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Ultra long and laterally aligned Zinc Oxide (ZnO) nanorod arrays were directly synthesized around the edges of SiNx micro pores by using a facile and effective chemical vapour deposition process without any catalysts or additives. ZnO nanorods can grow controllably with a preferential orientation as a bridge beyond the edges and gradually seal into a planar free-standing mesh layer. The optimized growth parameters have been thoroughly investigated and identified. A vapour solid synthesis mechanism with source vapour flow rate control has been tentatively proposed on the basis of the experimental data to explain the synthesis: ZnO nanodots first form around the edges of pores due to the local large binding energy and high Zinc (Zn) vapour concentration, and subsequently nanorods grow epitaxially from the nanodots. This precisely-controlled micro pore sealing approach is an important step towards a coherent mechanism for applications in DNA extraction, separation and the next generation DNA sequencing.

Introduction

Various bio-entities such as DNA, protein-based biomarkers, virus, bacteria and blood cells are being used for diagnostic and therapeutic purposes. Nano- or micro-fabricated devices are very feasible for separation and detection of these bio- particles. Nano bio-devices consist of nano-fabricated structures involving nano- and micro-pores as a novel experimental approach for detection of biomolecules have been applied, based on DNA sieving and electrophoretic migration behaviour[1, 2]. In researches of nanopore-based sequencing, these micro- or nanoscale structures are proximal to a nanopore and fabricated in front of a pore to offer strong support, to avoid DNA acceleration by interacting with the biomolecule prior to and during translocation through the nanopore region by the electric field concentration, and to reduce the entropy gap[3-6]. To obtain such a goal, these functional structures will be supposed to have a highly porous and tunable synthetic coating in front of a thin SiNx membrane containing a pore. Here, we propose a low-density, high-surface-area nanomesh layer fabricating process through growing lateral/horizontal ZnO nanorod arrays above a thin SiNx film pore by a high temperature nanowires growth on substrate side edge chemical vapour deposition process[7]. Lateral epitaxial ZnO nanorods can directly grow around the edge of the pore in free-standing SiN_X substrate to form mesh layers for sealing micro pores via this novel, facile single-step customizable thermal deposition method. The nanomesh layer growth process is scalable to cover pores from a few micrometres to a few hundred micrometres in size, and easily extendable to the nanometre and millimetre realms. This new approach for micro pores sealing is simple and cost-effective, and easily adaptable for large-scale, large-area fabrication requirements because it dispenses with pre-deposition of any catalysts and precursors before reaction in contrast to other available techniques.

ZnO nano-material is a particularly promising candidate of wide band gap semiconductor in numerous potential applications, like biosensing, nanophotodetectors, nanogenerators, and nanoresonators etc. due to its unique properties such as a wide band gap of 3.37 eV, exciton binding energy of 60 meV[8-12], low cost[13, 14]， and also, a variety of morphologies like nano thin- film[15-17], nanorods[18, 19],nanowires, nanobelts, nanoflowers, and so on[20, 21]. The catalyst-free, controllable thermal vapour deposition synthesis approach in this work can avoid the common problems such as the presence of defects and catalyst contamination which usually appeared in low temperature wet chemical methods[22]. All of these merits will play significant roles in our program of micro pore sealing. The Zinc Oxide nanostructured pore-sealing process will offer new possibilities for nanopore biosensor applications through the interaction between semiconductor nanomaterials and biological molecules through the unique optoelectronic and piezoelectric properties of Zinc Oxide nanomaterials[23].

Many techniques have been applied, like atomic layer deposition (ALD)[24], electron-beam-induced deposition (EBID)[25-27] and electro-less plating or evaporation of metals[28] for modifying and controlling the field in or around the pore. Wei et al. described vapour

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