To develop polycrystalline thin-film tandem solar cells, we fabricated BaCuSeF and related compounds thin films and applied their thin films to the back contact of CdS/CdTe solar cells. The CdS/CdTe solar cell with BaCuSeF back contact showed a conversion efficiency of 9.91% [1] and that with SrCuSeF showed 11.6% [2]. However, the conductivities of BaCuSeF (1.1 S/cm²) and SrCuSeF (0.11 S/cm²) films were much lower than those of n-type TCOs such as ITO, over 10³ S/cm². Therefore, we fabricated SrCuSeF/ITO bilayer films and applied them as the back contact of CdS/CdTe solar cells. SrCuSeF/ITO bilayer films showed ohmic I-V characteristics. The CdTe solar cell with the SrCuSeF(34 nm)/ITO(200 nm) bilayer back contact showed a high conversion efficiency of 14.3% (\(V_{oc} = 804\) mV, \(J_{sc} = 27.5\) mA/cm², and \(FF = 0.65\) ) [3].

In this study, we fabricated BaCuSF films by Pulsed Laser Deposition (PLD) and characterized their optical and electrical properties. The BaCuSF ceramic target was fabricated by a solid-state reaction of BaF₂, BaCO₃ and Cu₂S powders. A KrF excimer laser with a wavelength of 248 nm was focused on the ceramic target, and the BaCuSF films were deposited on borosilicate glass substrates at substrate temperature (Tₛ) of 150°C - 400°C. All the BaCuSF films were amorphous or microcrystalline. The transmittance of the films increased with increasing Tₛ up to 400°C. The maximum transmittance at the visible region of about 60% was obtained for the film deposited at Tₛ=400°C. The band gap energy of the film was estimated to be 3.1 eV. All the BaCuSF films showed p-type conductivity. The maximum conductivity of 30.4 S/cm was obtained for the film deposited at Tₛ=150°C. The CdS/CdTe solar cell with the BaCuSF back contact showed a conversion efficiency of 11.2%.

Then, we fabricated BaCuSF/ITO bilayer films. The ITO layer was deposited by RF sputtering. The BaCuSF/ITO bilayer film showed ohmic I-V characteristics. We applied the BaCuSF/ITO bilayer as the back contact of the CdS/CdTe solar cell. Figure 1 shows the illuminated J-V characteristic of the CdS/CdTe solar cell with BaCuSF/ITO back contact. Figure 2 shows the external quantum efficiency (EQE) of the CdTe solar cell shown in Fig. 1. The CdTe solar cell showed a high conversion efficiency of 12.2% (\(V_{oc} = 786\) mV, \(J_{sc} = 27.2\) mA/cm², and \(FF = 0.570\)). In the case of the CdS/CdTe solar cells with the BaCuSF/ITO bilayer back contact, high conversion efficiency was obtained for the thinner BaCuSF layer than those with the SrCuSeF/ITO bilayer back contact.