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# Nano-Scale Processing of Zeolite by High-Energy Corpuscular Radiation

Yukichi Sasaki[1], Toshiyuki Suzuki[1]

[1]Nanostructures Research Laboratory, Japan Fine Ceramics Center, Nagoya, 456-8587, Japan

Zeolites have excellent ion exchange capabilities and so synthesizing Ag-zeolite ($Ag_xAl_xSi_{1-x}O_2$) using an $AgNO_3$ aqueous solution is a simple procedure. When this Ag-type zeolite is irradiated with a high-energy electron beam of 200keV in a transmission electron microscope, the crystal eventually becomes amorphous [1]. We have found that ordered clusters of Ag atoms are formed in the amorphous region during this process (FIG. 1). It is anticipated that quantum effects would appear in this material [2]. Producing uniform cluster crystals in the zeolite crystal using high-energy electron beam irradiation is not easy because this type of irradiation breaks chemical bonds in the zeolite framework and simultaneously activates a rapid diffusion of Ag clusters in the amorphous $SiO_2$. Spatial distribution of Si and O atoms must remain in the amorphous silica, as in zeolite crystals. Apparently for this reason the zeolite keeps its porous structure, and Ag atoms are condensed into the pores (FIG. 2). However, controlling the distribution of Ag atoms in the amorphous silica is difficult, making the synthesizing of large Ag cluster crystals difficult.

A columnar amorphous phase is formed along ion tracks by high-energy ion irradiations of zeolite crystals (FIG. 3). Because the shape of columnar defects is related to the value of the stopping power calculated for irradiation conditions, such as irradiation energy, ion, and target material, the shape can be controlled by such conditions. Figure 3 shows that Ag clusters have been generated along the ion track. We believe that the patterning of Ag clusters can be arranged by high-energy ion irradiation of the Ag-zeolite. Recently, synthesis methods have been developed to obtain single LTA and FAU zeolite crystals of several hundred microns [4]. In addition, centimeter-long oriented films have also been prepared [5]. It is suggest that new practical materials with Ag clusters arranged in amorphous $SiO_2$ can be produced using the high-energy ion irradiation.

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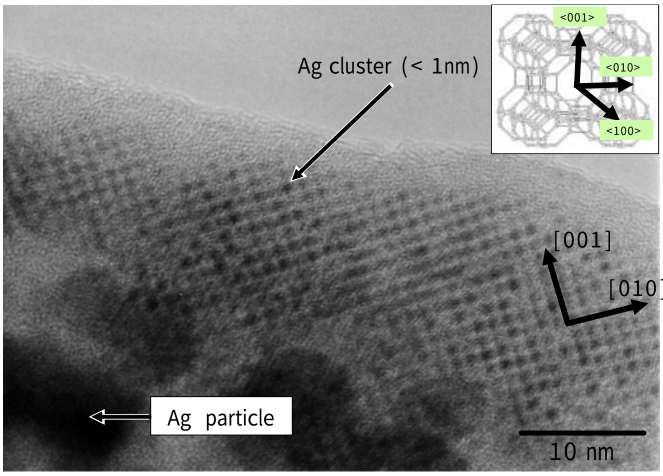


**FIG. 1 lattice image formed in Ag-zeolite (LTA) irradiated with electron beam**

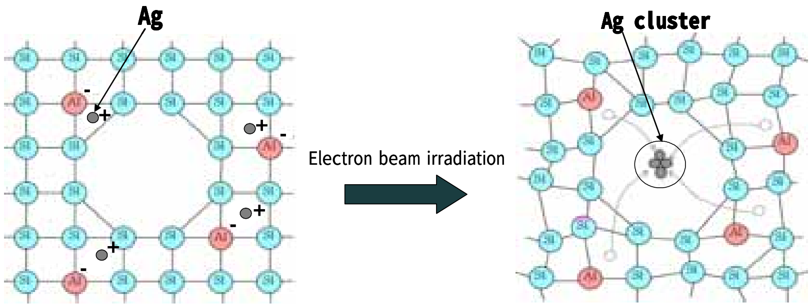


**FIG. 2 Formation mechanism of Ag cluster crystal in SiO2 by electron beam irradiations**

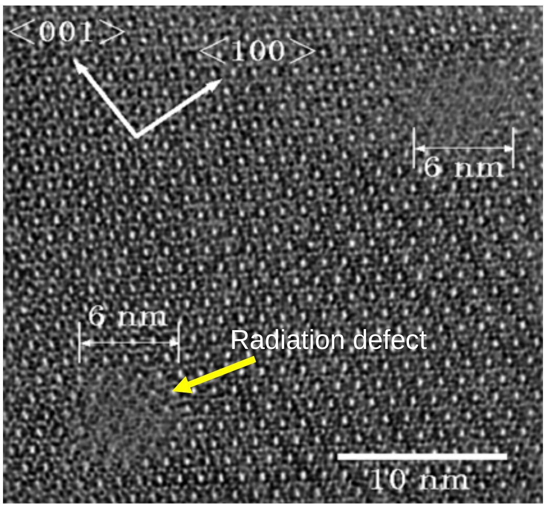


**FIG. 3 Radiation defects formed by Au-200 MeV ions**