TWO-DIMENSIONAL CORRELATION ANALYSIS OF RAMAN SPECTRA OF SUPERCONDUCTING YNi_2B_2C

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Abstract: This paper demonstrates the potential of two-dimensional (2D) correlation spectroscopy for characterizing the effects of magnetic fields and temperature on the Raman spectra of superconducting YNi_2B_2C single crystal.

In this study, we have applied two-dimensional (2D) correlation analysis to the magnetic filed- and temperature-dependent Raman spectra of the B_{1g} phonon mode near 204 cm^{-1} and the B_{1g} and B_{2g} superconducting gap feature near 40-50 cm^{-1} of superconducting YNi_2B_2C single crystal. Generalized 2D correlation spectroscopy has been applied extensively to the analysis of spectral data sets of a system under some external perturbations.[1,2] Because of the wide range of applications of this technique, it has become one of the standard analytical techniques for interpreting various types of spectroscopic data. This paper demonstrates the use of 2D correlation spectroscopy in characterization of the effect of magnetic fields and temperature on the Raman spectra of superconducting YNi_2B_2C single crystal.

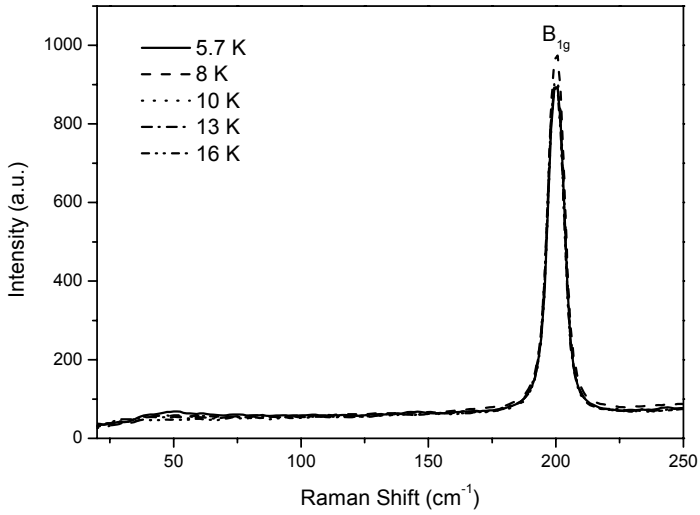

Fig. 1. Temperature-dependent B_{1g} Raman spectra of superconducting YNi_2B_2C single crystal.

In the synchronous 2D Raman correlation spectrum, the two prominent peaks at 204 and 42 cm^{-1} are strongly positively correlated. It means that the intensity of the B_{1g} phonon peak at 204 cm^{-1} decreases together with the intensity of the 2Δ superconducting gap peak at 42 cm^{-1} as the magnetic fields increase. Moreover, the gap peak at 42 cm^{-1} shows much greater variation in intensity than the phonon peak at 204 cm^{-1}. The corresponding asynchronous 2D Raman correlation spectrum suggests that the decrease in the intensity of the phonon peak at 204 cm^{-1} occurs before that of the gap peak at 42 cm^{-1} with the applied magnetic field.

2D correlation analysis on the temperature dependence of the B_{2g} superconducting gap peak shows that the gap peak shifts to lower frequency as the temperature increases, as BCS prediction for the temperature dependence of the superconducting gap.[3] However, the analysis on the B_{1g} phonon peak near 200 cm^{-1} shows that the peak is essentially composed of two peaks at 197 and 203 cm^{-1}, and only the weight of the two peaks changes as the temperature changes. The result suggests that there are two distinctive environment of the Ni-B bonds in YNi_2B_2C system. The Boron A_{1g} mode needs to be analysed in this aspect.

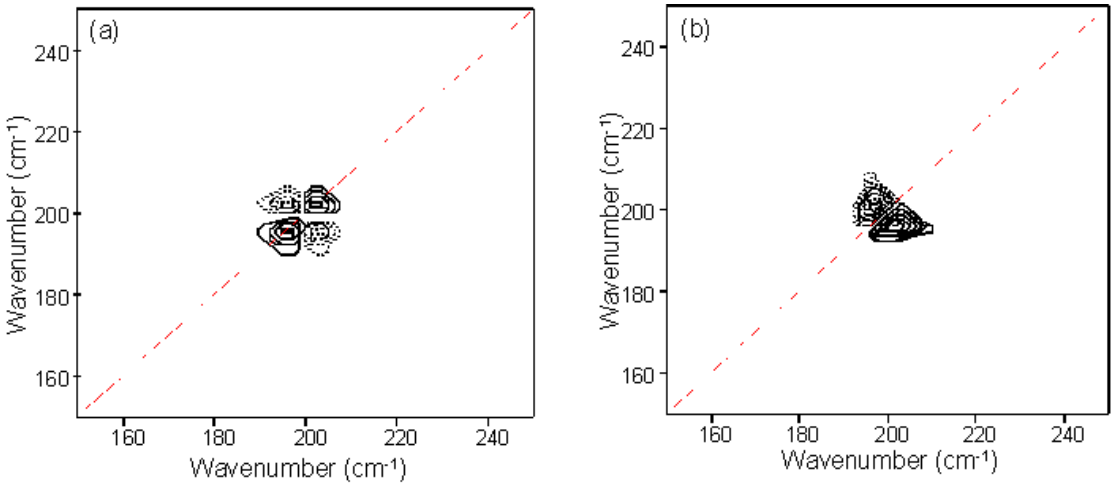

Fig. 2. Synchronous (a) and asynchronous (b) 2D correlation spectra from temperature-dependent B_{1g} Raman spectra of superconducting YNi_2B_2C single crystal.

Furthermore, we have applied 2D hetero-spectral correlation analysis to temperature-dependent Raman spectra of B_{1g} vibrational mode and B_2g superconducting gap mode to demonstrate the relation between B_{1g} and B_{2g} bands with increasing temperature. The results of 2D hetero-spectral correlation analysis of temperature-dependent Raman spectra of B_{1g} and B_{2g} modes will be also discussed.

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References:
1. I. Noda, Appl. Spectrosc. **47**, 1329, (1993).
2. I. Noda, A. E. Dowrey, C. Marcott, G. M. Story, and Y. Ozaki, Appl. Spectrosc. **54**, 236A, (2000).
3. I.-S. Yang, M. V. Klein, S. L. Cooper, P. C. Canfield, B. K. Cho, and S.-I. Lee Phys. Rev.B **62**, 1291 (2000).