Application of transmission EBSD in aluminium metal layer and GaAs/AlAs epitaxial layers

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Introduction

Background

As a powerful tool to analyze crystallographic and grain boundary information, EBSD has been widely employed in semiconductor industries. However, the lateral spatial resolution of EBSD (~100 nm) limits the applications of EBSD in semiconductor industries with aggressive size-shrinking trend. In this paper, the t-EBSD (transmission EBSD) configuration [2] is demonstrated o analyse the semiconductor-related materials.

Objective

- Instead of conventional EBSD which uses the backscattered electron, a novel configuration which utilizes the transmitted electron from a thin sample is demonstrated.
- EBSPs are properly indexed in order to construct the EBSD mapping.
- Monte Carlo simulation is used to compare the electron-sample interaction between conventional and transmission EBSD. The lateral resolution can also be estimated by the simulation.

Results and discussion

Fig. 1 shows the t-EBSD result of the cross-section of Al pad specimen. Different Al grains show different EBSP. All the patterns are well-defined and indexable. In the mapping, the grains with the size from 20nm-500nm were revealed. The appearance of the grain with 60 nm indicates the lateral spatial resolution of t-EBSD on the sample surface is better than conventional EBSD.

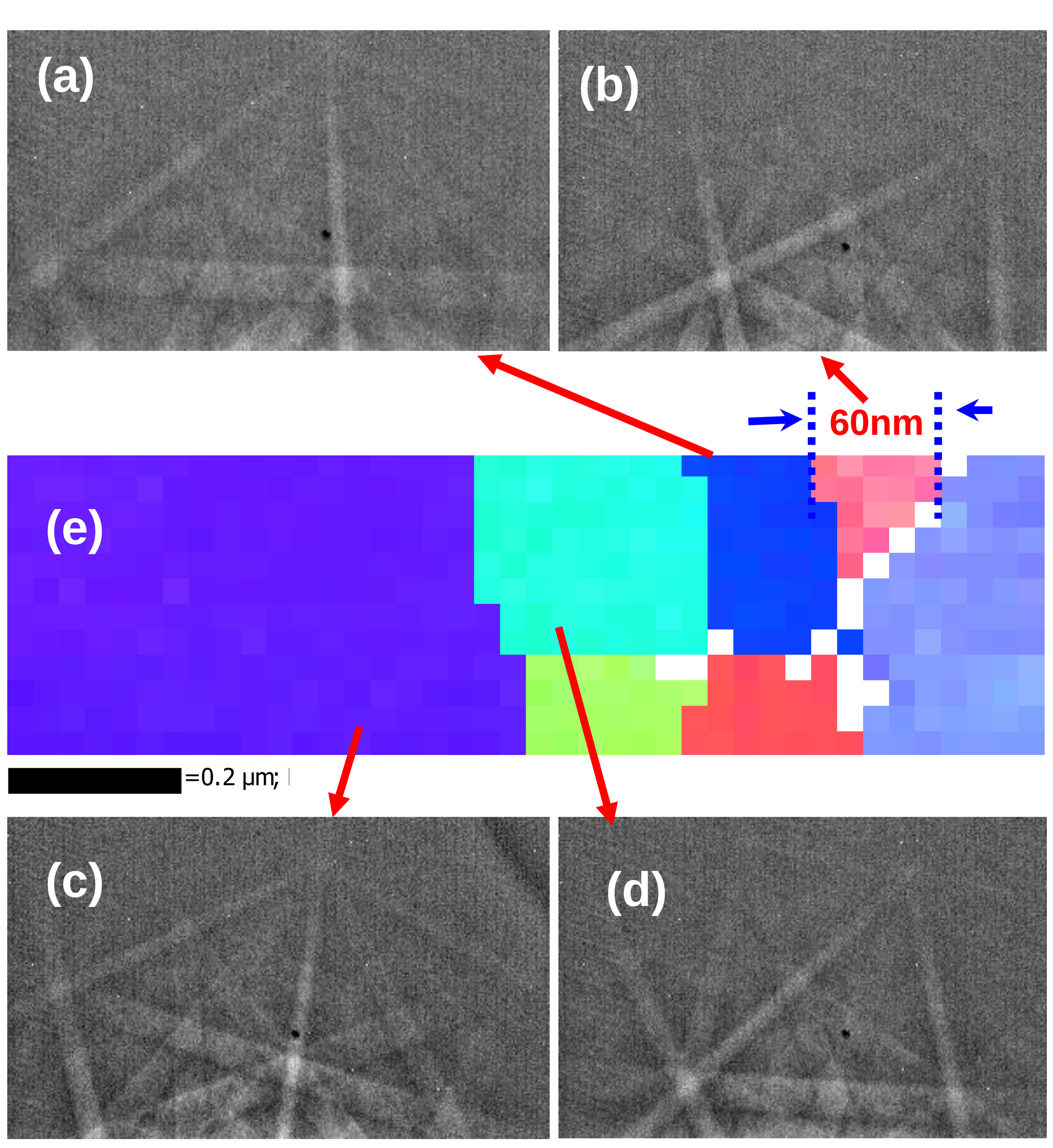

Fig. 1 transmission-EBSD results of the aluminium metal layer. (a)~(d): the EBSD diffraction pattern detected from different grains; (e): inverse pole figure mapping along scanning direction of electron beam, feature about 60 nm large is revealed.

In order to simulate the interaction between electron beam and the Al pad in the above case, Monte Carlo method is applied as shown in Fig. 2. The electron beam size at the exit surface can be roughly estimated as the lateral resolution [3]. In the case of conventional EBSD, the backscattered electrons, which are used to form EBSD pattern, cover the width about 200 nm on sample top surface. On the other hand, the electrons in t-EBSD setting travel through the sample and emerge from the bottom surface. The beam size at the exit surface is about 20 nm, which indicates good lateral spatial resolution on the surface.

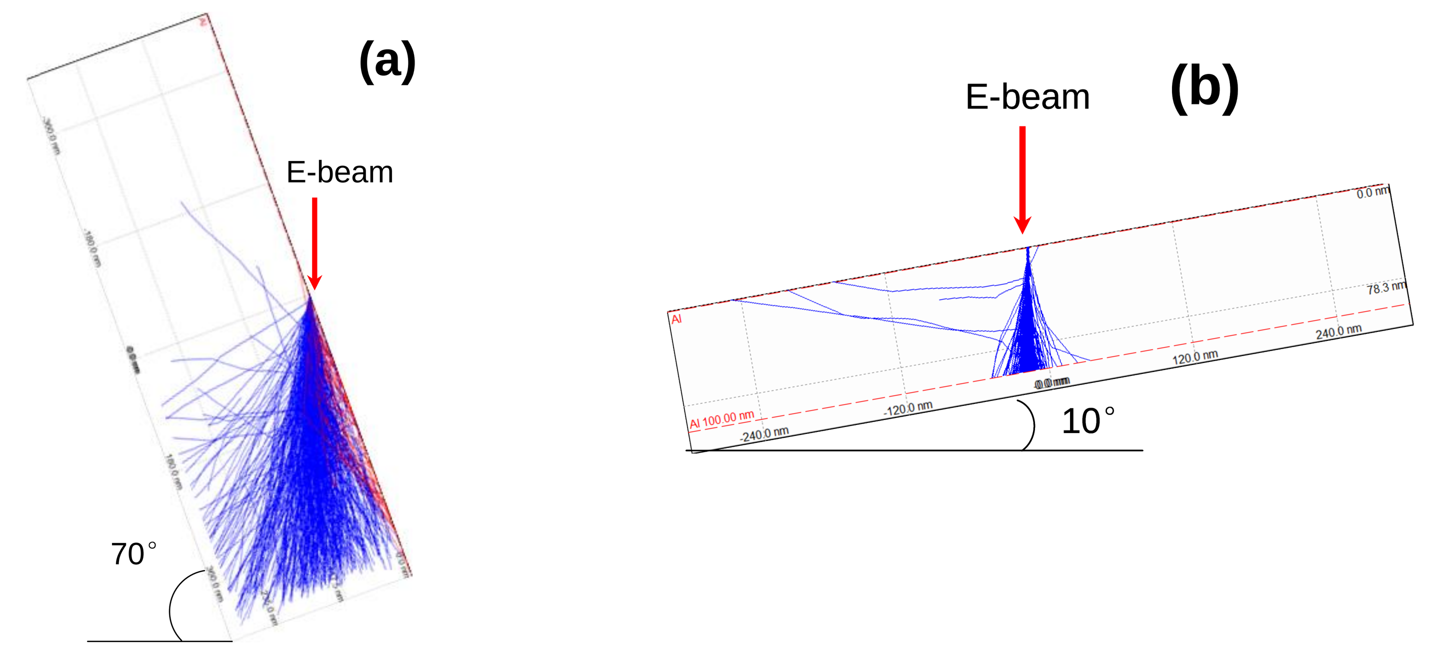

Fig. 2 Monte Carlo simulation of electron trajectories in conventional EBSD (a) and transmission EBSD (b) on aluminium surface.

