NANOMECHANICAL BEHAVIOUR OF INDIVIDUAL PHASES AND SIZE EFFECT IN WC-CO BY MEANS OF HIGH TEMPERATURE NANOINDENTATION AND ELECTRON MICROSCOPY: A STUDY FROM AMBIENT TO HIGH TEMPERATURE

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The dependence of the hardness and deformation mechanism of individual phases in WC-Co on microstructural parameters such as grain size and orientation was investigated by nanoindentation and electron microscopy from ambient to high temperature. At room temperature, the binder phase only exhibits a hardness of about 10 GPa, whilst the hardness of WC grains were measured about 29-30 and 37 GPa for the prismatic and basal orientation, respectively. All WC orientations exhibited a similar decrease in hardness as the temperature increased. A broad range of WC prismatic grain areas ($A_{WC\text{-}prismatic}$), from about 2 to 1000 μm^2, were selected and subsequently indented to investigate any size effect. A slight decrease in the hardness of WC prismatic grains ($H_{WC\text{-}prismatic}$) as a function of $A_{WC\text{-}prismatic}$ was observed. Damage mechanisms occurring in WC-Co during nanoindentation were investigated for the different grain orientation at various temperature. The damage was visualised using electron microscopy near the residual indent as well as focused ion beam sectioning across the indent. The three dimensional distribution of plastic deformation across multiple grains in the vicinity of an indent was examined using Electron Back Scattered Diffraction (EBSD) and Electron Channelling Contrast Imaging (ECCI). The ECCI enabled the observation of crystal defects, especially dislocations, in th plastic zone. The dislocation density and spatial distribution in the deformed WC-Co were compared to that of an untested WC-Co to relate the quantity of defects as well as their origin to the state of stress in the material. The collected data represent useful guidance for manufacturer of hardmetals, provides important information underpinning an understanding of the relationship between WC-Co microstructure and mechanical properties, and also highlight the performance of WC-Co at operating temperatures.

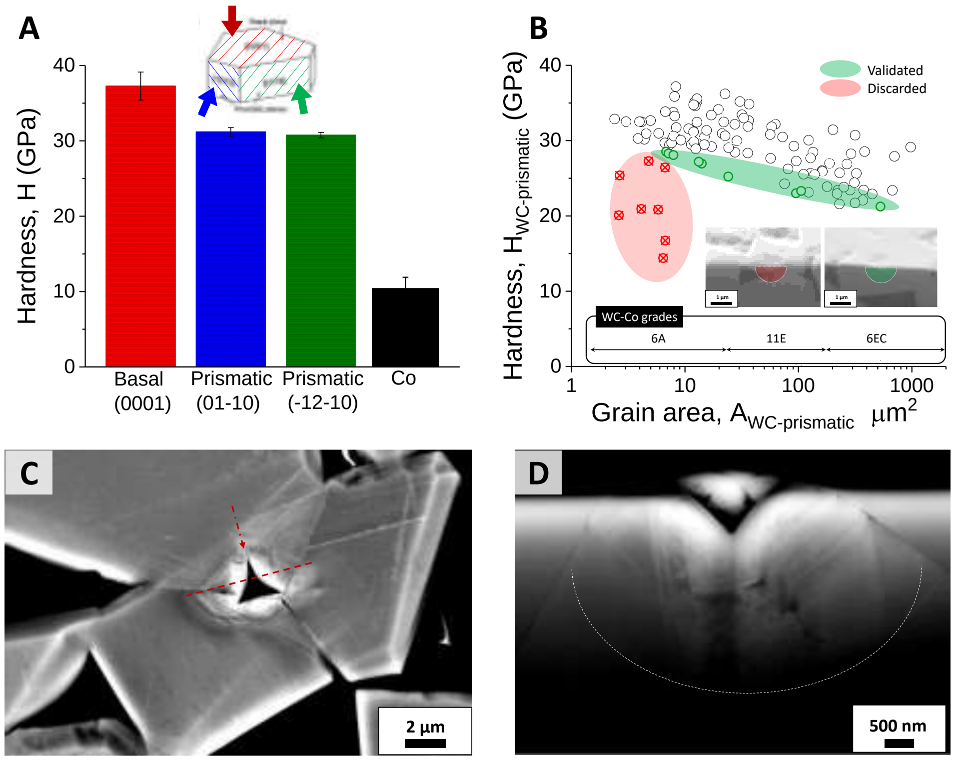

Figure 1. Nanomechanical investigation of WC-Co at room temperature. Hardness, grain size effect, top and cross-section deformation mechanisms evidenced by ECCI (A, B, C and D, respectively).