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Firearm Serial Number Restoration with Electron Backscatter Diffraction

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Serial numbers are the primary means of identifying and tracking firearms, and it is common for serial numbers to be destroyed in an effort to mask the identity of the specific firearm used in a crime. Fortunately, the initial stamping of the serial number results in a deformation field much larger than the mark itself. In some cases, defaced serial numbers can be restored via acid etching techniques, which etch deformed and undeformed materials at different rates [1]. This restoration technique, however, is not always reliable, and is somewhat easily defeated via overstamping or heat treating. A more sensitive reconstruction technique may allow for reconstruction of even severely defaced serial numbers.

The basis of serial number restoration is the detection of sub-surface microstructural change imparted by the marking tool. There are SEM imaging modes, including forward scattered (FS) imaging and electron backscatter diffraction (EBSD), which probe material microstructure and can be extremely sensitive to localized changes the crystal structure of a material. In fact, the use of EBSD in serial number restoration has been proposed previously [2], but a full proof-of-concept has not been demonstrated. In this work, the letter "X" was die-stamped into a polished piece of 316L stainless steel (figure 1a) and then polished away such that the imprint was no longer visible (figure 1b). After the surface was polished, the sample was imaged with the FS and EBSD imaging modes of the SEM.

A tessellation of forward scattered images produced a faint reconstruction of the stamped imprint, outlined by arrows in figure 2a. While the change in microstructure is apparent in the FS image, it is difficult to discern the "X" shape without previous knowledge of the imprinted shape. Conversely, EBSD pattern quality maps, which can provide qualitative information about the localized deformation produce a clear and unambiguous reconstruction of the original imprint, shown in figure 2b.

Further, pattern quality mapping of a cross-section of a stamped imprint indicated that damage detectable via EBSD extends approximately 520 μm beneath the imprint (or approximately 760 μm beneath the surface of the sample). It is yet unclear how this depth sensitivity compares to the traditional acid-etching-based methods of serial number reconstruction. This specific comparison between EBSD and acid etching restoration is the basis of future research on the topic.

Unfortunately, with current detector hardware, the EBSD image acquisition is time consuming. With hardware-based limits of EBSD pixel sizes (6.72 μm), reconstruction of a single character requires up to nine hours of microscope time. Undersampling of the data in figure 2b provides a virtual pixel size increase, indicating that an unambiguous reconstruction can be performed with pixel sizes as large as 67.2 μm, decreasing acquisition time to approximately 5.4 minutes for a single character, and less than 1 hour for an 8-character serial number.[3-4]

[1] J. I. Thornton and P. J. Cashman, Journal of the Forensic Science Society **16**(1976), p. 69-71
[2] C. Necker and R. Forsyth, Microscopy and Microanalysis **16** (2010), p. 1579-9
[3] R. White acknowledges funding from the National Research Council Postdoctoral Research Associateship Program.

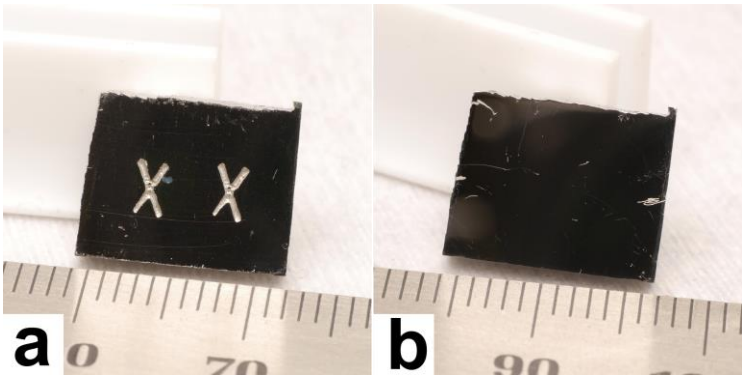

Figure 1. The letter "X" was a) die stamped into a piece of 316L stainless steel and b) ground/polished away to simulate destruction of a firearm serial number. The scale shown in the images is in millimeters.

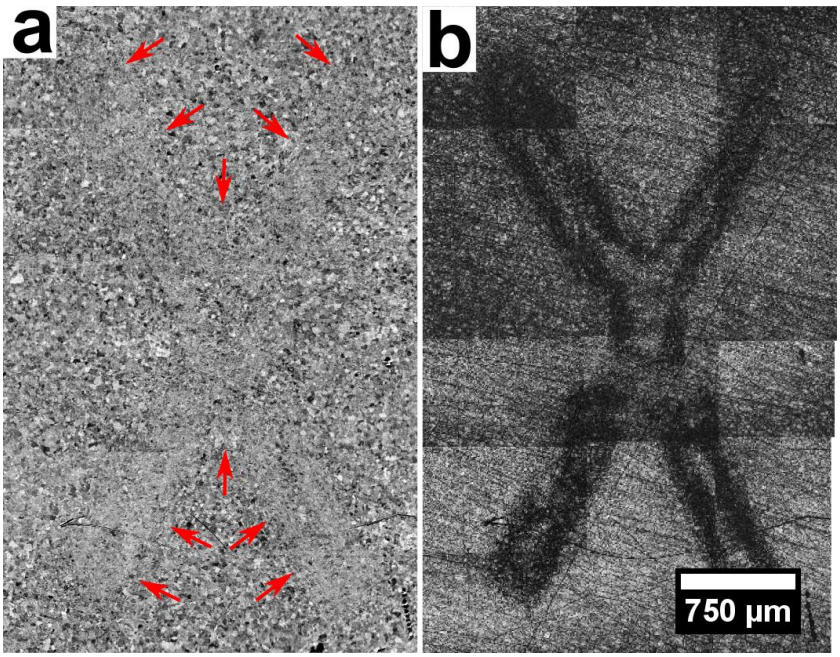

Figure 2. The imprinted/polished area visualized with tessellations of a) forward scattered electron images and b) EBSD pattern quality maps. While the "X" imprint is lightly visible in the forward scattered images, the EBSD pattern quality images produce an unambiguous reconstruction.