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Low Energy, Low Angle, Large Area Ion Polishing for Improved EBSD Indexing

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Good sample preparation is essential for acquiring successful electron backscattered diffraction (EBSD) patterns in the SEM. Mechanical polishing to obtain the required surface quality with minimal sub-surface defects and deformation that does not interfere with the quality of the diffraction data is, more often than not, an art form. Special polishing techniques, such as low force lapping fixtures, electrochemical-mechanical polishing, and vibratory polishing, have been used to minimize the sub-surface damage, but have not eliminated it. Ion polishing has been used to reduce the damage layer further. However, the commercially available ion systems suffer several drawbacks, including: 1) small area treatment (≤ 1 cm) decreasing beam current density with accelerating voltages, 3) inability to process non-conducting samples. Barna and Pecz have shown that at 5° and 3 keV, approximately 25 nm of ion damage occurs in Si and GaAs, but at 250 eV, there is less than 1 nm of damage [1]. They also showed that a glancing angle across the surface is essential for removing topographic features [2].

A Kaufman and Robinson, Inc. 1 cm ion source (KDC-10) was adapted to fit the etch port of a South Bay Technology, Inc. sputter coating/etching system (SBT IBS/e). This ion source overcomes the above limitations. It has a 1 cm beam size that can be collimated, or be convergent or divergent. It can be operated between 100 eV and 1200 eV with a high beam current, and a neutralizer can be used to produce a neutral beam of gas ions that can polish non-conducting samples. This study reports the use of the KDC-10 in the IBS/e to ion polish samples for EBSD analysis. Soft metal samples, typically difficult to polish mechanically, were used such as copper and solder balls. The initial EBSD mapping was done using an Oxford Instruments (HKL) Nordlys camera interfaced to a Zeiss LS15 EVO SEM and latter samples were examined with the same EBSD system on a Zeiss Ultra Plus SEM. Optimal conditions were used for each microscope. Mapping was done using a pixel step size of 0.1μm.

Figure 1A,B shows an EBSD pattern of copper from an integrated circuit package substrate after a mechanical polish with 0.3 μm Al_2O_3 suspension followed by a short 0.05 μm silica polish. A pattern from the same sample is shown in Fig. 1C,D after ion polishing with 250 eV Ar for 40 min at an angle of incidence of 5° and a total beam current of 2.5 mA. Figure 2 shows a band contrast map and a Z-oriented inverse pole figure colorization of a region of the copper within the printed circuit board. The ion polishing step improved the EBSD "hit rate" (fraction of pixels with successful indexing) from about 41% to 81% that is attributed to a significant reduction in grain smearing due to poor mechanical polishing. With some noise reduction, the software was readily able to identify boundaries, including CSL boundaries in the copper. The ion polishing is also being investigated for improved EBSD pattern identification in aluminum and Ti 6AL 4V alloys.

References

[1] A. Barna, B. Pecz, and M. Menyhard, *Ultramicroscopy.* 70, (1998) 161.
[2] A. Barna, and B. Pecz, *Proc. Mat. Res. Soc.* 254, (1992) 7.

