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# Self-powered Organic-Inorganic Broad-spectrum Se Microwire/Perovskite-based Photodetectors

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**Abstract**

**Because the efficient and stable p-type doping semiconductors are still difficult to achieve up to now. To solve this problem, p-type Se microwires with high quality were fabricated by chemical vapor deposition in this work. The photodetector based on single Se microwire shows broadband photoresponse with peak responsivity of 2.8 $mAW^{-1}$ at 600 nm under 5 V bias. The cutoff wavelength is estimated to be 675 nm. Besides, we also fabricate p-n heterojunction photodetector based on p-type Se microwire and n-type $CH_3NH_3PbCl_3$ materials. The p-n heterojunction photodetector shows obvious broadband photoresponsivity property without external power supply. The peak responsivity can reach up to 0.7 $mAW^{-1}$. These results demonstrate that high performance self-powered photodetectors operating in UV-Visible spectrum range can be realized in Se microwire and $CH_3NH_3PbCl_3$ heterojunctions.**

## 1. Introduction

Nowadays, photoelectric sensors have played important role in our social life, like industrial production, environment protection, medical diagnose and other fields.[1] Therefore, the further research of photodetectors is of great significant to the development of society. Among the various kinds of photodetectors, photovoltaic detectors have attracted more and more attention because they can realize light detection without external bias.[2-5] However, due to the existence of intrinsic defects, high quality and stability p-type semiconductors with high quality and stability are still difficult to obtain by doping method.[6] As an elemental semiconductor, selenium is naturally p-type conductive. In this work, Se and $CH_3NH_3PbCl_3$ ($MAPbCl_3$) were combined to fabricate p-n heterojunction to realize self-powered broadband photodetection. Due to the high carrier mobility of $MAPbCl_3$, photogenerated carriers can be effectively separated thus improve the performance of the photodetectors.

## 2. General Instructions

The Se microwires used in this work were prepared by thermal evaporation method. During the experiment, high purity Se powder was used as the reaction source and the clean silicon wafer was used as the substrate for the growth of the microwires. After the growth, single Se microwires were selected to fabricated MSM devices for the next test.

To fabricated p-n junction, we chose $MAPbCl_3$ as n-type materials. $MAPbCl_3$ was prepared by chemical method. MACl and $PbCl_2$ powders were chosen as the reaction source. They both were dissolved in a mixed solution of N, N-dimethylformamide and dimethyl sulfoxide to obtain the $MAPbCl_3$ precursor solution. Then place a single Se microwire on the quartz glass and drop the precursor solution prepared before on the microwire. In order to obtain $MAPbCl_3$, we need to heat the precursor at 100 ℃ for 10 minutes. After those procedures, indium was selected as the electrode of the device. The photodetector based on Se microwire and $MAPbCl_3$were prepared.

Fig.1(a) and (b) show the SEM images of Se microwires. The average length of the microwires is 1 cm. it can be found that the lateral size of the microwires is about 8 μm and they have a relatively smooth surface. The cross-sectional image shows that the Se microwire has a triangle shape.

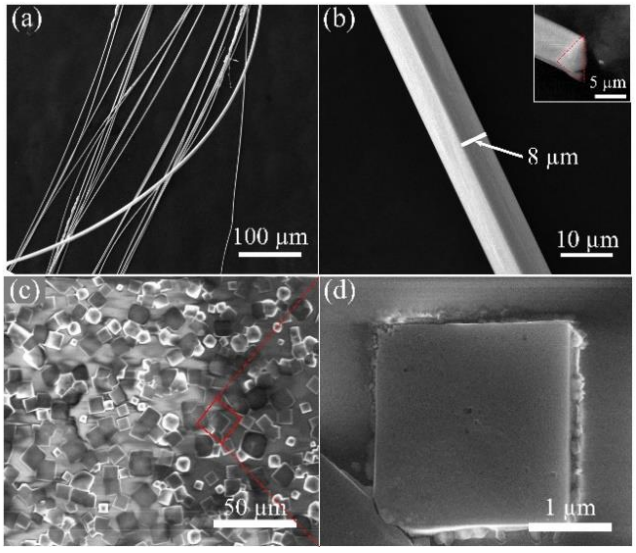


Fig.1 The SEM images of as-grown Se microwires on Si substrate. (a) Low magnification SEM image. (b) High magnification SEM image. The inset is the cross section of Se MW. (c)(d) The SEM images of as-grown MAPbCl3 on quartz substrate

