

Integration of single-crystalline nanocolumns into highly ordered nanopore arrays

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Abstract

Single-crystalline nanocolumns were integrated into highly ordered nanopore arrays in anodized aluminum oxide (AAO) membranes. The nanocolumns were grown in the pores of the AAO membranes by a hydrothermal method. The nanocolumns were highly ordered and aligned with the pores of the AAO membranes. The nanocolumns were single-crystalline and had a diameter of about 10 nm. The nanocolumns were highly ordered and aligned with the pores of the AAO membranes. The nanocolumns were single-crystalline and had a diameter of about 10 nm. The nanocolumns were highly ordered and aligned with the pores of the AAO membranes. The nanocolumns were single-crystalline and had a diameter of about 10 nm.

1. Introduction

Single-crystalline nanocolumns have attracted much attention in recent years because of their unique properties and potential applications in nanotechnology. The nanocolumns can be used as building blocks for nanoscale devices and structures. The nanocolumns can be used as building blocks for nanoscale devices and structures. The nanocolumns can be used as building blocks for nanoscale devices and structures. The nanocolumns can be used as building blocks for nanoscale devices and structures.

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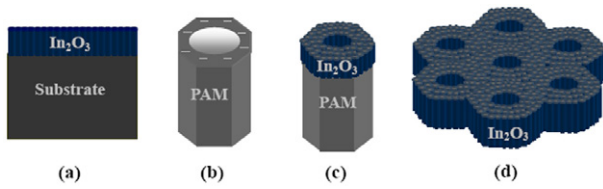


Figure 1. Schematic diagrams of the experimental setup. (a) In₂O₃ film on a substrate. (b) PAM on a substrate. (c) In₂O₃ film on a PAM substrate. (d) In₂O₃ film on a porous PAM substrate.

The porous PAM substrate was prepared by a sol-gel process. The porous PAM substrate was prepared by a sol-gel process. The porous PAM substrate was prepared by a sol-gel process.

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2. Experimental details

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3. Results and discussion

The porous PAM substrate was prepared by a sol-gel process. The porous PAM substrate was prepared by a sol-gel process. The porous PAM substrate was prepared by a sol-gel process.

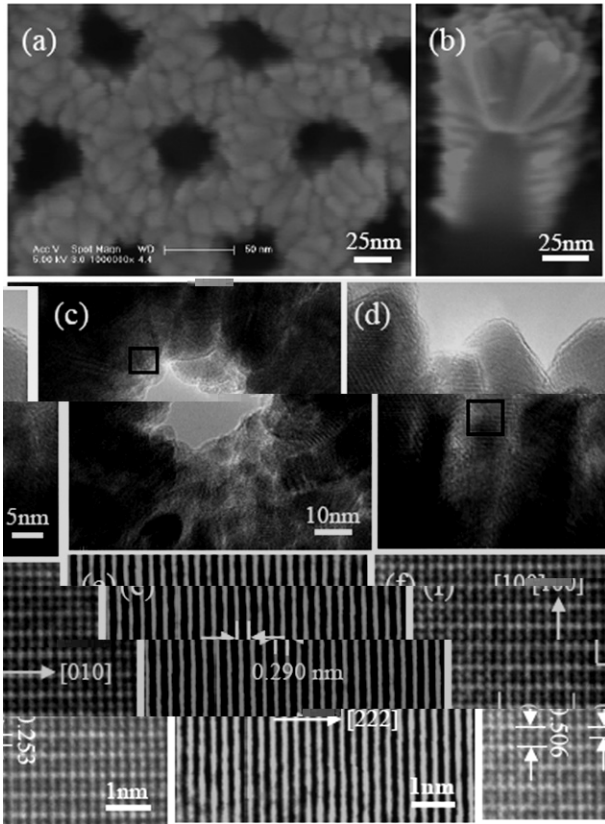


Figure 2. (a) and (b) TEM images of the porous structure. (c) and (d) are higher magnification TEM images. The bottom part shows HRTEM lattice fringes with d-spacings of 0.290 nm and 0.506 nm, and crystallographic directions [010] and [222] indicated.

