LETTER TO THE EDITOR

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Letter to the Editor

High resolution patterning of silica aerogels

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Abstract

Three-dimensional metallic structures are fabricated with high spatial resolution in silica aerogels. In our method, silica hydrogels are prepared with a standard base-catalyzed route, and exchanged with an aqueous solution typically containing Ag^+ ions (1 M) and 2-propanol (0.2 M). The metal ions are reduced photolytically with a table-top ultraviolet lamp, or radiolytically, with a focused X-ray beam. We fabricated dots and lines as small as 30×70 μm, protruding for several mm into the bulk of the materials. The hydrogels are eventually supercritically dried to yield aerogels, without any measurable change in the shape and spatial resolution of the lithographed structures. Transmission electron microscopy shows that illuminated regions are composed by Ag clusters with a size of several μm, separated by thin layers of silica.

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1. Introduction

Two- and three-dimensional patterning of polymer and insulator matrices can be employed to fabricate integrated mechanical and electronic devices on a micro- and nanoscale [1–4]. Complex metallic patterns have been produced in a polyvinyl carbazole matrix loaded with photoreducible dyes, metal salts and metal nanoparticles [2], and in silica gels loaded with Ag salts [3]. In all those reports, metal atoms are formed by photoreduction of metal ions, usually Ag^+. The metal atoms condense on metal clusters added prior to illumination [2], or form small clusters that grow into full-fledged metallic structures in a post-illumination reduction stage [3,4]. These techniques are promising candidates for development of industrial processes, since they have a spatial resolution of a few microns, the materials are fairly simple to prepare, and the process occurs at room temperature.

Here, we report a three-dimensional photolithographic creation of metallic nanostructures with lateral dimensions as small as 30 μm that can extend for several mm in the bulk of silica aerogels. Our method is based on photoreduction of metal ions inside hydrogels, followed by supercritical drying leading to aerogels [5,6]. Different from Refs. [3,4], our lithographic method does not require post-illumination developing, which may limit the spatial resolution. In comparison to the method of Ref. [2], our method is less elaborate, and the materials are more easily prepared. Most importantly, however, our patterned aerogels might be employed as low dielectric constant materials for high-speed electronic applications.

2. Experimental

In brief, we prepare silica hydrogels with a conventional base-catalyzed route, and wash them with an

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