Grain Orientation Mapping of Polycrystalline Organic Molecules by Electron Backscattered Diffraction (EBSD) in SEM

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Electron backscattered diffraction (EBSD) is a powerful technique widely used for crystal orientation determination in scanning electron microscopy (SEM). When coherent diffraction is obtained in spot mode (regular SEM imaging mode with a focused electron beam), crystal orientation of the area under the beam can be derived. Such diffraction comes from a depth in the range of a few 10s of nanometers. Even though EBSD is widely used to study inorganic materials, e.g. metals and ceramics, it is very difficult to apply on organic materials due to the nature of the organic materials, i.e. low electron and heat conductivity.

Tetraphenyltetracene or Rubrene is a promising organic semiconductor due to its demonstrated high field-effect transistor mobilities [1]. It is composed of carbon and hydrogen with a chemical formula of $C_{42}H_{28}$ [2]. Polycrystalline rubrene takes at least three distinct crystal structures. In this study, the rubrene films are orthorhombic with space group of 64 (Cmcm). Its unit cell dimensions are a= 2.68nm, b=0.71nm, and c=1.44nm.

Rubrene film used in this study was grown on a piece of glass slide coated by a layer of Indium Tin oxide (ITO) with a film thickness of 100nm (as shown in Fig.1). A FEI Nova Nanolab 200 FEG-SEM scanning electron microscope was used to investigate the film microstructure. The microscope is equipped with an Oxford Nordlys Nano EBSD detector with forward scattered detectors (FSDs).

Fig.2 is an EBSD map acquired by defocusing the beam by 2 mm with a step size of 10 μm, beam at 10 kV and 3.7 nA, and 480 ms detector exposure time per step. The obtained orientation map resembles typical EBSD maps of inorganic material, i.e. pixels cannot be indexed at the grain boundaries due to pattern overlap. Overall, the index rate is well above 90%. The map shows crystals in the rubrene film are highly textured and is confirmed in pole figure (Fig. 3c). This confirms the c-axis is parallel to growth direction and a random distribution based on rotations of the crystal around c-axis.

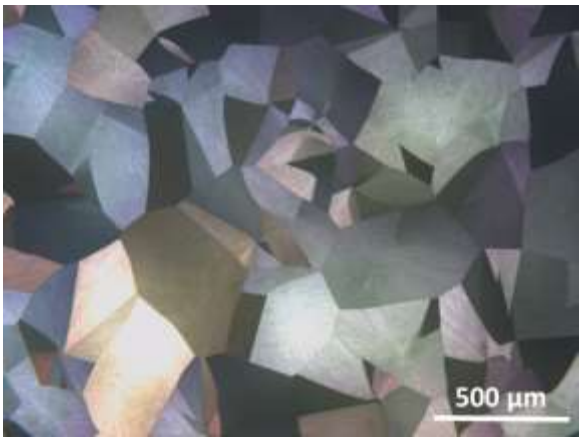

Fig. 1 Polarized optical microscopy image shows a polycrystalline structure with a grain size of about 150µm.

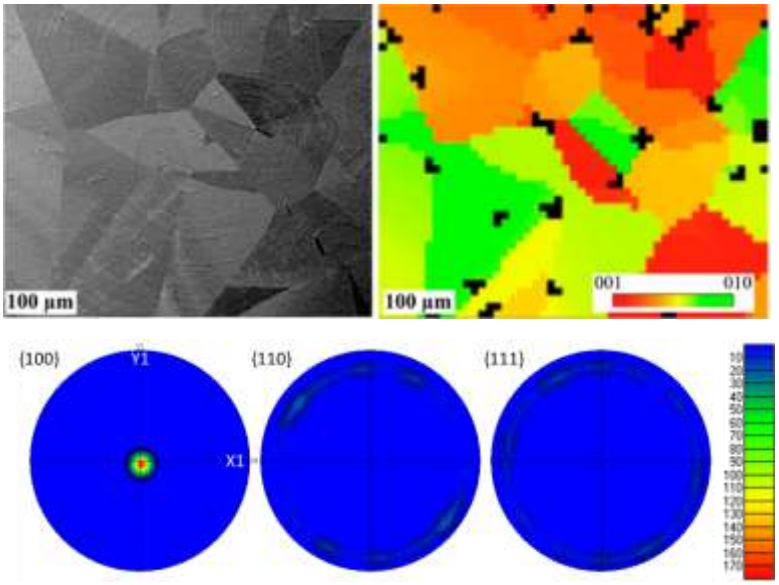

Fig. 2 (a) SEM image and (b) corresponding orientation map (inverse pole figure -X) of the same region. (c) is pole figures of the orientations obtained from map (b).

References

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