Polarization resolved photocurrent characterization of 2D rhenium disulphide photodetectors

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The low crystal symmetry of rhenium disulphide (ReS_2) allows for dichroic optoelectronic responses not found in other transition metal dichalcogenides (TMDs). However, most spectroscopy studies performed on ReS_2 have only focused on optical characterization, such as photoluminescence, absorbance or reflectance spectroscopy. To exploit the whole range of properties of the material, an extensive study of the optoelectronic behaviour of ReS_2 is required. We have measured the polarization resolved photocurrent spectra of few-layer ReS_2 photodetectors on both room temperature and cryogenic conditions (14 K). The results show two main exciton lines at energies matching those of previous literature, as well as their excited states. Not only that, we also report an exciton-like spectral feature with comparable photoresponse intensity as the main exciton lines. Nevertheless, this phenomenon hasn't been observed in earlier photoluminescence measurements. Our hypothesis is that this feature corresponds to a non-radiative exciton transition. The three exciton features are subject to changes in intensities under linear polarized light, with each of the three reaching maximum intensity at different polarization angles. First-principles exciton calculations conducted with the Bethe-Salpeter formalism corroborate our experimental findings. These results provide new perspectives for studying and exploiting exotic optoelectronic phenomena on ReS_2-based devices.

Figures

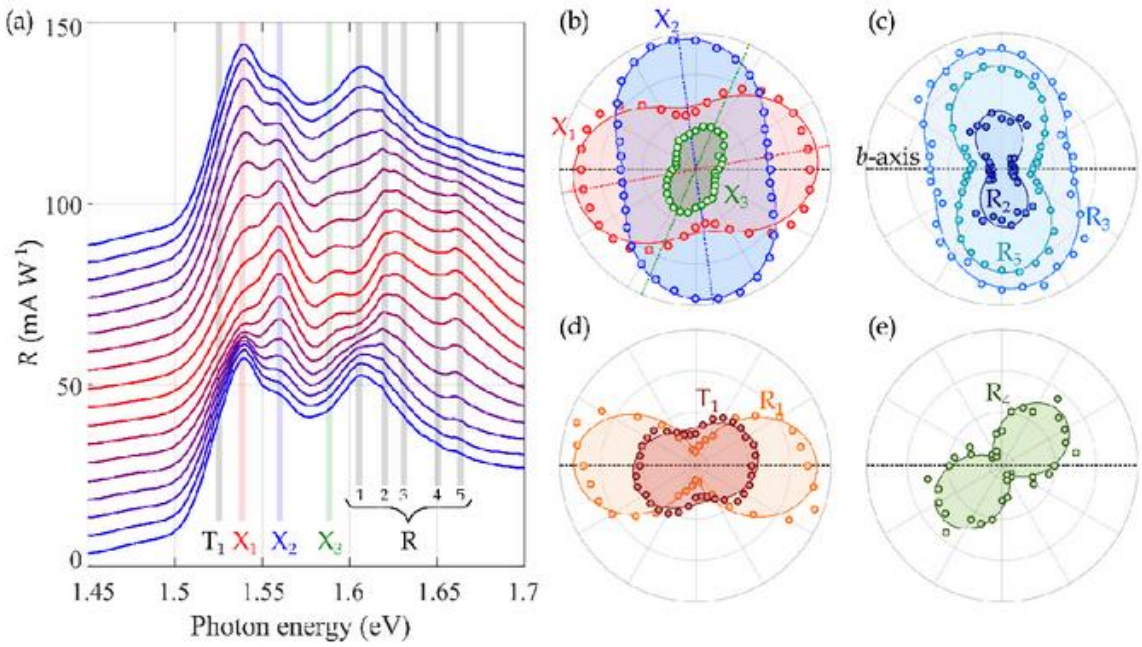

Figure 1: (a) Photocurrent spectra acquired for different angles of light polarization, from 0 to 170° relative to the *b* crystalline axis with V_{sd} = 5 V, V_{gate} = 45 V and a power density of 500 W m^{-2} . Consecutive spectra have been shifted vertically in steps of 5 mA W -1 for easier visualization. (b-e) Polar plots showing the modulation of the different spectral features as a function of the polarization direction, extracted from fittings to multi-Lorentzian curves.