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Low-Cost Additive Manufacturing of Silver Films for Concentrated Solar Thermal Power Plants

Background

By converting sunlight to heat, concentrated solar thermal power (CSP) technology presents a viable form of thermal energy storage that directly addresses grid integration and storage challenges. Current CSP mirror manufacturing processes require depositing multiple layers of films, including silver which requires physical vapor deposition (PVD) or wet chemical processing (such as electroless plating). However, because PVD involves a hightemperature, high-vacuum process, it is not ideal for highthroughput production. Electroless silver deposition has pronounced disadvantages too, as it typically requires toxic and corrosive chemical baths, and usually results in rough film surfaces that adversely affects specular reflection. As a whole, the tools and processes for PVD and wet processing are bulky, capital intensive, or environmentally unfriendly.

Additive manufacturing (AM) is particularly appealing for CSP mirror manufacturing and onsite maintenance because it offers reduced material waste, lower energy intensity, reduced time to market, justintime production, and economical production runs. Despite these benefits however, AM metal printing usually relies on thermal/laser-assisted metal fusion or inkjet printing of metal powders that do not produce smooth films and are incompatible with polymer materials.

Invention Description

Researchers at Arizona State University have developed a novel methodology to optically print metallic features on various substrates using polymer-assisted projection stereolithography. Metallic patterns are fabricated via polymer-assisted photoreduction, which converts metal ions into continuous materials via seeded growth. Metallic patterns of various shapes and compositions can be directly printed from aqueous precursor under ambient conditions and without need for postfabrication treatment. The asobtained metal features possessed excellent quality, with surface roughness and optical properties equivalent to sputtered metal films. This printing method is applicable to a variety of substrates, including glass, plastics, polymers, hydrogels, papers, and inorganic substrates. The application to curved 3D structures has also been demonstrated. Fabricated reflectors showed excellent reflectance, exceeding the 95% reflectance of commercial silver mirrors on average. Hence, this technique possesses great potential for lowcost, largescale manufacturing of polymeric CSP collectors.

Potential Applications

- Mirrors for concentrated solar-thermal power (CSP)
- Additive manufacturing
- Metallic film printing

Benefits and Advantages

- Scalable for high-volume and just-in-time production
- Cost-effective
- Portable and suitable for on-site mirror maintenance and repair
- Produces high-quality films comparable to those achieved by sputtering
- Applicable to a variety of substrates

Laboratory Homepage of Professor Chao Wang