Micromachined Slits for Imaging Spectrometers

Slits can now be made about 100× the precision previously attainable.

NASA's Jet Propulsion Laboratory, Pasadena, California

Slits for imaging spectrometers can now be fabricated to a precision much greater than previously attainable. What makes this possible is a micromachining process that involves the use of microlithographic techniques. This micromachining process supplants a prior machine-shop process.

In the specific application that gave rise to this development, there is a requirement to make imaging-spectrometer slits 27 μm wide and 1.7 cm long. In the prior machine-shop process, the slits were formed by electrical-discharge machining (EDM). The slit widths could not be maintained accurate to within less than about 12 μm, and there was some long-range drift over the 1.7-cm slit lengths. The present micromachining process affords about 100× the precision of the EDM process, with corresponding reductions in the tolerances for slit-width error and long-range drift.

An overview of the micromachining process for fabricating slits consists of the following steps:

1. Grow low-stress silicon nitride via low-pressure chemical vapor deposition (LPCVD) on both sides of a silicon wafer.
2. In a photolithographic subprocess, spin the front-side silicon nitride coated wafer with a photoresist, expose the photoresist through an optical mask to define the opening to be formed, and develop the photoresist to transfer the pattern into the resist.
3. Transfer the photoresist pattern via a dry etch, such as a reactive ion etcher (RIE), through the exposed nitride.
4. Repeat steps 2 and 3 on the backside of the wafer with a pattern to define the opening for the nitride window.
5. Etch through the exposed silicon using an aqueous solution of potassium hydroxide or another suitable strong base.
6. Deposit an opaque, low-stress layer of a suitable metal (e.g., titanium/gold) on both sides.

This work was done by Daniel Wilson, James Kenny, and Victor White of Caltech for NASA's Jet Propulsion Laboratory.

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Fabricating Nanodots Using Lift-Off of a Nanopore Template

Applications include nano-scale electronic and magnetic devices.

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A process for fabricating a planar array of dots having characteristic dimensions of the order of several nanometers to several hundred nanometers involves the formation and use of a thin alumina nanopore template on a semiconductor substrate. The dot material is deposited in the nanopores, then the template is lifted off the substrate after the dots have been formed. This process is expected to be a basis for development of other, similar nanofabrication processes for relatively inexpensive mass production of nanometer-scale optical, optoelectronic, electronic, and magnetic devices.

Alumina nanopore templates are self-organized structures that result from anodization of aluminum under appropriate conditions. Alumina nanopore templates have been regarded as attractive for use in fabricating the devices mentioned above, but prior efforts to use alumina nanopore templates for this purpose have not been successful. One reason for the lack of success is that the aspect ratios (ratios between depth and diameter) of the pores have been too large: large aspect ratios can result in blockage of deposition and/or can prevent successful lift-off. The development of the present process was motivated partly by a requirement to reduce aspect ratios to values (of the order of 10) for which there is little or no blockage of deposition and attempts at lift-off are more likely to be successful.

The process consists mainly of the following steps:

1. The substrate is cleaned by use of solvents and acids in a subprocess known in the art as Shiraki cleaning.
2. By use of electron-beam evaporation at a deposition rate of 0.5 nm/s, a layer of chromium is deposited to a thickness of 5 nm thick on a silicon substrate and then an aluminum layer 0.4 μm thick, consisting of grains smaller than 0.1 μm, is deposited on the chromium layer. Smallness of the aluminum grains is essential for success.
3. The aluminum layer is anodized at a potential of 10 V in sulfuric acid at a concentration of 0.1 M. The potential of 10 V is considered to be low in the anodization art and results in slow anodization, but the slowness of the anodization is also essential for success.
4. Pores are widened and alumina barrier layers removed by use of phosphoric acid at a concentration of 5 volume percent.
5. The nanodot material is deposited by use of electron-beam evaporation.
6. The alumina template is lifted off by use of a solution of sodium hydroxide at a concentration of 1 M.

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