Cube-textured metal substrates for reel-to-reel processing of coated conductors

This thesis presents the results of a study aimed at investigating important fabrication aspects of reel-to-reel processing of metal substrates for coated conductors and identifying a new substrate candidate material with improved magnetic properties. The effect of mechanical polishing on surface roughness and texture in Ni-5at.%W tapes in the cold-rolled condition was studied as a function of polishing grade. The surface roughness of the tape in the polished and annealed condition, and after subsequent coating with a Gd2Zr2O7 buffer layer was investigated taking grain boundaries into account. It was observed that the initial mean surface roughness decreased after annealing except after very fine polishing. Additionally, the roughness of the buffer layers were found to increase slightly for the ne polished substrates. Grain boundary grooving was observed to impose a lower limit for the mean surface roughness. Fractions of cube texture within deviations of 5° from the ideal cube orientation, in the annealed substrates, were found to be very sensitive to the surface roughness before annealing. Microstructure, texture and topography were studied in a strongly cube-textured Ni-5at.%W substrate before and after an additional annealing (condition A1 and A2, respectively) simulating a buffer layer crystallisation heat treatment. Condition A1 was characterised by a high fraction of cube texture, a high fraction of low angle grain boundaries and a low fraction of 3 boundaries. A strong correlation was observed between the grain boundary groove depth and boundary type. Coherent twin boundaries and low angle grain boundaries were characterised by the smallest average groove depth while significantly deeper grooves were observed at other boundary types. A similar correlation was observed between the inclination angle at groove walls and the boundary type. The microstructure was slightly coarser in condition A2 and it was accompanied by a cube texture strengthening and an increase in the fraction of low angle grain boundaries. The average depth of grain boundary grooves increased considerably at boundaries characterised by large misorientation angles, except for coherent twin boundaries. Significant changes were observed between the groove depth at stationary boundaries which generally increased in depth and the grooves at migrating boundaries which typically became shallower compared to condition A1. Furthermore, migrating boundaries were found to abandon grooves and generate grooves at new positions. Despite the observed changes in the extent of grain boundary grooving, the mean surface roughness was almost identical before and after the additional annealing. Microstructure, texture, hardness and magnetic properties have been studied in a series of new Ni-Cu-W substrates. Adding 5 at.% copper to Ni-5at.%W was observed to substantially decrease the Curie temperature and the saturation mass magnetisation without significantly modifying the microstructure and texture compared with Ni-5at.%W. The hardness of this Ni-5Cu-5W substrate was only slightly less than the hardness of the reference Ni-5at.%W substrate. Further increasing the Cu-content was observed to result in a great decrease in the Curie temperature and saturation mass magnetisation values, but also a significant decrease in the fraction of cube texture and the fraction of low angle grain boundaries. Finally, a Ni-5Cu-5W substrate may be a good candidate material as a substrate in future coated conductors.