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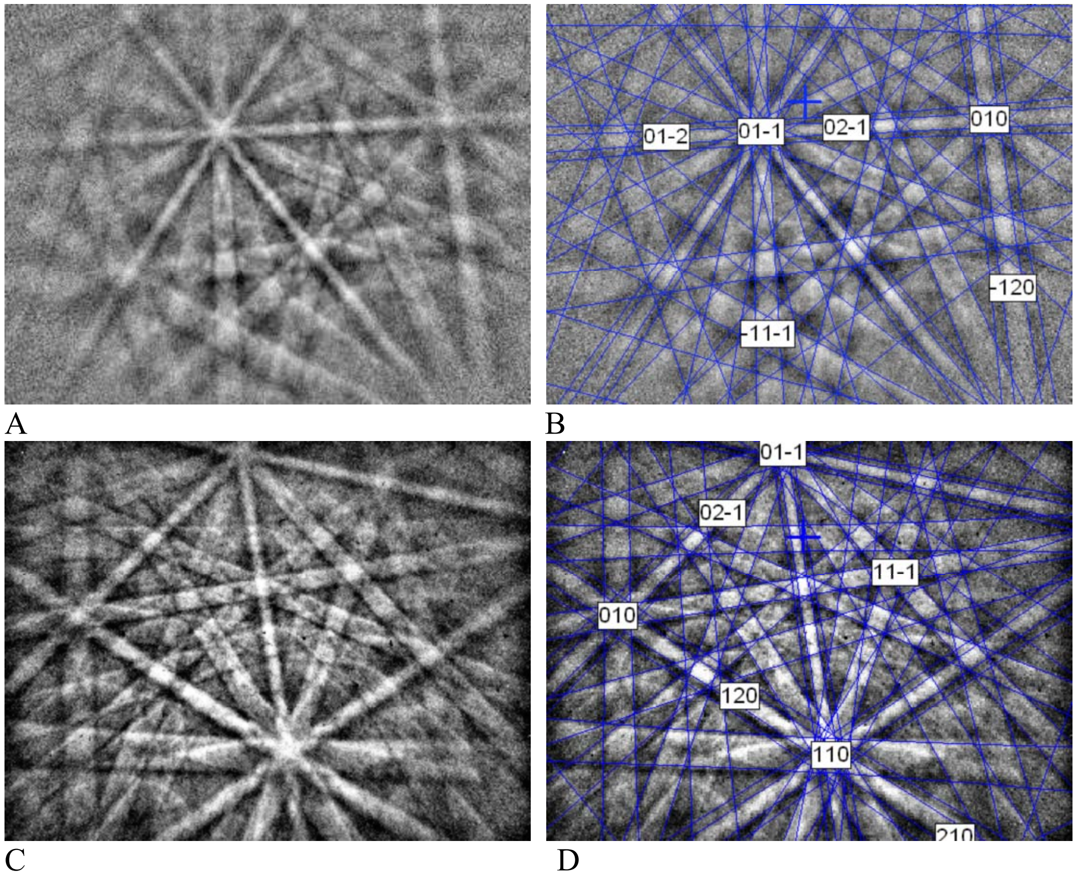

Figure 1. Indexed pattern of copper before (A &B) and after (C & D) ion polish. (B & D are indexed.)

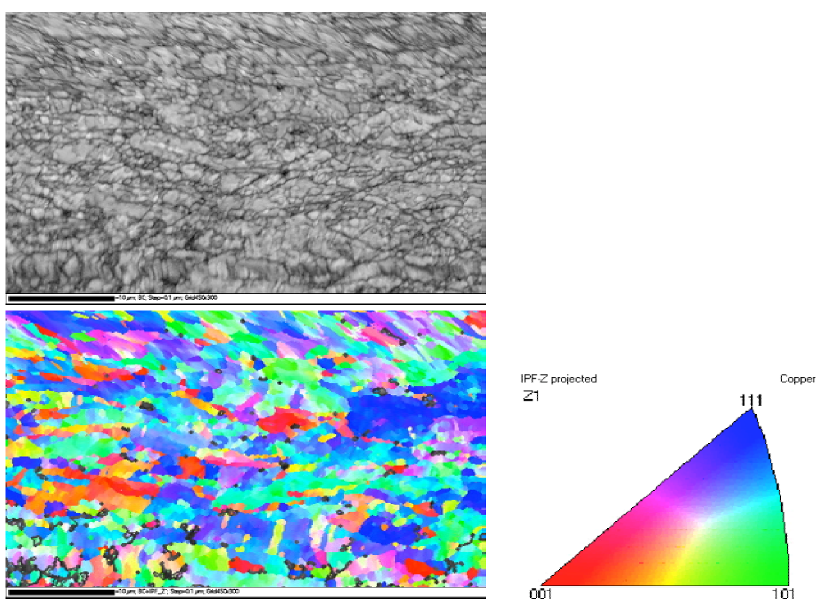

Figure 2. Band contrast image and Z-IPF colorization of copper cross-section in printed circuit board.

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