19th INTERNATIONAL CONFERENCE ON DIFFUSION IN SOLIDS AND LIQUIDS
DSL2023
HERAKLION, CRETE | GREECE
26-30 JUNE 2023

ABSTRACT:

Interdiffusion and Interface Effects in Bimetallic Nanowhiskers

Y. Qi1,2, A. Bisht1, G. Richter3, E. Suadiye3, M. Kalina1, E. Rabkin1

1Department of Materials Science and Engineering, Technion – Israel Institute of Technology, 3200003 Haifa, Israel
2Department of Materials Science and Engineering, Guangdong Technion – Israel Institute of Technology, No.241 University Road, Shantou, Guangdong, P.R. China, 515063
3Max Planck Institute for Intelligent Systems, Heisenbergstrasse 3, 70569 Stuttgart, Germany

In this work, we utilize chemical stresses from imbalanced interdiffusion to manipulate the shape of metal nanowhiskers. Bimetallic Au-Fe and Au-Pd nanowhiskers with an ultra-high bending strength were synthesized employing molecular beam epitaxy technique. The one-sided Fe coating on the defect-free, single-crystalline Au nanowhisker exhibited both single- and poly-crystalline regions [1]. A similar one-sided Pd coating was fully heteroepitaxial with the Au nanowhisker [2]. At low temperatures, the bending was limited and reversible, indicating that it is caused by thermal stresses due to the mismatch of thermal expansion coefficients of Au, Fe and Pd. Annealing the bimetallic nanowhiskers at higher temperatures led to gradual change of curvature and irreversible bending. In the Au-Fe nanowhiskers, the plastic bending was dominated by Kirkendall effect during diffusion of Au along the grain boundaries in the Fe layer, whereas in the Au-Pd nanowhiskers the plastic bending was related to partial coherency loss at the interface. At higher temperatures and longer annealing times, the bending of both types of bimetallic nanowhiskers was dominated by the interdiffusion of Au and the material of one-sided coating (Pd, Fe), and concomitant change of the lattice parameter of the formed Au-Fe and Au-Pd alloys. The directional anisotropy of interdiffusion in the Au-Fe nanowhiskers was attributed to the finite mobility of interphase boundaries.

[1] Y. Qi, G. Richter, E. Suadiye, M. Kalina, E. Rabkin, ACS Nano. 14 (2020) 11691.
[2] A. Bisht, M. Kalina, E. Suadiye, G. Richter, E. Rabkin, Acta Mater. 243 (2022) 118504.