Fig. 3 shows the t-EBSD results of GaAs/AlAs layered samples. The kikuchi bands in the EBSPs are well defined. GaAs and AlAs have similar crystal structures with only 0.1% lattice mismatch. Therefore, it is unable to the distinguish different layers by indexing the EBSP. In fact, the elastic scattering cross sections are different between GaAs and AlAs due to their different atomic weights. By using their average atomic weights, the total electron elastic cross section values Ω of GaAs and AlAs can be estimated as 5.5 E-17 cm2 and 7.4 E-17 cm2 respectively. Larger Ω value means more elastic scattering events occur. Therefore, more elastic scattered electrons from GaAs contributing to the intensity of kikuchi bands arise from the background in EBSP as compared to that of AlAs, which results in higher kikuchi band contrast in EBSP.

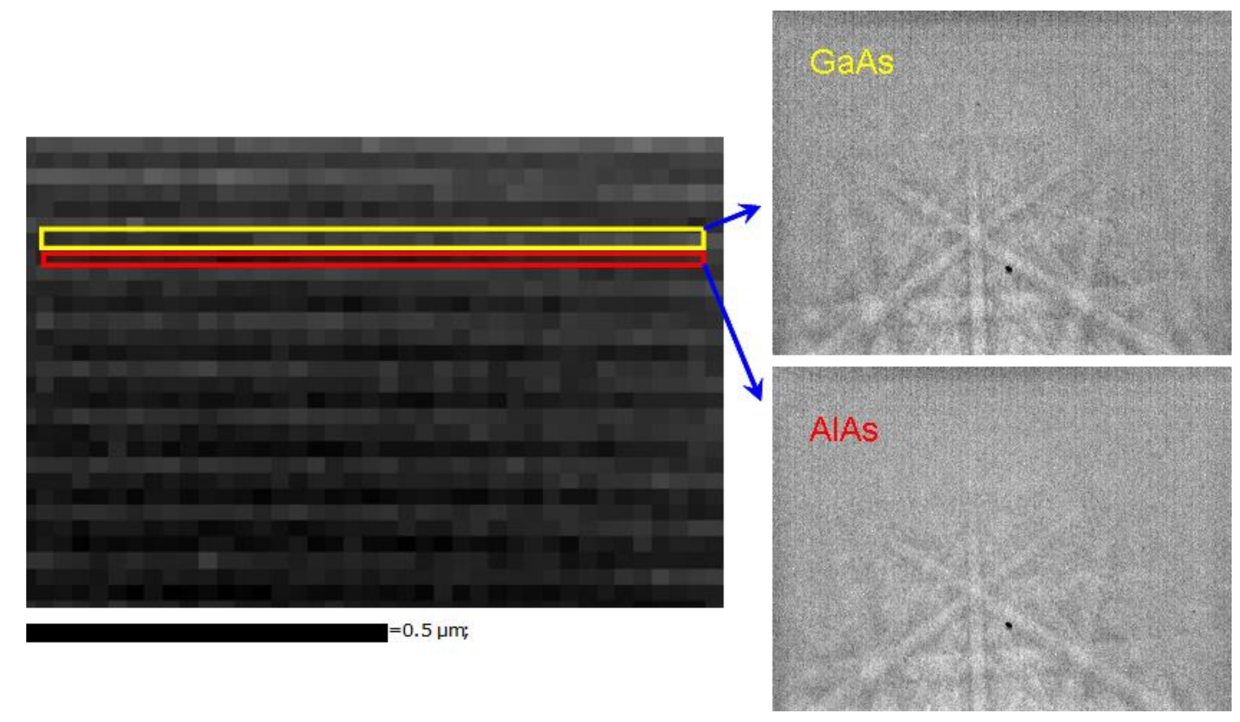

Fig. 3 transmission-EBSD results of GaAs/AlAs epitaxial layers. The EBSPs from GaAs and AlAs layers are identical. By using the band contrast mapping, GaAs layers of 50 nm thick and AlAs layers of 30 nm can be differentiated.

Conclusion

Transmission configuration of EBSD is successful demonstrated. Such configuration pushes EBSD beyond its lateral resolution limits and can be applied to analyze aluminum metal layer and GaAs/AlAs epitaxial layers with the feature size less than 100nm. As for aluminum layer, the resolution is better than 20 nm. Useful information such as EBSP, orientation mapping and band contrast mapping can be obtained. The transmission configuration will also result in better signal-to-noise ratio. Transmission EBSD exhibits great potential in the semiconductor industries.

References

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