Fig.1(c) and (d) show the SEM images of $MAPbCl_3$. It can be found that the $MAPbCl_3$ film contains many small grains. The grains show a quadrangular shape and their size is about 5 μm.

To further confirm the crystal qualities of the materials, they were investigated by XRD. As shown in Fig.2, the sharp

diffraction peaks indicated good crystal quality of the materials. The peaks of XRD pattern belong to hexagonal phase of Se and cubic phase of perovskite, respectively.

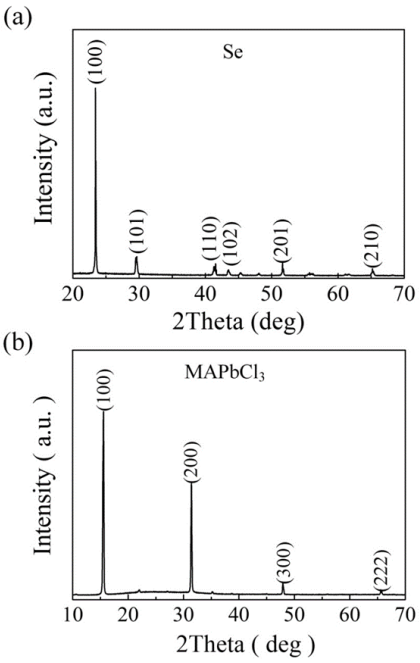


Fig.2 (a) XRD pattern of Se microwires. (b) XRD pattern of $MAPbCl_3$ film

To explore the performance of the device, the spectra responsivity of both devices ranging from 300 to 800 nm was measured as shown in Fig.3. it can be found that all the devices show broadband photodetection. The peak photoresponsivity

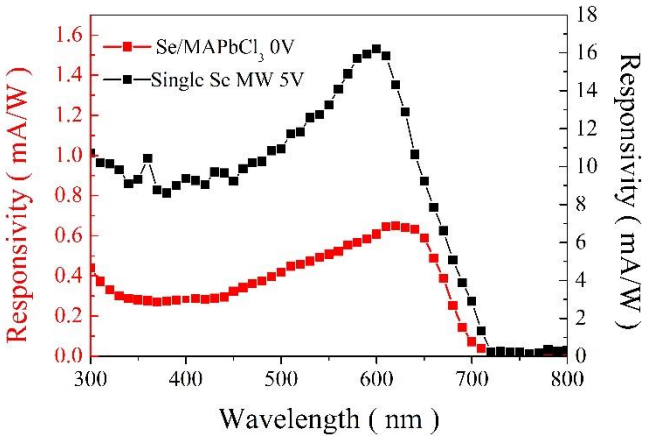


Fig.3 Responsivity of single Se microwire at 5 V bias and Se/$MAPbCl_3$ p-n heterojunction at 0V bias, respectively.

of Se microwire under 5 V bias is 1.5 $mAW^{-1}$. The p-n heterojunction shows obvious self-powered property. Its peak photoresponsivity can reach up to 0.7 $mAW^{-1}$. This indicates that our photodetector based on Se and $MAPbCl_3$ heterojunction can be well used in the UV-Visible photodetection.

## 3. Conclusions

Since it is difficult to obtain high quality p-type semiconductor by doping method for high performance photodetector. In this work, we chose Se as the p-type material to combine with high performance organic perovskite material, $MAPbCl_3$, to fabricate p-n heterojunction. The devices show obvious self-powered performance and the peak responsivity can reach up to 0.7 $mAW^{-1}$. This provides an effective method for us to realize high performance broadband photodetectors.


## Acknowledgements

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