Local characterization of superconductivity in BaFe$_2$(As$_{1-x}$P$_x$)$_2$

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We use magnetic force microscopy (MFM) to characterize superconductivity across the superconducting dome in BaFe$_2$(As$_{1-x}$P$_x$)$_2$, an isovalently doped pnictide that exhibits a peak in the penetration depth ($\lambda_{ab}$) at optimal doping ($x_{opt}$), as shown previously in sample-wide measurements. Our local measurements show a peak at $x_{opt}$ and a $T_C$ vs. $\lambda_{ab}^{-2}$ dependence similar on both sides of $x_{opt}$. Near the underdoped edge of the dome $\lambda_{ab}$ increases sharply, suggesting that superconductivity competes with another phase. Indeed MFM vortex imaging shows correlated defects parallel to twin boundaries only in underdoped samples and not for $x \geq x_{opt}$. Furthermore, in underdoped samples we report stripes parallel to twin boundaries that are visible even in the absence of vortices.

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