Control of magnetic anisotropy and observation of room-temperature antiskyrmions in Pd-doped $(Fe,Ni)_3P$ with S_4 symmetry

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Magnetic skyrmions, vortex-like topological spin textures, have attracted much interest in a wide range of research fields from fundamental physics to spintronics applications [1]. Recently, growing attention has also been paid to antiskyrmions with opposite topological charge in non-centrosymmetric magnets with anisotropic Dzyaloshinskii-Moriya interaction (DMI). However, most antiskyrmion studies have been restricted to Heusler compounds with D_{2d} symmetry [2, 3]. Recently, we have discovered a new antiskyrmion material $Fe_{1.9}Ni_{0.9}Pd_{0.2}P$ with S_4 symmetry. Using Lorentz transmission electron microscopy, we observed square antiskyrmions in a wide temperature region including room temperature, and found their topological transformation to elliptic skyrmions upon changing magnetic fields and lamella thickness [4]. In antiskyrmion materials, not only the anisotropic DMI but also the uniaxial magnetic anisotropy and the magnetic dipolar interaction are important factors determining the magnetic texture, but the relation between the stability of antiskyrmions and these magnetic interactions remains unclear. We then systematically controlled the magnetic anisotropy of $(Fe,Ni)_3P$ by doping and investigated its impact on the stability of antiskyrmions. Our magnetometry and ferromagnetic resonance spectroscopy studies show that the variation of the Ni content and slight doping with 4*d* transition metals considerably change the magnetic anisotropy. In particular, Pd doping induces the easy-axis anisotropy, leading to the stable antiskyrmion formation, while a temperature-induced spin reorientation is observed in a Rh-doped compound. We mapped the stable region of antiskyrmions as functions of uniaxial magnetic anisotropy energy and demagnetization energy, and demonstrated that their subtle balance is necessary to stabilize antiskyrmions [5].

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