Boring Deep Cylindrical Nanoholes in Silicon Using Silver Nanoparticles as a Catalyst

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*Advanced Materials, 17, 1045-1047 (2005)*

No.68 in "100 Papers Selection" (p.72)

We deposited silver nanoparticles on the surfaces of silicon wafers by electroless plating (Fig. A). Then we immersed the wafers in an aqueous solution containing hydrofluoric acid (HF) and hydrogen peroxide ($\text{H}_2\text{O}_2$). Since silver is a good catalyst for reduction of hydrogen peroxide, hydrogen peroxide in solution would be reduced by drawing electrons from silicon. This would lead to oxidative dissolution of silicon from the surface. This is what we expected. However, interestingly, the dissolution proceeded preferentially in the <100> directions at the silver/silicon interface, resulting in nanoholes in silicon. When the treatment was performed for 30 min, the depths of the nanoholes reached about 40 µm (Fig. B), and silver particles were observed at the bottoms of the holes (Fig. C). When the treatment was continued for 10 h, some of the silver particles penetrated through a 500-µm-thick silicon wafer, making through-wafer holes with diameters of about 100 nm. Such a boring process will be a useful method in the fields of nanotechnology and nanoscience.

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Real-Time Omnidirectional Image Sensors

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No.71 in "100 Papers Selection" (p.72)

We created several new real-time omnidirectional image sensors consisting of a CCD camera and a convex mirror placed in front of the camera, which can observe panoramic images simultaneously. We also propose methods for map generation, localization and route navigation. COPIS, which uses a conical mirror, is suitable for mobile robot navigation because its main field of view is a side view. An important feature of HyperOmnVision is that it has a focal point (a single center of projection), and an input image can easily be transformed to any desired image projected on any designated image plane, for example, as a pure perspective image or a panoramic image. The resolution of the omnidirectional camera is not yet sufficient for detailed analysis of interesting objects. As well, the anisotropic property of the convex mirror results in blurring in the input image, and it is difficult to miniaturize these sensors. TOM, which consists of two paraboloidal mirrors, has good optics which satisfy the important requirement of a single center of projection, for creating a small omnidirectional image sensor. Wide side view omnidirectional images could be acquired by TOM. The multiple-image sensing system, MISS, can obtain an omnidirectional image and binocular vision images on a single camera; helpful since compactness and light weight structures are important factors for a mobile robot. These sensors can be applied to a variety of fields such as autonomous navigation, telepresence, virtual reality and remote monitoring.