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Production of Various Species of Focused Ion Beam*

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Focused ion beams (FIBs) have been used extensively in the semiconductor industry for many applications such as micromachining, mask repair, circuit modification and failure analysis. As the lateral dimensions of semiconductor devices are scaled down, next-generation lithography (NGL) techniques will be needed to replace optical lithography for integrated-circuit manufacture. Among four major alternative NGL approaches, ion beam lithography is the only one which can provide both maskless and resistless patterning. As such, it can potentially make nano-fabrication much simpler. For this to happen, the ion source must produce a variety of ion species. In a conventional FIB system, the liquid-metal ion source (LMIS) is limited to producing only certain metallic elements such as gallium.

The new FIB system that is under development at the Lawrence Berkeley National Laboratory (LBNL) employs a multicusp plasma ion source. One of the advantages of this type of source is that it can produce various ion species, such as noble gas, phosphorus, boron, oxygen, etc. Low-energy P^+ and BF_2^+ beams can be used in direct ion implantation processes to form shallow p-n junctions; a low-energy O_2^+ beam can be used to selectively oxidize a poly-Si film to form a thin SiO_2 film which can be used as a hard mask for gate patterning in a CMOS process. This makes the multicusp plasma ion source promising for maskless, resistless lithography application.

In this paper, the mass spectrum of positive ions and negative ions will be shown for phosphorus, BF_3 and oxygen multicusp plasmas. Optimization of source operation parameters to achieve high purity of ion species will also be discussed.

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