Six-types of decagonal quasicrystals (DQCs) and some crystalline approximants have been found in Al-Co-Ni alloys which have a wide range of compositional ratios of Ni/Co and a nearly constant Al composition of approximately 70 at %. It is considered that various structures of the DQCs are stabilized by chemical ordering of Co and Ni. The arrangements of transition-metal (TM) atoms have been determined by Cs-corrected HAADF-STEM observations [1-3]. However, the study of the chemical ordering in Al-Co-Ni DQCs is difficult in HAADF or ABF STEM observations, because atomic number difference between Co and Ni is only one, resulting in very low contrast between these atomic columns in STEM images. Recent developments of an X-ray detector with large solid angle and an ultrafine and intense probe realized with a Cs-corrector enable us to perform atomic-resolution chemical analysis. Our intention in this paper is to detect the chemical ordering of Co and Ni in Al-Co-Ni crystalline phases, which are closely related to the structure of the Al-Co-Ni DQCs, by the atomic-resolution EDS. However, this method has been considered to be difficult for some materials, which are easily damaged by intense electron irradiation in STEM. To reduce the electron dose on a specimen, we have tried to obtain an EDS map formed by integration of several EDS maps from fresh areas. The maps from the areas were obtained by periodic sample shifts, which are determined by translational vectors of a and c, where a and c are lattice parameters in the unit cell of the crystalline phase. It should be noted that this method applicable to the crystalline phases that have periodic arrangements.

Figure 1 shows atomic-resolution EDS maps of a W-(AlCoNi) crystalline phase, taken with a newly developed silicon drift detector (SDD), installed on an aberration corrected microscope (JEM-ARM200F). The chemical ordering of Co and Ni is clearly seen in the map, shown in Fig. 1(d), which is a superimpose map of Co and Ni.

Fig. 1: Figure 1 HAADF-STEM image (a), atomic-resolution EDS maps of Co and Ni (b, c) and a superimposed map (d) for the W-(AlCoNi) crystalline phase. The locations of atomic clusters are indicated by circles in images. Note that the chemical ordering of Co and Ni occurs at regions between the Co-rich atomic clusters and Ni-rich regions.