Nano-Imprint Mold and Direct Imprinting Technique Creates Single Sub-20-Nanometer-Wide, Centimeter-Long Nanofluidic Channel

Many leading-edge applications in biochemical sensors and microfluidics require isolated, continuous fluidic channels, with lengths on the order of a cm, and widths on a 20-nm scale. Traditional nanolithographic tools are challenged by the strict limits on line edge roughness (to prevent clogging) over the desired centimeter-long channel length, which is much larger than typical writing fields. X. Liang and colleagues at Princeton University have demonstrated a novel direct imprinting technique to fabricate a single fluidic channel of uniform width (11–50 nm) and over 1.5 cm long.

As reported in the December 2007 issue of *Nano Letters* (p. 3774; DOI: 10.1021/nl072253x), the researchers first created the nano-imprint mold. They grew about 10 nm of SiO_2 on a (110)-oriented silicon-on-insulator wafer, then lithographically patterned a 0.5 cm × 1.5 cm rectangle in the SiO_2. The long edge was aligned to the {111} crystallographic axis in Si. An anisotropic KOH-based etch of the silicon, using the silicon dioxide as a mask and the underlying insulator as a stop layer, created a mesa with vertical sidewalls of {111} planes. The much slower etching rate in the <111> directions versus the <110> directions ensured that the sidewalls were nearly atomically smooth, despite the severe edge roughness of the original etch mask. Subsequently, the SiO_2 was stripped away. A thin layer of Si_xN_y was then deposited uniformly and conformally, by low-pressure chemical vapor deposition, over the entire wafer surface including the sidewalls. The thickness of this film defined the channel width. An anisotropic reactive ion etch (RIE), acting in the vertical direction, removed the Si_xN_y on all horizontal surfaces while leaving some on the relatively tall sidewalls. By selectively etching away the remnants of the Si mesa, the long "fin" of Si_xN_y was isolated and became the protrusion of an imprint mold.

During the imprinting step, the mold was pressed into a UV-curable material layer. The resulting nanochannel could be used directly or as an etching mask to transfer the channel into an underlying substrate (e.g., SiO_2) using RIE.

The researchers characterized the channel dimensions using scanning electron microscopy and completed a nanofluidic device by fabricating a pair of liquid reservoirs at each end. They passed water containing a fluorescent marker through the nanochannel and also flowed DNA in solution (which stretched as it passed into and through the device).

"This approach to creating and precisely placing a single long, narrow and continuous nanofluidic channel removes a key obstacle to developing many innovative biological and chemical sensors such as single-strand DNA sequencers," Liang said.

RICH LOUIE

Metallodielectric Multilayer Stacks Show Enhanced Ultrafast Optical Nonlinear Response

In the December 1, 2007 issue of *Optics Letters* (p. 3435), G. Ma and S.H. Tang of Shanghai University in China and the National University of Singapore, respectively, reported the enhancement of the nonlinear optical response in Ag-TiO_2 multilayer stacks determined through femtosecond optical Kerr effect measurements.

Nonlinear materials with large third-order nonlinear susceptibility, $\chi^{(3)}$, and ultrafast response are key elements in developing ultrafast all-optical switches. In the past decade, researchers have studied metallic nanoparticles embedded in dielectric matrices. However, these composite materials have exhibited a common drawback: the close association of a large $\chi^{(3)}$ with a large linear absorption, which in turn leads to large propagation losses and might induce thermal damage of the potential device.

In recent years researchers have shown that metal dielectric multilayer structures can show a high transmission in specific regions of the spectrum due to multiple Bragg reflections, even when the total metal thickness significantly exceeds the conventional skin depth. In this work, the researchers prepared Ag-TiO_2 multilayer stacks by using alternate sputter deposition. By selecting suitable thicknesses for the metal and dielectric layers, they have designed a Ag-TiO_2 structure with a maximum transmission of about 35% at 800 nm, even though the transmission of a similar thickness of pure Ag film is <1.5%. The researchers performed femtosecond optical Kerr measurements at 800 nm using Ti:sapphire laser pulses with a temperal duration of 120 fs and repetition rate of 82 MHz. The results show that the optical nonlinearity of the multilayer structure can be as large as 3.2×10^{-9} esu, which is much larger than that shown by a pure 25-nm-thick Ag film studied for comparison (1.1×10^{-9} esu). By using the matrix transfer method the researchers showed that the amplitude of the electric field within the Ag metal layers was clearly larger within the metal layers in the metal-dielectric multilayer structure than in pure metal films. The researchers concluded that the origin of the large nonlinearity arose from the fact that the light can penetrate the intrinsically high nonlinear metallic layers due to the specially designed metal-dielectric structure. They said that these results demonstrate that metal-dielectric multilayer composites are suitable candidates for fabricating all-optical switching photonic devices.

ROSALÍA SERNA

Laser Control of Alignment and Rotation of Polyatomic Molecules Demonstrated

The reactivity of molecules is strongly correlated to their spatial orientation, and the ability to manipulate that orientation can enhance applications such as ultrafast x-ray imaging and time-resolved photoelectron spectroscopy. S.S. Viftrup at the University of Aarhus in Denmark,

Correction

The volume number for the December 2007 issue of *MRS Bulletin* was incorrectly printed on the cover as **34**. The correct volume number is **32**.