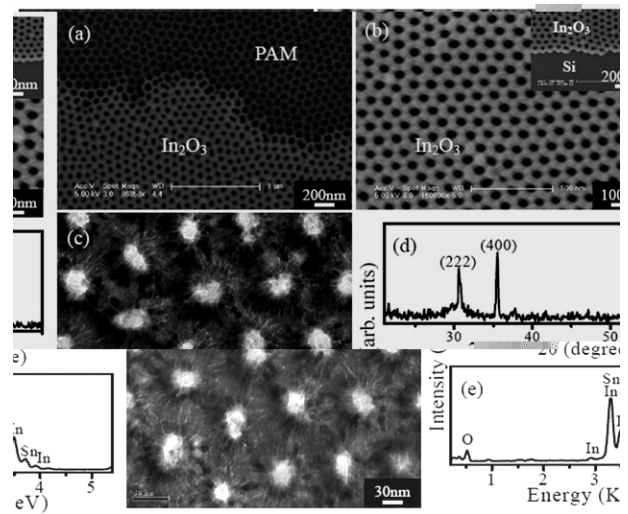


Figure 3. (a) and (b) XRD patterns for PAM and In₂O₃/Si. (c) TEM image of In₂O₃ particles. (d) XRD pattern of In₂O₃ with peaks at (222) and (400). (e) EDS spectrum showing Sn and In peaks.

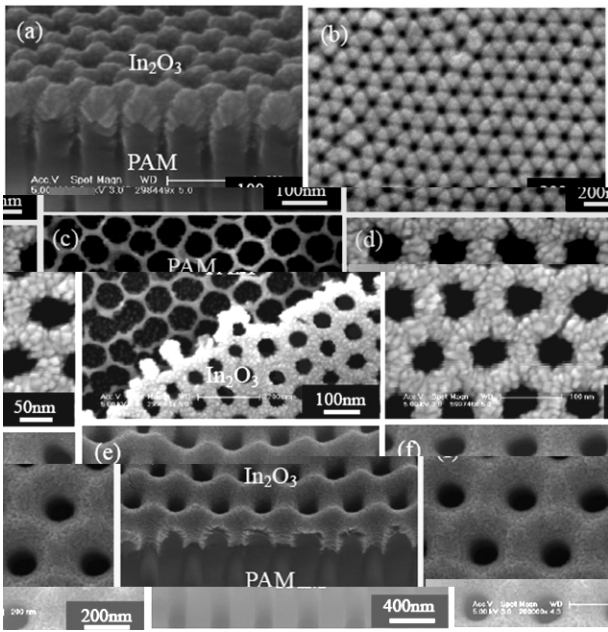


Figure 4. (a) SEM image of the porous structure. (b) Magnified SEM image of the porous structure. (c) SEM image of the porous structure. (d) Magnified SEM image of the porous structure. (e) SEM image of the porous structure. (f) Magnified SEM image of the porous structure.

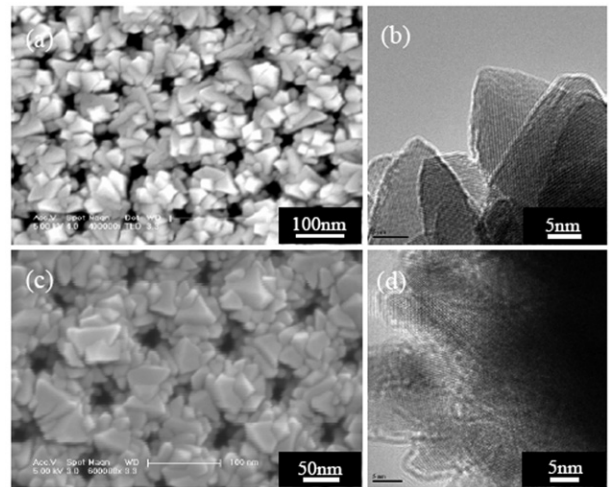


Figure 5. (a) SEM image of the porous structure. (b) Magnified SEM image of the porous structure. (c) SEM image of the porous structure. (d) Magnified SEM image of the porous structure.

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 A₁ ...
 A₁ ...
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 A₁ ...
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 ~25 ... ~100 ...
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 4 ...
 A₁ ... (~60 ...)
 (... 4 ...) ... (~10 ...)
 A₁ ... (~170 ...)
 ~350 ... 140 ... 0.5 ...
 (~140 ...) ... (~350 ...)
 (... 4 ...) ...
 A₁ ... (... 4 ...) ...
 A₁ ...

...
 A₁ ...
 2 ...
 A₁ ...
 5 ...
 2 ... 3 ...
 250°C ...
 20 ...
 5 ... B ...
 30, 31 ...
 ~25 ... A₁ ...
 (... 2 ...) ...
 2 ...
 5 ...
 30, 31 ...
 37 ...
 0.3 ...
 5.0 ... 29 32 ...
 5 ...
 180°C ... 1.0 ...

($\mu = 5()$)
($\mu = 5()$). 2

4. Conclusions

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... A
... 1,
... A
... 38
... A
... 3

Acknowledgments

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References

1 ... C, 2005 *Nature* **434** 1085

2 ... A, C, 2000 *Appl. Phys. Lett.* **77** 666
3 ... C, 2003 *Nature* **422** 599
4 ... C, 2004 *Nano Lett.* **4** 423
5 ... A, 2004 *Nat. Mater.* **3** 380
6 ... B