Preparation of Aluminum Specimen with Gallium and Xenon Plasma Focused Ion Beam for Further Nano-characterization

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Focused ion beam scanning electron microscopes (FIB-SEM) enable highly-localized and site-specific material removal with practically no restriction on sample composition. Depending on the ion source (e.g. Ga^+, Xe^+), the rate of material removal differs significantly. In general, the design of Xe^+ source allows using high ion beam currents that can be up to a few µA while maintaining beam quality and performance, something which is not possible with the Ga^+ sources. Such high ion currents are achievable due to the fact that the Xe^+ source is broader, more collimated and has higher angular intensity. In addition, Xe^+ ions are more massive than Ga^+ thus more atoms are ejected from the target per incident ion, which also contributes to obtain significantly higher sputtering rates. However, the most relevant feature of Xe ions for this study is their non-metallic and inert nature which prevents any chemical interaction with the target material and formation of unwanted metallic compounds that alter the original properties of the sample that is being analyzed. Furthermore, the penetration depth of Xe ions is significantly less than Ga ion for a given energy resulting in less ion implantation that could induce local changes in the crystalline structure of the sample and, in turn, lead to changes in the mechanical properties of the sample. As some materials such as Al, Cu and Ga are sensitive to Ga ions, Xe+ ion milling can be a good asset for many FIB applications that involve working with these materials. This can be considered as a significant advantage over Ga ion source FIBs especially in microanalysis and nano-mechanical characterization. A way to perform nano-mechanical characterization of materials is to prepare nano-pillars to test their mechanical properties. As the Ga^+ ions penetrating into the material (aluminum in our case) during the FIB milling process, they get implanted and can even weaken the material intended for testing. In contrast, it is advantageous to prepare aluminum nano-pillars with Xe^+ plasma FIB since – for the reasons mentioned above – does not introduce significant changes in the material and, as a consequence, the results will be more reliable compared to those in which the pillars had been prepared with a Ga source FIB. Taking these facts into consideration, we pursue the following objectives: (1) Demonstrate the process of pillar preparation with Ga^+ and Xe^+ FIB and show the advantages of the wider ion beam range offered by the Xe^+ plasma FIB. (2) Indicate the influence of gallium implantation on Al materials, (3) Describe the effect of gallium on properties of micron-range grains of aluminum sample treated by the ECAP method via different methods.