Resonant Raman scattering of few-layers $CrBr_3$

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Chromium bromide belongs to the family of magnetic layered materials with the general formula CrX_3 (X = Br, Cl and I). In bulk form, the intralayer and interlayer exchange couplings in CrB_3 are ferromagnetic, in contrast to $CrCl_3$ and CrI_3 characterized by the antiferromagnetic interlayer orders [1, 2].

In this work, we performed the Raman scattering (RS) experiment on thin $CrBr_3$ flake with thicknesses from 4 to 7 layers at low (T=5 K) and room (T=300 K) temperatures using 5 different excitation energies, *i.e.* 1.96 eV, 2.21 eV, 2.41 eV, 2.54 eV, and 3.06 eV. The thickness of the flakes was confirmed by atomic force microscopy.

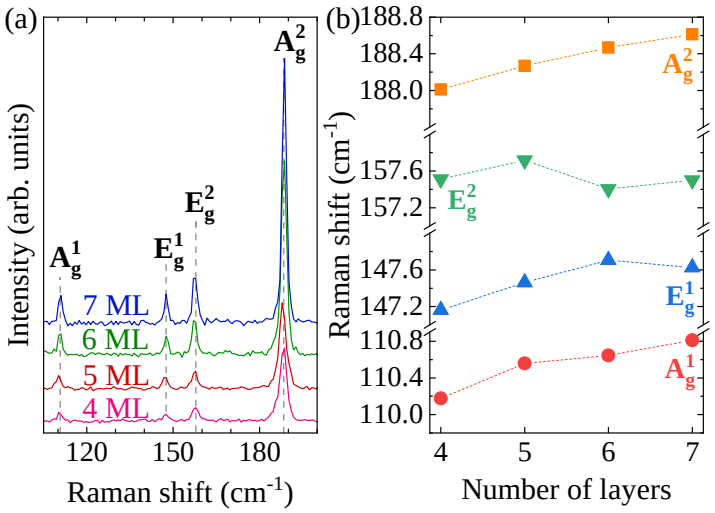

Figure 1: (a) Raman scattering spectra of thin flakes of $CrBr_3$ with thickness ranging from 4 to 7 layers. (b) Thickness dependence of the energies of the RS peaks.

In order to find the best resonant conditions for RS, we compared the intensities of the Raman peaks of $CrBr_3$ measured under different excitations. We found that the most intense Raman signal is observed under 2.41 eV excitation at room temperature. However, a substantial enhancement of the RS signal of about 3 times as compared to the aforementioned case was obtained under 3.06 eV excitation at T=5 K. The latter laser energy was chosen to investigate the thickness evolution of the Raman spectra, see Fig. 1(a).

As was reported in Ref. [1], four phonon modes, assigned as A_g^1, E_g^1, E_g^2, A_g^2, are Raman-active in $CrBr_3$. Note that the top indexes are additional numbering to resolve the peaks sharing the same notation. The thickness dependence of the observed phonon energies is presented in Fig. 1(b). A clear monotonic blueshift of the A_g^1 and A_g^2 peaks is seen when the number of layers increases with the relative energy difference between 4 and 7 layers of about 0.6 cm^{-1}. The corresponding evolutions of the E_g^1, E_g^2 energies reveal a more complex behavior with the relative difference of around 0.4 cm^{-1}. Our results confirm that the Raman technique can also be very useful in determining the thicknesses of the flakes in magnetic layered materials.

[1] D. P. Kozlenko, et al., *npj Quantum Materials* **6**, 2397-4668, (2021).
[2] M. Gilbertini, M. Koperski, et el., *Nat. Nanotechnol.* **14**, 408-419, (2019).