpretation of the data. The electromagnetic fields of a plasma excite a complex scheme of harmonics that vary in intensity based on plasma chemistry, geometry, and power. Extracting useful information from the intricate RF spectra proves difficult. In addition, Traditional VI probe installation, involving the placement of sensors between the electrode and the RF match, poses issues for semiconductor manufacturers.

In this paper, INFICON presents a pioneering RF sensor that is non-invasive and focuses on predicting the end point of low open area etching processes and for chamber clean steps. This innovative approach employs E-field and B-field probes positioned in the near field of the plasma, outside of the process chamber. The content of E and B field harmonics proves exceptionally sensitive to the state of the process and wafer. Many of these harmonics are generated from the creation and collapse of the plasma sheath, in close proximity to the electrode and wafer, where plasma chemistry is indicative of wafer surface condition.

The sensitivity of RF spectroscopy to changes in wafer surface conditions presents a distinct advantage to traditional Optical Emission Spectroscopy (OES) technologies for low open area etching endpoint detection. In addition to sensitivity to detection, this sensor presents an advantage in timing as well. OES signals can only indicate endpoint when a sufficient quantity of emitting particles leaves the plasma through the vacuum, or enter the bulk plasma from the wafer. By contrast certain harmonics in the RF spectrum begin changing immediately when the composition of the plasma sheath changes.

Low open area endpoint detection using an RF sensor requires discrimination between changes occurring in the bulk plasma and those occurring in the deep via structures on the wafer. We have developed an approach using machine learning technology that is grounded in the underlying plasma physics. The algorithm we are developing can be used on a variety of recipes. Machine learning algorithms identify relevant spectral components and learn to detect the endpoint signal within those components in real time. Additionally, separate machine learning algorithms operate between runs to optimize and account for variation in wafer conditions from run to run. This approach, merging real time detection and run-by-run analysis allows the detection algorithm to detect endpoints in short steps, ensures stability, and minimizes the need for user input.

INFICON have performed demos at multiple tier 1 and tier 2 fab and IDMs for the detection capability to the low open area. Results from lab shows the capability of sub 1% open area. We have also proved that signal layer end pointing as well as multi-layer end pointing.

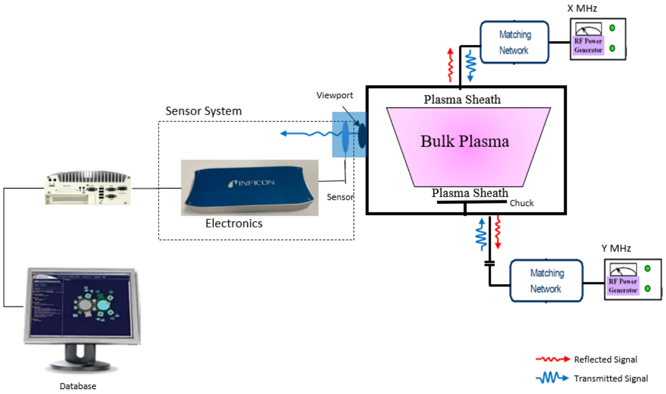

Fig. 1: Overview of INFICON IRAD sensor

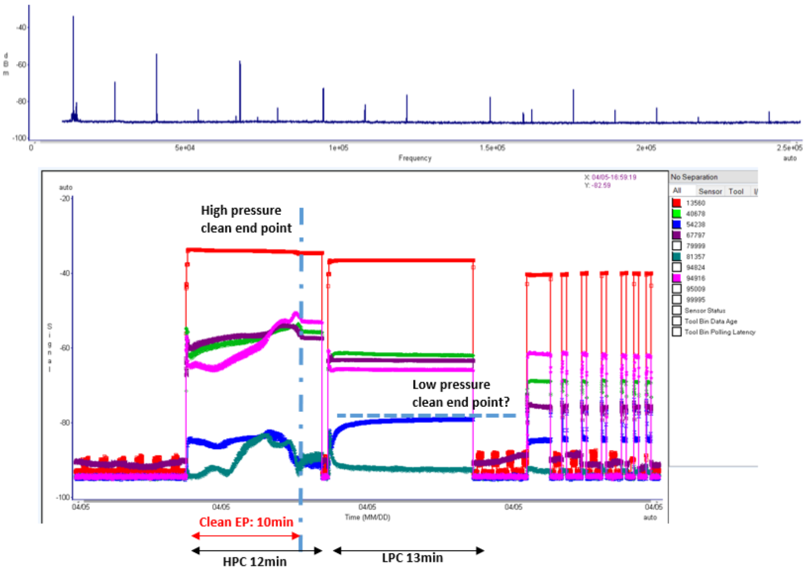

Fig. 2: example of clean end point for field test

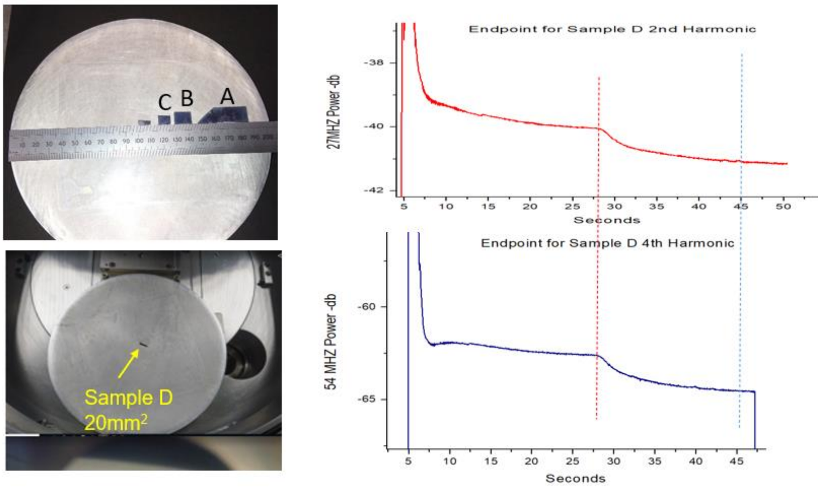

Fig. 3: example of etching end point for lab.