PATTERNING OF SILICALITE-1 FILMS USING CO$_2$ LASER ABLATION AND IMPACT ON THEIR OPTICAL CHARACTERISTICS

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ABSTRACT

Nanostructured materials represent an intriguing foundation on which to build new devices for applications in electronics, photonics, energy storage, and biological/chemical analysis. The standard methods used to pattern such devices are based on typical microfabrication techniques, which involve multiple complex and time-consuming steps with several limitations.

Here, we present a simple, flexible alternative to both techniques: CO$_2$ laser ablation. We demonstrate the effects of this technique on a model zeolite thin film system, pure-silica MFI (silicalite-1), to evaluate its potential for patterning complex, multicrystalline, nanostructured materials. Using this technique, we demonstrate that it is possible to make 3D structures in these films, such as channels of varying width (82-611.98 µm), depth (2.58-7.13 µm), separation distance (minimum 25 µm), and edge effects, by varying laser power, spot size, and raster speed. The resulting randomly and b-oriented films of thickness 94.324-550.89 nm showed the ability to reach a range of refractive indices (1.327-1.678), depending on film orientation and deposition technique. The intensities of their IR and Raman absorption regions indicate an increase in crystallinity with CO$_2$ laser irradiation from 10 to 20% power, and then a decrease above 30%. Determining these fundamental optical properties will allow us to explore the functionality of these materials for a wider array of applications in optoelectronics, where nanostructured materials can make a significant difference in scale, cost, efficiency, and overall performance.