Diffraction Elastic Constants from Electron Backscatter Diffraction Data and Finite Element Models

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Diffraction elastic constants are used to convert lattice strain measurements to macroscopic stress values. Many models for calculating diffraction elastic constants exist, often based on continuum properties of the macroscopic structure or average properties of single ellipses modeled as Eshelby inclusions. While some of these models are in qualitative agreement with experimentally measured trends, quantitative agreement remains a challenge, particularly when trying to limit bias errors in the macroscopic stress.

In this work, we present a new method for calculating diffraction elastic constants and apply this method to the example of biaxially strained ferritic BCC (body centered cubic) steel. We incorporate EBSD (electron backscatter diffraction) data measured from biaxially strained samples into a finite element model (OOF2) and elastically strain the model to measure the diffraction elastic constants. In addition to providing values for the diffraction elastic constants, the EBSD based finite element model provides insight into the source of the non-linear behavior often observed in the (211) reflection in BCC steels. The non-linear behavior is largely due to two clusters of grain orientations with different stiffness along the normal direction of the sheet, shown in Figure 1.

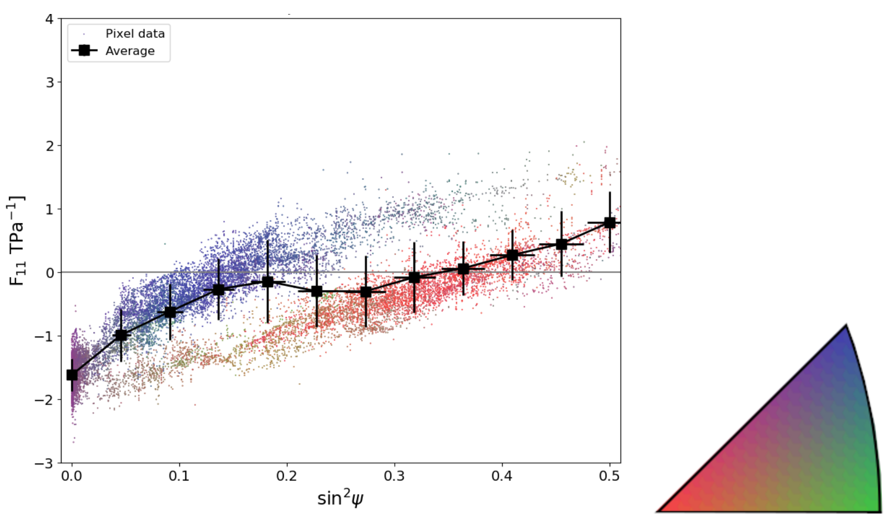

Figure 1: Diffraction elastic constants F_{11} vs $\sin^2\psi$ calculated from an EBSD dataset of biaxially strained steel strained using finite element model OOF2. The dots are the elastic strain aligned with the diffraction vector for each EBSD pixel, color mapped to the crystal direction along the normal direction (IPF color key to the right of the image). The black squares are the mean values binned by $\sin^2\psi$, with y error bars representing the standard deviation values and x error bars indicate the width of each bin.