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Ion source life and defect control for ion implanters used in semiconductor device manufacturing

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Semiconductor device manufacturing involves a complex series of processes on silicon wafers. Implanting ions for transistor doping or surface modification is performed at ion energies from sub-keV to a few MeV and require ion currents ~ uA to 100 mA. This wide range requires a broad set of implanter tool types. Across that range are requirements that the ion source has 400 hours of life and up-time is greater than 90%. The ion beam transport across analyzing magnets, parallelizing magnets, and quadrupoles assure high ion beam quality.

We review the ion sources that are utilized in wafer processing with ion implanters. The variety of implant species used on a single implanter demand that the ion source tolerate gaseous molecules of fluorides, hydrides, oxides, chlorides, and iodides [1-3]. Stable and uniform ion beam current, long source life, low beam arcing (<10/hr), and short species transition time are important and competitive metrics for implanters.

Though high mass resolution in analyzer magnets separate contaminant ions from the intended ion beam before impacting the wafer, sputtering, residual gas charge exchange with ions, and other harmful effects, can create particles that land on the wafer. Defects on wafer are detrimental on advanced nodes and imaging sensors directly impact the device yield as shown in Fig.1. The defects specification for 45nm node of was < 50 adders @45nm size to 5nm node < 9 adders @ 32nm to 2nm node of < 2 adders @ 26 nm size. Aggressive mitigation techniques are necessary to maximize wafer device yields.

Ref :

[1]: Tseh-Jen Hsieh, Et al, Enhanced Life Ion Source for Germanium & Carbon, Ion Implantation Tech (IIT) Conf, Nov.2012

[2]: Tseh-Jen Hsieh, Et al, Improved ion source stability using H2 co-gas for fluoride-based dopants, IIT Conf, Oct 2014

[3]: Tseh-Jen Hsieh, Et al, Exemplary Ion Source for the Implanting of Halogen and Oxygen Based Dopant Gases, IIT Conf, Sept. 2016

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