Nanowires for Optoelectronic Devices (FZ2-15)

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Overview:

In the past years, conventional nanowire fabrication techniques were not applied in many industries to manufacture electronic components due to its expensive cost and complex procedures, even though it had been developed to construct unique physical structures and reduce power consumption. Nowadays, a cost-effective and scalable nanowire fabrication technique is alternatively utilized via porous anodic alumina oxide (AAO) template assisted the method of Chemical vapor deposition (CVD). Therefore, by using this technique in this project, a potential material of Methylammonium Lead Bromide Perovskite (MAPbBr$_3$ or CH$_3$NH$_3$PbBr$_3$) could be successfully investigated as nanowires to further develop optoelectronic devices, such as light-emitting diode (LED) and photodetector that will be manufactured in smaller size and lesser power consumption.

Objective:

- Improve nanowire fabrication technology
- Investigate the performance of perovskite nanowire how make it as potential candidates for use in optoelectronic devices.

Characteristic:

Nanomaterial - Methylammonium Lead Bromide Perovskite
- High electron mobility
- Larger bandgap

Methodology:

**AAO template fabrication**

Standardization

Electropolishing

2nd Anodization

1st Anodization

1st Etching

AAO template

AAO has been utilized as a template for fabrication since it allowed direct assembly of nanomaterial. The process scheme of AAO fabrication is shown below:

1. The process begins with the aluminum (Al) foil that is electropolished in an acid solution to obtain Al substrate.
2. In order to accomplish the diameter AAO, the anodization and etching are needed to widen the pores and constitute the large-diameter segment of the membrane.
3. Therefore, the desired pores of AAO are dense and uniform in a diameter and length.

**Perovskite nanowire array fabrication using AAO template**

A. Barrier Thinning Process: Sub-channels are formed between aluminium and channels.
B. Metal Deposition: Lead is deposited in channels and sub-channels.
C. Chemical Vapor Deposition: CH$_3$NH$_3$PbBr$_3$ perovskite nanowire is grown in the channels by CVD process.
D. AAO Removal Method: Al is removed to form free-standing CH$_3$NH$_3$PbBr$_3$ perovskite nanowire.

Result:

Measurement:

We have successfully fabricated CH$_3$NH$_3$PbBr$_3$ perovskite nanowire and it is certified by X-ray Diffraction (XRD).

Four additional measurements are applied into the nanowire: Photoluminescence (PL), Absorption, Reflection and I-V characteristics.

A. The peak value of wavelength at 525nm in PL spectra result indicates that this material can fabricate green LED with nanowire, according to the reference of visible light (Fig. D). Absorption is shown that this material can absorb the large amount of light from 400nm to 525nm.
B. Three reflection of different lengths of channels are reported that if the channel length is increase, the absorption is increase.
C. I-V characteristics are explained that a larger current with the same voltage in light condition, suggesting a pathway to further develop for photodetectors with nanowires.

Conclusion:

Methylammonium lead bromine CH$_3$NH$_3$PbBr$_3$, were found to be nanowire material for further developing optoelectronic devices with nanowires, especially LED in green light. In addition, the properties of this material are observed that is operated as function of typical photodiode. Last but not least, the different channel length of CH$_3$NH$_3$PbBr$_3$ perovskite nanowire array with 1um, 2um and 3um demonstrate as the thickness increase, the auto-reflection of the material will increase. Thus, CH$_3$NH$_3$PbBr$_3$, perovskite nanowires have a great potential for making optoelectronic application.