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Optimization of High Current Xenon Plasma Ion Beams for Applications in Semiconductor Failure Analysis and Development

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The introduction of Xenon (Xe) plasma focused ion beam (PFIB) columns in scanning single and dual beam tools are a significant step forward in the development of ion beam instrumentation for scientific and technological exploration. PFIB's provide significant improvements in ion beam operating currents with as much as 20 times the beam current of conventional Gallium (Ga) Liquid Metal Ion sources (LMIS) and show significant benefits over Ga LMIS sources at currents exceeding 20nA [1]. This substantial increase in beam current makes it possible to perform conventional FIB milling activities in a small fraction of the time previously required. In addition, these advantages have opened up the possibility of using FIB instrumentation in novel applications for FIB sample preparation and macromachining of large structures [2]. Another potential advantage of Xe PFIBs results from the inert nature of Xe as opposed to Ga which could be beneficial in minimizing implant artifacts [3, 4].

The main focus of this work is aimed at characterizing the Xe PFIB from a semiconductor stand-point with emphasis on operation and optimization of the tool for high throughput failure analysis and sample preparation activities. Some of the key aspects of optimizing the tool to achieve these goals revolve around developing a thorough understanding and characterization of the PFIB column. Column characteristics such as condenser and objective voltage settings, aperture selection, adjustment and wear are some of the key parameters that determine how we can optimize the Xe PFIB column to obtain the desired results. Ion beam burns can be used to understand primary probe characteristics and secondary shadow artifacts of the primary probe. Here we address ways and means these parameters can be recorded and optimized. Figure 1 is a plot showing the effect of aperture wear on the primary beam current with higher wear resulting in as much as 3X increase in current. Figure 2 is a combined plot showing the effect of condenser voltage variation on the primary and secondary probe characteristics correlated to ion beam burns shown in the SEM image. Figure 3 shows the effect of varying objective voltage conditions to obtain under-focus/focus/over-focus conditions which can be used for specific FIB applications.

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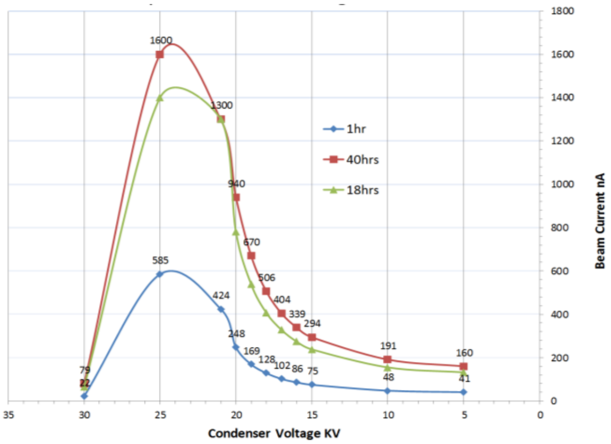

Figure 1. Effect of aperture (400um) wear in hours on final probe current.

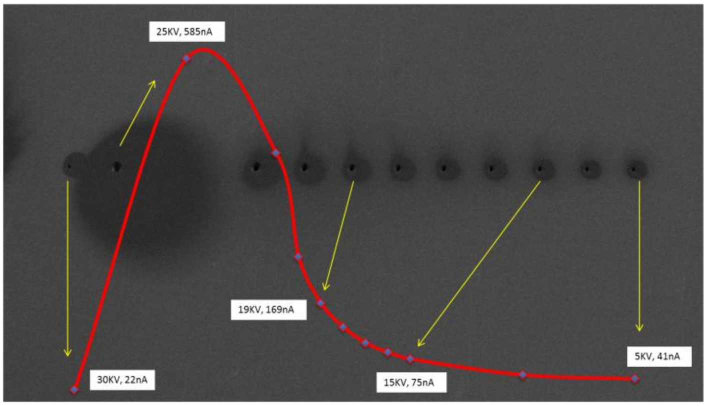

Figure 2. Effect of condenser voltage on primary probe and secondary shadow profile for 400um aperture.

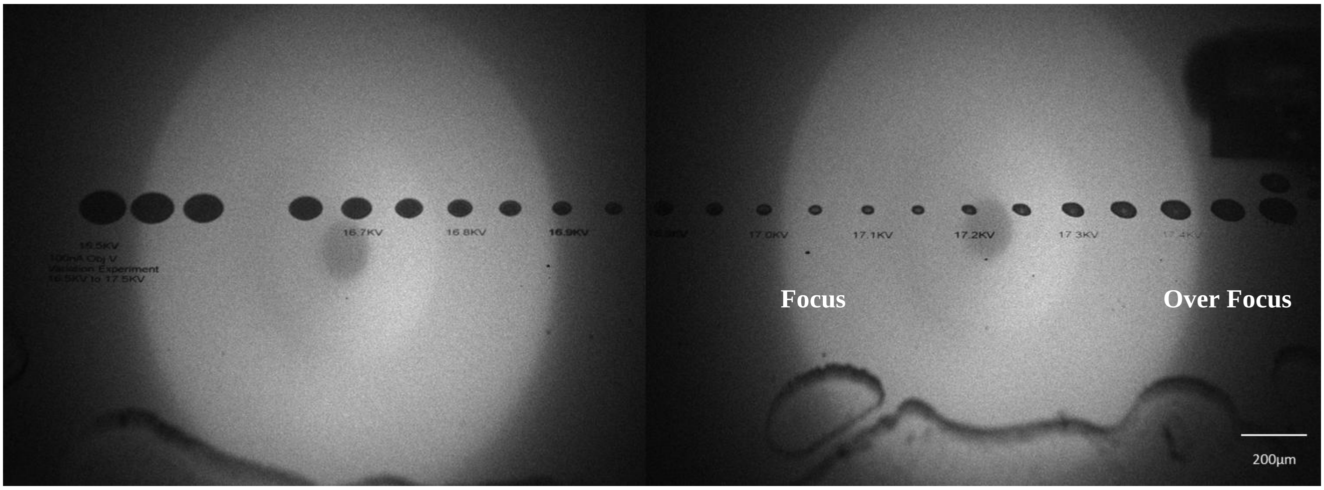

Figure 3. Effect of objective voltage settings to create range of focus conditions for specific milling applications.

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