ZnO Nanowire Structures to Flexible Substrates (#5110)

A fabrication process to grow horizontal, high aspect ratio ZnO nanowires on a ZnO substrate

Zhong Lin Wang, Sheng Xu, and Yue Shen from the School of Materials Science and Engineering at Georgia Tech have developed a fabrication process to grow horizontal, high aspect ratio ZnO nanowires on a ZnO substrate. They have also demonstrated transfer of the ZnO array to a flexible substrate. The nanowire array is grown on a single crystal ZnO substrate covered in polymethyl methacrylate (PMMA) resist. An array of rectangular openings is etched using electron beam lithography (with a dose of 260-360 C/cm^2). ZnO nanowires grow along the c-axis, so the long axis of these openings parallels the substrate's c-axis. The substrate is floated on a nutrient solution of zinc nitrate hexahydrate and hexamethylenetetramine in a 1:1 ratio. at 80 to 85°C for 2.5 hours. The horizontal nanowires emerge from the openings in the resist. Openings 400 nm wide and 5?m long produce horizontal nanowires 1?m wide and 13.2?m long. Each nanowire has a shared epitaxial relationship with the substrate and each other. Thus, when nanowires coalesce, they create monolithic single crystal structures such as long nanowires on the order of millimeters in length. After cooling to ambient, the ZnO array is cleaned using isopropyl alcohol to remove absorbed water. To remove the array of horizontal nanowires, a thin layer of PMMA prepolymer is spun on the array and allowed to polymerize to the resist. With the ZnO nanowires buried, the PMMA thin film is peeled from the substrate

Benefits/Advantages

- Horizontal ZnO nanowires are epitaxially grown on a crystal ZnO substrate with a precisely controlled orientation, distribution, and width.
- Each nanowire has a shared epitaxial relationship with the substrate and each other.
- When nanowires coalesce, they create monolithic structures such as long nanowires on the order of millimeters in length.
- Burying the nanowires in a polymer thin film permits the arrays to be lifted off and transferred to flexible substrates.

Potential Commercial Applications

Potential applications of horizontal ZnO nanowire arrays include chemical and biological sensors, light emitting diodes, optical gratings, integrated circuit interconnects, and high output power alternating nanogenerators.

Background/Context for This Invention

ZnO is a versatile material with many potential applications in electronics, optical electronics, and piezoelectronics. Substantial research has focused on the growth of vertically oriented ZnO nanowires on a wide range of substrates. However, few researchers have attempted to develop techniques to grow horizontal nanowires, and the resulting processes have had poor control over the position and uniformity of the ZnO nanowires produced.

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More Information

Publications

For more information about this technology, please visit:
https://licensing.research.gatech.edu/technology/zno-nanowire-structures-flexible-substrates

Images:

The automated sequential delivery of multiple fluids. A varying number of delay gates imprinted in the branches are shown in the figure.

COVID-19 and flu saliva test on paper: (A) The automatic sequential delivery of multiple reagents required for virus test; (B) Water pouring into the device triggers the virus assay, allowing the presence of SARS-CoV-2 and influenza A & B viruses to be visually identified by the color changes in the corresponding detection spot