Sub-40-nm patterning of Au on GaAs for Nanowire Catalysis

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In this work, we demonstrate sub-40-nm patterning of Au features on GaAs substrates using a bilayer-resist structure. Patterning of small Au features onto GaAs substrates is of particular interest due to their use as metal catalysts for GaAs and GaAs-alloy nanowire growth. Semiconducting nanowires have a variety of potential applications, such as field-effect transistors (FETs) [1], and their size-dependent properties have been exploited for a variety of optoelectronic devices [2]. However, much work remains in creating lithographically-templated nanowires for integration into future manufacturing processes.

Au in particular has shown particular promise in producing oriented, size-selected nanowires [3]. While the patterning of Au features onto other III-V materials, such as InP, have been demonstrated down to 50 nm [4], sub-100-nm patterning of Au on GaAs has not been demonstrated, due to the poor adhesion of Au onto GaAs substrates. Because nanowire diameter exhibits a strong dependence on catalyst particle size [5], the smallest-diameter nanowire that can be grown is limited. By using a bilayer-resist process, and through the introduction of a Cr adhesion layer, metal feature sizes under 40 nm were achieved.

The bilayer-resist structures used had a 50-nm-thick top layer of polymethyl methacrylate (PMMA), and a bottom layer of polymethyl glutarimide (PMGI) with thicknesses between 50 and 150 nanometers. The PMMA/PMGI resist stack was exposed by electron-beam lithography, then the PMMA and PMGI layers were developed in turn. PMMA layer was first developed by a cold development process [6], and then a controlled undercut was created in the PMGI layer [7]. A metal stack of Au and Cr was evaporated, with the Cr serving as an adhesion layer. Using a 3-nm-thickness of Cr, we were able to create sub-40-nm metal structures. These structures were subsequently used to grow GaAs nanowires by metal-organic chemical-vapor deposition (MOCVD) with diameters as small as 30 nm.

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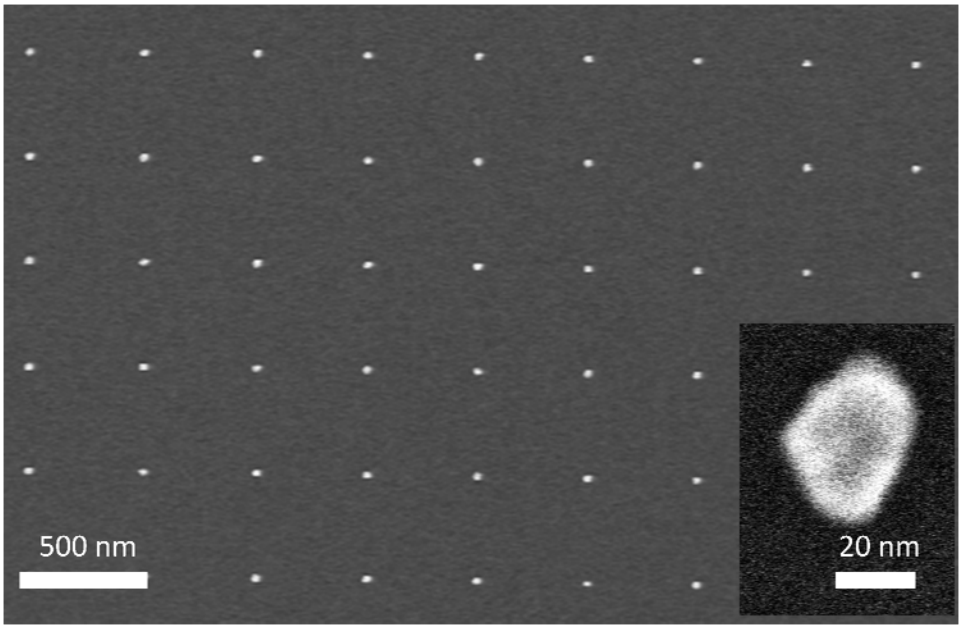

Fig. 1 An array of sub-40-nm-diameter features consisting of a metal stack of 10-nm Au atop 3-nm Cr on a GaAs substrate, deposited by metal-evaporation onto a patterned PMMA/PMGI bilayer resist stack.

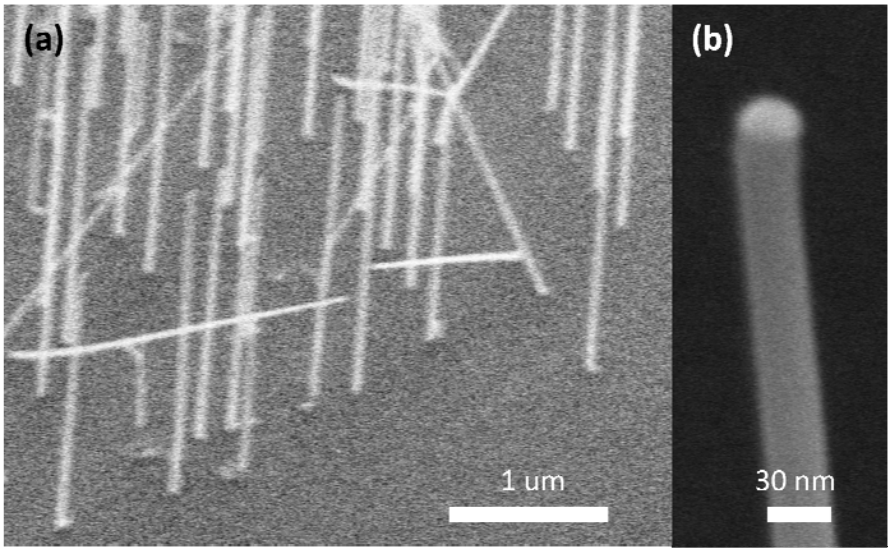

Fig. 2: (a) An array of GaAs nanowires grown epitaxially by MOCVD, catalyzed by patterned Au/Cr metal features. (b) A 30-nm-diameter GaAs nanowire, with the metal catalyst clearly visible at the top of the nanowire.