Advances in Electron Backscatter Diffraction

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The Electron Backscatter Diffraction (EBSD) analytical technique has evolved into an accurate and efficient tool for crystallographic analysis. The development of commercial indexing software in the late 1990s led to a flood of interest in the technique, as shown in figure 1 by the exponential increase in EBSD-related publications. Several extensive reviews of EBSD have been published [1-3], with the most recent by Dingley in 2004 [4]. Recent software developments, improvements in camera and SEM technology, and ambitious experiments have advanced the technique considerably. Here we briefly review some highlights of the past few years including our own, recent endeavors.

The spatial resolution of EBSD has improved significantly, mainly as a result of newer FEG SEMs with higher probe current at the smallest spot sizes and lowest accelerating voltages. It is now possible to map grains less than 100nm in diameter for most materials [5], and this has enabled significant research on damascene lines in Cu interconnects [6-9]. Sample preparation methods have also advanced. For nonconductive sample regions, a dual masked-gold/carbon coating may significantly reduce beam drift and charging [8]. Wet coating with a colloidal Sn-Pd suspension is reportedly advantageous for porous ceramics [10]. For softer materials, electrolytic polishing generally yields the best results, although final mechanical polishing with colloidal silica may be sufficient [11-13].

Strain quantification using EBSD is becoming a reality. Although pattern quality has been previously used to qualitatively measure strain, measuring the spread of the crystal orientation within a grain provides a quantitative measurement for plastic strain [14]. Furthermore, increases in CCD camera speed and resolution, along with improved pattern correlation algorithms, have made it possible to measure the elastic strain tensor from shifts in zone axes [15]. On the software side of EBSD, several methods for improving automatic indexing have been suggested. These include a revised Hough algorithm [16] and methods to identify *a priori* crystallographic regions of psuedo-symmetry that are problematic [17]. New research areas for EBSD include tribological studies [18], in situ recrystallization and annealing [19, 20], and in situ mechanical testing [21].

Through our current research efforts we have obtained energy-filtered EBSD patterns, utilizing a lens system to retard and collimate the backscattered electrons, which are then filtered through an energy grid with a resolution of ~10 eV. The system was developed by STAIB intruments [22], and a schematic is shown in figure 2. The energy-filtered patterns have enhanced contrast that should aid automatic indexing and phase identification [23]. Moreover, the filter has enabled the investigation of the energy dependence of EBSD patterns, confirming that low-loss electrons are the major contributors [24]. Consequently, our understanding of the EBSD interaction volume and the ultimate resolution of the technique is enhanced.

In summary, several advances in EBSD have been realized in the past few years. Over the next decade we expect increases in the speed and accuracy of EBSD acquisition as well as improvements in phase identification, spatial resolution, and strain quantification [25].

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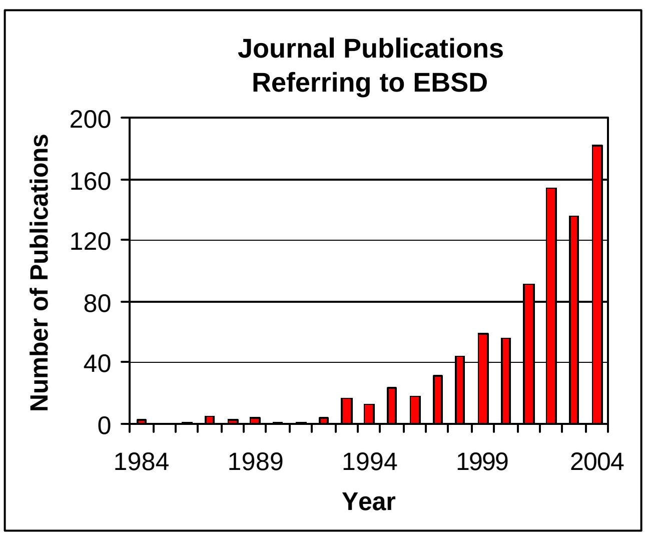

FIG 1. Number of journal publications per year referencing the EBSD technique. Source: SciFinder Scholar using key phrases “Electron Backscatter(ed)(ing) Diffraction” or “Backscatter(ed)(ing) Kikuchi Diffraction”

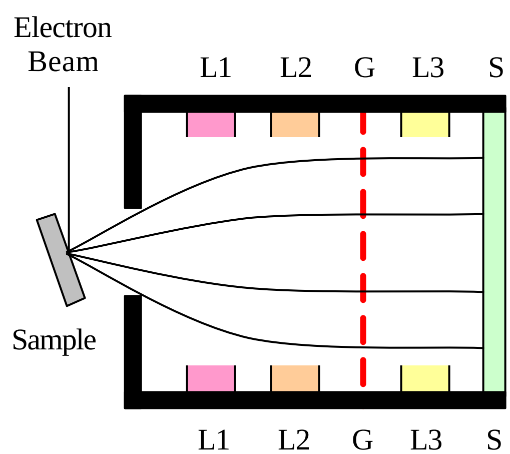

FIG 2. Schematic of the EBSD energy filter. L1, L2 are focusing and retarding lenses, G is the energy grid, L3 is the accelerating lens, and S is the phosphorescent screen.