Gold nanocone probes for near-field scanning optical microscopy

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Apertureless near-field scanning optical microscopy (ANSOM) provides the possibility to collect simultaneously high-resolution topographical and sub-diffraction limited optical information from a surface. When optically excited, the scanning probes act as optical antennae with a strong field enhancement near the tip apex [1]. Spatial resolution and optical near-field enhancement depend strongly on the properties and geometry of the scanning probe - in particular on the radius of the tip. Various possibilities for fabricating good antennae have been pursued. Most commonly, scanning probes consist of electrochemically etched gold wires which are sharp but not well-defined in geometry. In order to create strongly localized light-sources at the probe tips with improved control of their characteristics, single gold spheres and rods have been placed on glass fiber tips [2-4] and cantilevers [5,6] or bowtie antennas have been added at the apex of cantilever tips [7].

We present two different approaches for ultra sharp and well-defined antennae based upon gold nanocones with a tip radius smaller than 10 nm [8] which can be used in ANSOM [9]. The cones are fabricated by thin-film metallization, electron beam lithography with hydrogen silsesquioxane as negative resist and subsequent Argon ion milling. A transfer process [10] is presented that enables the attachment of single gold nanocones to non-metallic probes such as sharp glass fiber tips. Alternatively, new processes are presented to fabricate cones directly on pillars of different materials such as silicon, silica and bismuth (see e.g. Fig. 1, 2), which can be applied to cantilever tips for ANSOM scanning applications.

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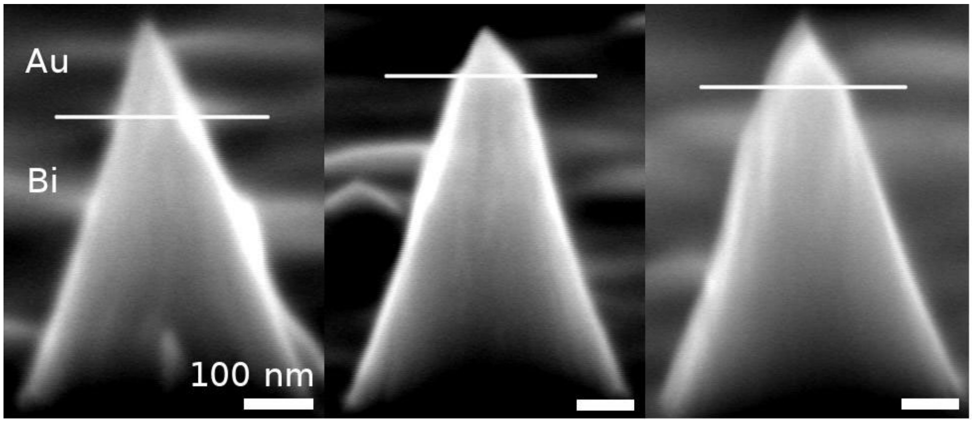

Figure 1. Gold nanocones on top of bismuth pillars on silicon substrate. The structures have a height from 580 to 720 nm. The bismuth pillars have a base diameter from 480 to 580 nm and a height from 460 to 600 nm and the gold nanocones themselves a height from 90 to 130 nm with a base diameter from 110 to 130 nm. Note the steeper angles of the bismuth pillars compared to the gold cones. This is due to faster Argon ion-milling of bismuth versus gold (viewing angle 70° with respect to the perpendicular, all scale bars represent 100 nm).

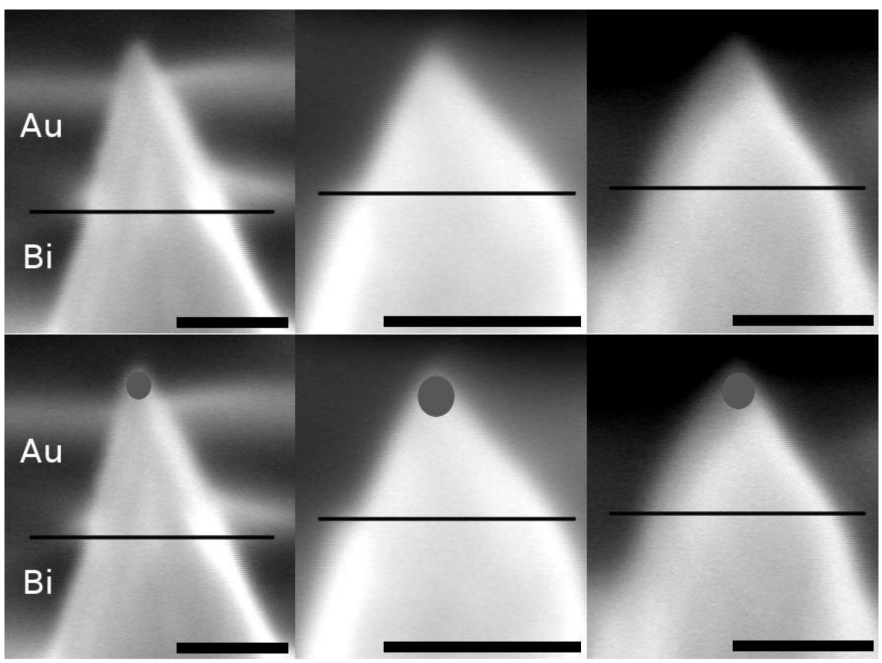

Figure 2. Gold nanocones on top of bismuth pillars (tips taken from the structures in Fig. 1). The radii are estimated with help of circles fitting in the apexes. The radii are 10 nm, 9 nm respectively 11 nm (viewing angle again 70° with respect to the perpendicular, all scale bars represent 100 nm).