Brillouin and Raman scattering studies of the isotopically induced ferroelectric phase transition of $SrTi^{18}O_3$

T. Yagi, M. Kasahara, Y. Tsujimi, M.Yamaguchi[a)], H.Hasebe, R.Wang[b)] and M.Itoh[b)]
Research Institute for Electronic Science, Hokkaido University, Sapporo 060-0812, JAPAN
a) School of Engineering, Hokkaido University, Sapporo 060-0812, JAPAN
b)Materials and Structures Laboratory, Tokyo Institute of Technology, Yokohama 226-8503, JAPAN

The quantum paraelectric $SrTiO_3$ has attracted a lot of interest of many researchers since the quantum-mechanical stabilization of the paraelectric phase below 4K was pointed out as a quantum effect on the polarization fluctuation.[1)] Recently a ferroelectric phase transition has been reported in the $SrTiO_3$ crystal exchanged of isotope ^{18}O for ^{16}O.[2)] The difference of mass between ^{16}O and ^{18}O seems to suppress the quantum fluctuations and to bring divergence of the spatial correlation of the fluctuating polarization at the paraelectric-ferroelectric phase transition. In the present study, the dynamical mechanism of the ferroelectric phase transition of the isotopically exchanged $SrTiO_3$ has been studied by both of the Brillouin- and Raman scatterings.[3-5)] The exchange rate of the isotope ^{18}O is 87% which gives the ferroelectric transition temperature Tc=24K.[2)]

Brillouin scattering study found anomalous temperature dependence of the acoustic mode near Tc; a transverse mode shows a softening behavior in contrast to no anomaly of the longitudinal c_{33} mode. The rather complicated behavior of the acoustic modes near Tc has been elucidated. A strong central component appeared in the Brillouin scattering spectra suggests existence of the dynamical cluster near Tc. The isotope effect on the doublet problem is discussed.

Raman scattering study elucidates a broad spectrum characteristic for the ferroelectric micro-region (FMR) reported previously for $SrTi^{16}O_3$.[5,6)] The size of FMR increases anomalously when temperature approaches to Tc in the paraelectric phase. The soft mode spectra are not clear below Tc, though every soft-ferroelectric mode should be Raman active in the ferroelectric phase.

The ferroelectric phase transition induced isotopically in $SrTiO_3$ seems to be caused by somewhat complicated cluster dynamics rather than by homogeneous fluctuation of polarization.

1)K.A.Muller and H.Burkard:Phys.RevB19(1979)3593.
2)M.Itoh, R.Wang, Y.Inaguma, T.Yamaguchi, Y-J.Shan and T.Nakamura;Phys.Rev.Lett.82_(1999)3540.
3)M.Yamaguchi, T.Yagi,R.Wang and M.Itoh: Phys.Rev.B**63** (2001)in print.
4)Y.Tsujimi, H.Hasebe, R.Wang, M.Itoh and T.Yagi:Ferrolectrics **239**(2001) in print.
5)M.Kasahara, R.Wang, M.Itoh and T.Yagi: J.Phys.Soc.Jpn.**70**(2001)in print.
6)H.Uwe, H.Yamaguchi and T.Sakudo:Ferroelectrics **96**(1989)123.