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Defect induced magnetic phase transition in CrSBr

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As an air-stable Van der Waals magnetic semiconductor, CrSBr is receiving great research attention due to its exceptional optical, electronic, and magnetic properties. Below the Néel temperature of 132 K, CrSBr exhibits a typical A-type antiferromagnetic order comprised of antiferromagnetically coupled ferromagnetic monolayer. This special structure makes it susceptible to external stimuli, such as defects. In this work, we present the magnetic phase transition from antiferromagnetic to ferromagnetic in CrSBr crystals irradiated by non-magnetic ions. We observe the rise and fall of the ferromagnetic phase in antiferromagnetic CrSBr with increasing the irradiation fluence, while confirm the evolution of interlayer AFM coupling. The irradiated CrSBr shows ferromagnetic critical temperature ranging from 110 to 84 K, well above liquid N2 temperature. Raman spectroscopy reveals phonon softening, suggesting the formation of defects. Structure analysis of the irradiated crystals in conjunction with density functional theory calculations suggest that the displacement of constituent atoms due to collisions with ions and the formation of interstitials favors ferromagnetic order between the layers. Increasing irradiation fluences gradually lowers the Curie temperature, reflecting the impact of crystalline degradation. This suggests that by finely tuning the irradiation parameters and employing precise lithography techniques, it is possible to selectively modulate induced ferromagnetism in CrSBr in terms of magnetization strength, critical temperature, and spatial distribution.

Reference:

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