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3D Metallic Gyroid Nanostructures: Preparation, Characterization and Stability

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Plasmonic nanostructures are of great interest due to their optical properties driven by the collective oscillation of their free electrons upon electromagnetic excitation. Despite common use of gold for the fabrication of the plasmonic nanomaterials, its replacement with silver is highly desirable since silver exhibits lower optical losses in the visible spectral range. However, silver's strong tendency to atmospheric degradation is a great drawback for long-term applications. In principle, the degradation of silver nanostructures can be reduced by using a sacrificial metal or applying a protective inorganic or organic layer around the silver nanostructure. However, this alters the optical response of the silver nanostructure due to changes in the permittivity of the silver-surrounding medium. Furthermore, these passivation methods are limited to simple 1D and 2D nanostructures. The stabilization of complex silver nanostructures remains a challenge in the field of plasmonics.

Here, silver 3D gyroid nanostructures were fabricated via the templated deposition into voided polyisoprene-b-polystyrene-b-poly(ethylene oxide) (PI-*b*-PS-*b*-PEO) triblock terpolymer thin films. Later, an optimized plasma etching treatment in an argon atmosphere was used to remove the sacrificial polymer matrix from the nanocomposite. The results confirm the formation of a very thin carbonaceous layer covering the silver gyroid network. The carbonaceous layer is presumably created by the mechanical bombardment of the polymer template's polystyrene with argon ions during plasma etching. This carbonaceous layer covering the silver gyroid network plays an essential role in the chemical stability of the silver replicas stored under standard laboratory conditions and harsh degradation environments. In fact, it acts as a passivization layer against degradation of silver.

The second phase of thesis involves investigating the feasibility of using the proposed argon plasma treatment protocol to fabricate gyroid nanostructures made from other degradation-sensitive metals including nickel and copper. The fabrication of stable metal replicas was achievable due to the formation of carbonaceous materials, which were created as the side products of physical bombardment of the PS-containing polymer templates with argon energetic ions.

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