DSL2019

15th International Conference on Diffusion in Solids and Liquids
ATHENS (Greece) from 24-28 June, 2019

Synthesis of hollow metal nanostructures by short-circuit diffusion

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Hollow metallic nanostructures (nanotubes, nanoparticles) are at the forefront of a number of nanotechnology-related applications. We demonstrate that nanotubes and hollow nanoparticles of pure metals and intermetallic compounds can be produced at low homological temperatures employing a combination of surface, interface, and grain boundary diffusion. Silver nanowhiskers and nanoparticles were manufactured employing molecular beam epitaxy and solid state dewetting techniques [1, 2]. A thin nanocrystalline gold overlayer was then deposited on these silver nanostructures, and the composite systems were annealed at low homological temperatures at which no bulk interdiffusion occurs. After annealing, gold nanotubes and nanoshells were formed. The hollowing process was discussed in terms of surface-diffusion assisted bulk intermixing (SDIBI) mechanism. Silver atoms rejected by the hollowing structures were absorbed by a layer of silver-gold alloy forming on the gold film surface, resulting in significant thickening of the film. Similar experimental procedure applied to the Al-Au core-shell nanoparticles on sapphire resulted in hollow nanoparticles of the $AlAu_2$ intermetallic compound. In this case, Al outdiffusion along the Au-sapphire interface and simultaneous diffusion of oxygen along the grain boundaries in Au with concomitant Al oxidation and epitaxial growth of alumina played a leading role in hollowing. In another process, hollow gold nanoparticles were produced by a combination of solid state dewetting of the silver-gold alloy, selective dissolution of silver, and subsequent coarsening heat treatment [3]. This process allows synthesis of porous gold nanoparticles with both open and closed porosity. Finally, we explored optical [4] and mechanical properties of hollow nanoparticles.

References:

[1] S. Baylan, G. Richter, M. Beregovsky, D. Amram, E. Rabkin *Acta mater.* **82** (2015) 145.

[2] N. Gazit, L. Klinger, G. Richter, E. Rabkin, *Acta mater*. **117** (2016) 188-196

[3] A. Kosinova, D. Wang, P. Schaaf, O. Kovalenko, L. Klinger, E. Rabkin *Acta mater.* **102** (2016) 108.

[4] A. Kosinova, D. Wang, E. Baradács, B. Parditka, T. Kups, L. Klinger, Z. Erdélyi, P. Schaaf, E. Rabkin *Acta mater.* **127** (2017) 108-116