Sintering behavior and microstructural evolution of NbC-Ni cemented carbides

Mathilde LABONNE

Supervisors: Jean-Michel Missaen et Sabine Lay

Friday, November 20th 2020 2:00 pm

Auditorium E - ENSIMAG

Jury :
Hans-Olof ANDREN, Professeur, Chalmers University of Technology, Suède, Rapporteur
Jozef VLEUGELS, Professeur, KU Leuven, Belgique, Rapporteur
Luis Fernando GARCIA, Docteur Ingénieur, Hyperion Materials & Technologies, Espagne, Examinateur
Damien FABREGUE, Professeur, INSA Lyon, France, Examinateur

Abstract: For more than 70 years, WC-Co materials have been used worldwide for numerous applications in tooling, mining equipment or wear parts. Unfortunately, it has been recently determined that the cobalt and tungsten oxides present risks and health issues. Furthermore, the worldwide demand for tungsten and cobalt has been continuously growing, although the mining stocks of both elements are limited, which increased their price over the years. This global context has led industrial companies to investigate alternative carbide based materials. Niobium carbides are increasingly considered to replace tungsten carbides for specific applications. Although those carbides present a slightly lower hardness, they have impressive wear properties and are twice less dense than WC. Furthermore, no particular health hazards were identified for the use of bulk metallic niobium, niobium carbides and niobium oxides. Previous studies of NbC based materials have mostly focused on their microstructures and the resulting mechanical properties, notably the hardness, toughness and wear properties. However, the sintering process of niobium carbide based cemented carbides and the carbide grain growth mechanism involved have not yet been fully investigated. The present study aims to analyze the sintering behavior and grain growth of NbC-Ni materials and the effect of secondary carbides addition. It was first determined that the carbon content has a significant impact on the sintering behavior and the microstructural evolution. Notably, increasing the carbon content decreases the carbide phase contiguity. The addition of secondary carbides leads to a delay of solid state sintering and limits grain growth. The contiguity increases with these additions. Finally, a particular focus was made on grain growth mechanism in such materials. By combining classic growth theories and a simplified model, it was estimated that growth kinetics are controlled by a cooperative migration of grain boundaries and phase boundaries.