CHARPY IMPACT TESTING OF ELECTRODEPOSITED NANOCRYSTALLINE COBALT

A.A. Karimpoor, U. Erb
Department of Materials Science and Engineering, University of Toronto, 184 College St., Toronto, Canada
amir.karimpoor@utoronto.ca

Nanocrystalline metals and alloys with grain sizes less than 100 nm show mechanical properties quite different from the properties observed for their polycrystalline counterparts. While their hardness and tensile properties have been widely studied [1, 2] no data on their Charpy impact properties have been published, mainly because of the unavailability of nanocrystalline samples with appropriate overall size to carry out such tests.

Following a study of the hardness and tensile properties [3, 4], we recently performed Charpy impact tests on electrodeposited bulk nanocrystalline cobalt samples. In this paper the impact energy, fracture surfaces and hardness for nanocrystalline cobalt with the average grain size of 18 nm, will be compared with the same properties for conventional polycrystalline cobalt produced by electrowining and an average grain size of about 1 μm.

Plates of nanocrystalline cobalt (thickness: 2.5 mm) and polycrystalline cobalt (thickness: 10 mm) were received from Integran Technologies Inc. Canada and Falconbridge Ltd. Canada, respectively. Impact samples were cut from these plates based on the ASTM E23 standard (V notched Charpy impact samples, simple beam, sub-size type A) (Fig. 1).

Impact tests were carried out at room temperature and at 200 ºC (10 min.) in a Charpy tester machine with the maximum energy of 406.75 J (300 ft-lb). Fracture surfaces were studied in a Hitachi S570 Scanning Electron Microscope. The Vickers micro-hardness of samples was measured at 500 g load and 10 sec. dwell time.

At room temperature the impact energy for nanocrystalline cobalt (table 1) is considerably lower than for polycrystalline cobalt. However, at 200 °C (with nearly no hardness reduction) nanocrystalline cobalt has an impact energy close to polycrystalline cobalt, while maintaining about 60 % higher hardness. The increase in the impact energy without hardness reduction for the nanocrystalline samples could be due to a structural relaxation of the high energy grain boundaries.

The fracture surfaces of nanocrystalline samples tested at room temperature showed some shear edges (Fig. 2), and dimple-like features (Fig. 3), similar to those observed for polycrystalline samples. The shear edges in nanocrystalline samples tested at 200°C were increased to an extent, comparable to polycrystalline samples tested at room temperature (Fig. 2).

References:

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[3] A.A. Karimpoor, U. Erb, K.T. Aust and G. Palumbo G., Scripta Mater. **49** (2003) 651
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Figures:

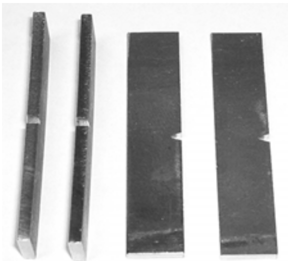

Fig.1: Impact samples

Table 1: Charpy impact energy and hardness of cobalt

Cobalt	Grain size	VHN	Temp.	Energy (J)
Nanocrystalline	18 nm	479	Room	2
		462	200°C	5
Polycrystalline	1.1 µm	297	Room	6
		292	200°C	6.5

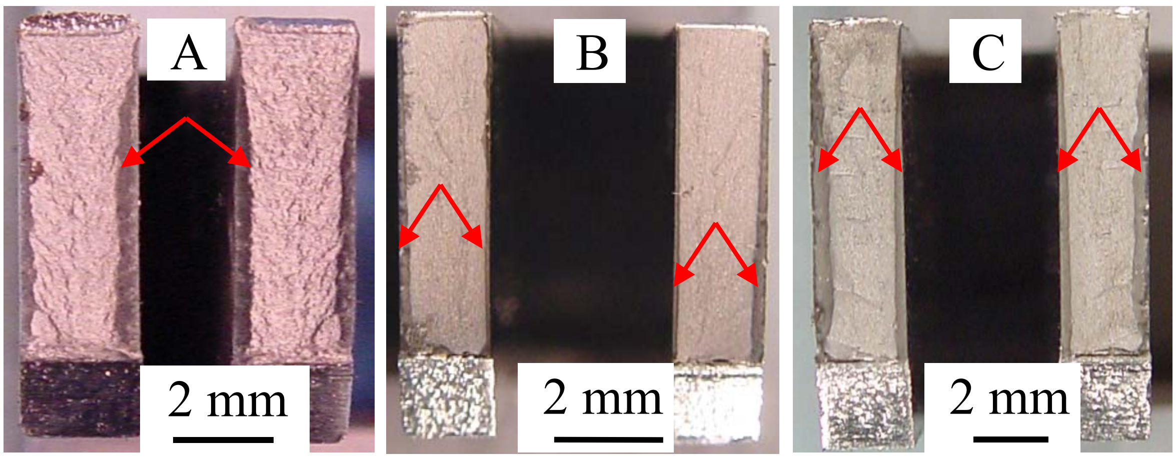

Fig.2: Impact fracture profiles: Polycrystalline Co at RT (A), nanocrystalline Co at RT (B) and 200°C (C). Shear edges increased in C comparable with those in A.

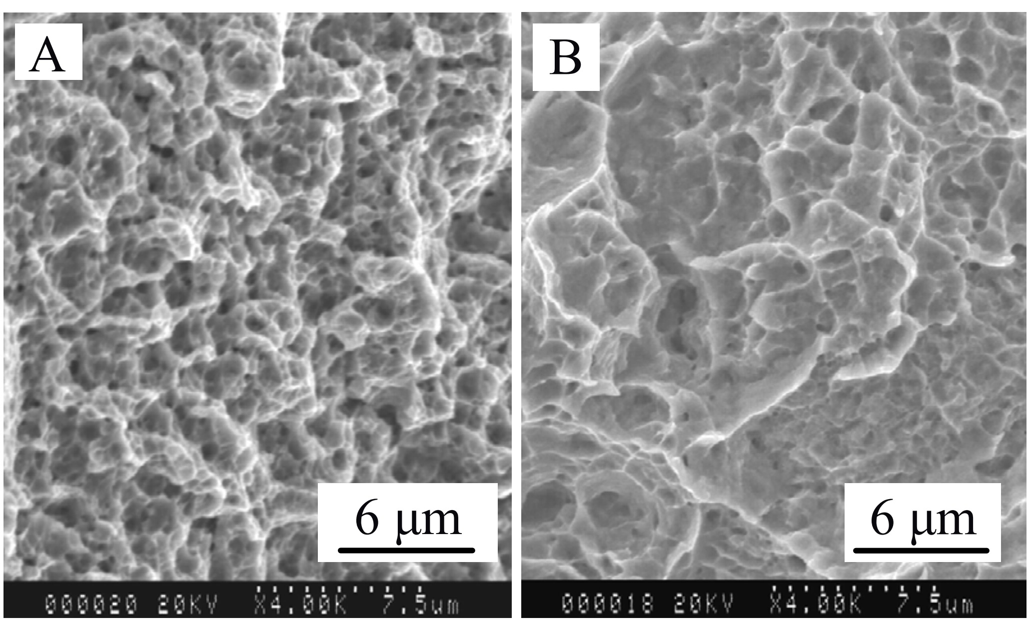

Fig. 3: Fracture surfaces at room temperature: a) nanocrystalline, b) polycrystalline cobalt. Dimple-like features are seen on the fracture surface of both materials.