Towards the perfect neck for HPHT PCD

Differences in the microstructure of PCD have an enormous influence on cutter life. Although there are many suggestions, concrete evidence for which factors are most important is limited. As a result, there is no clear understanding of what the optimum microstructure should be for a given drilling region and therefore no clear direction for the future development of processing.

An important example is the effect of grain size. Fine grained PCD has excellent wear resistance compared with coarser grained grades but tends to undergo catastrophic failure well before the diamond table has worn away to a great extent. Conversely, coarser grades wear more quickly but are less prone to fracture. This suggests an inverse relationship between damage tolerance and wear resistance. However, all microstructures do not plot on the same line of wear resistance against damage tolerance. The ambition is to understand the factors that move PCD towards the top right hand corner of such a plot, i.e. high wear resistance and long life in service, and hence to be able to tailor the microstructure to achieve this in different conditions.

There is now a reasonably rich literature concerning (i) the general processes occurring during service and (ii) the room temperature, monotonic mechanical properties of PCD. However, (i) suggests that both high local temperatures during service (which could cause graphitisation, modification of residual stresses or of innate properties) and gradual damage accumulation are important, which is entirely inconsistent with the conditions of the laboratory work in (ii). In addition, it is thought that subtle differences in processing conditions have a significant effect (e.g. different manufacturers' apparently similar products give different results in different environments).

It is evident from the above that there is room for a materials science investigation of processing/composition/heat treatment-microstructure-property relationships but, in contrast to much previous work, focusing on the conditions of importance to the application such as mechanical properties at the temperatures encountered in service (~ 800 C) and cyclic loading. In addition, state-of-the-art electron optical and other characterisation techniques, using Oxford's extensive range of equipment and expertise, will be used to investigate the differences in microstructure caused by processing variations and subsequent heat treatment and deformation.

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