Pavements of the Nanoworld

Texture patterns of electrodeposited Ni-based mesoscale structures resemble the patterns seen in cobblestone pavements

Lisbon Pavement, Portugal

One effective method of producing nanocrystalline materials (grain size < 100 nm) is pulsed electrodeposition. It has been observed that electrodeposits form and grow in a nodular fashion each nodule representing a "colony" of nanosized grains (Cizek et al.). Orientation measurements performed in the vicinity of the boundaries separating two neighboring colonies suggest that the colonies in a nanocrystalline Ni-20% Fe electrodeposit might display a distinct ''cobblestone'' mesotexture characterized by a <001> fiber axis approximately perpendicular to the local curvature of the colony growth surface.

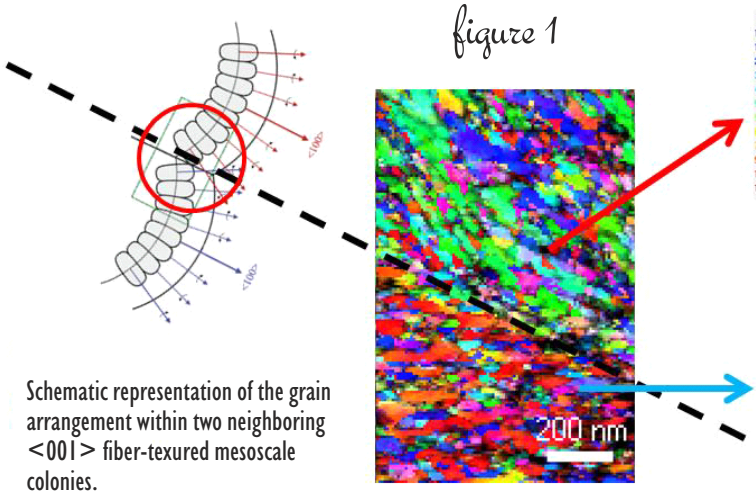
TEM has been used to investigate the local microtexture and misorientation characteristics of nanosized grains comprising mesoscale colonies in electrodeposited Ni, Ni-20 % Fe, and Ni-50 % Fe materials. Optical microscopy revealed the presence of mesostructure colonies in all three Ni-based electrodeposits studied. Consequent TEM analysis on specimen sections parallel either to the Deposition Plane (DP) or the Deposition Direction (DD) provided the size and shape distribution of the nanograins for all the materials studied.

ASTAR analysis indicated that both the bulk texture and the local microtexture and mesotexture of the as-deposited specimens are dominated by the <001>//DD fiber, which has also been observed in many other experimental studies.

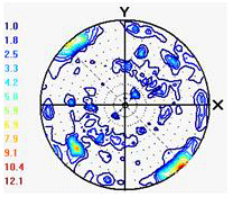
The challenge:	Identify the orientation of crystallites with size < 50 nm
Solution:	ASTAR technique coupled with precession electron diffraction

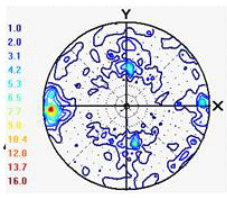
Researchers attribute this fact to the influence of hydrogen co-deposition which is more active in {001} than {111} crystallographic planes. For all three alloys, the coarsened grains, obtained by annealing, within the mesoscale colonies showed with EBSD-SEM a fiber mesotexture characterized by a <111> axis approximately perpendicular to the colony hemispherical growth surface (parallel to the local DD). From such EBSD-SEM measurements it has been surmised that the as-deposited texture patterns in Ni-based materials might resemble the patterns often seen in cobblestone pavements found in many European cities. This has indeed been confirmed by ASTAR orientation measurements made on a local nm scale in the as-received materials (see the figure below). Further work is needed to reveal the exact formation mechanisms of this cobblestone mesotexture as the aforementioned features will likely affect both the homogeneity and anisotropy of mechanical and physical properties of the nanocrystalline electrodeposits and many properties such as corrosion resistance, toughness or ductility, coefficient of friction and wear resistance could be affected by the characteristics of the mesoscale colonies.

figure 1



Schematic representation of the grain arrangement within two neighboring <001> fiber-texured mesoscale colonies.





Pole figures revealing ocal orientation measured at the interface between two colonies.

Crystal Structure

Nickel: fcc cubic, a = 3.52 Å

Experimental Data

TEM type: Jeol 3010
Map resolution: < 10 nm
Scanned area: 2 x 1 µm

Cizek et al *Metall. Mater. Trans. A* 42 (2011) 2048-2060